

**SPEECH IN SRI LANKAN  
CLEFT PALATE SUBJECTS  
WITH DELAYED PALATOPLASTY**

**Deborah Anne Sell**

***A Thesis submitted in partial fulfilment of the requirements of the  
Council for National Academic Awards  
for the degree of Doctor of Philosophy.***

***December, 1991.***

***Leicester Polytechnic in association with the  
Sri Lankan Cleft Lip and Palate Project,  
The Hospitals for Sick Children, Great Ormond Street, London.***

# Contents

<b>Abstract</b> .....	<b>i</b>
<b>Acknowledgements</b> .....	<b>ii</b>
<b>Tables</b> .....	<b>iii</b>
<b>Figures</b> .....	<b>v</b>
<b>Chapter 1 – Introduction</b> .....	<b>1</b>
<b>Chapter 2 – Literature Review</b> .....	<b>9</b>
<b>Part A – A review of aspects of speech associated with cleft palate</b> .....	<b>9</b>
<b>I. Historical Aspects</b> .....	<b>9</b>
<b>II. General Characteristics of Cleft Palate Speakers</b> .....	<b>13</b>
<b>III. Review of Speech Characteristics</b> .....	<b>17</b>
<b>IV. A Critique of Approaches in ‘Cleft Palate Speech’ Research</b> .....	<b>26</b>
<b>V. Structural Issues</b> .....	<b>29</b>
<b>a. Velopharyngeal Function.</b> .....	<b>29</b>
<b>b. Fistulae</b> .....	<b>32</b>
<b>VI. Speech Therapy</b> .....	<b>34</b>
<b>Part B – Speech in patients with unoperated palates</b> .....	<b>38</b>
<b>Chapter 3 – Issues and Hypotheses</b> .....	<b>49</b>
<b>Chapter 4 – Methodology</b> .....	<b>55</b>
<b>I. Materials</b> .....	<b>55</b>
<b>II. Procedures</b> .....	<b>58</b>
<b>a. Speech</b> .....	<b>58</b>
<b>b. Velopharyngeal Function</b> .....	<b>59</b>
<b>c. Intra-oral Examination</b> .....	<b>64</b>
<b>d. Surgical Observations</b> .....	<b>65</b>
<b>e. Other procedures</b> .....	<b>66</b>
<b>III. Speech Therapy Courses</b> .....	<b>66</b>
<b>Chapter 5 – Method of Speech Analysis</b> .....	<b>70</b>
<b>I. The Rating Scale</b> .....	<b>70</b>
<b>II. Speech Patterns</b> .....	<b>80</b>
<b>III. Speech Categories</b> .....	<b>85</b>
<b>Chapter 6 – Results</b> .....	<b>90</b>
<b>I. Overall Articulation Results</b> .....	<b>90</b>
<b>II. Patterns of Change In relation to Pre-operative Speech</b> .....	<b>94</b>
<b>III. Surgical and Speech Therapy Intervention</b> .....	<b>97</b>
<b>IV. Age</b> .....	<b>99</b>

V. Cleft Type .....	109
VI. Structural Issues .....	116
a. Velopharyngeal Function .....	116
b. Fistulae .....	129
c. Surgical Observations at Palate Repair .....	141
VII. Intervention: Therapy .....	147
VIII. Imitation of Singletons and Imitation of Trisyllables.....	152
IX. Years of Education .....	157
Chapter 7 – Discussion .....	160
I. The Research Problem .....	160
II. Methodological Issues.....	161
III. Critique of the Method of Measuring Speech .....	163
IV. Critique of the Method of Measuring Velopharyngeal Function .....	166
V. Critique of the Method of Measuring Fistulae .....	169
VI. Major Hypotheses .....	170
VII. Minor Hypotheses .....	183
VIII. Other Factors .....	187
IX. Further Research .....	190
Chapter 8 – Conclusion .....	192
References .....	198
Appendix I – Selected photographs .....	210
Appendix II – The Sri Lankan Cleft Palate Project: The Unoperated Cleft Lip and Palate Mars et al. (1990) .....	215
Appendix III – The Language of Sinhala .....	216
Appendix IV – The Speech Sample .....	226
Appendix Va – Oral-Motor Assessment .....	228
Appendix Vb – Palatal Surgery Rating Scale .....	229
Appendix Vc – Nasopharyngoscopy Speech Sample and Framework of Analysis.....	230
Appendix Vd – Psychosocial Forms .....	231
Appendix VI – Early Results based on Quantitative Data .....	232
Appendix VII – Associated Publications .....	237
Sell D. and Grunwell P. (1990) Speech results following late palatal surgery in previously unoperated Sri Lankan adolescents with cleft palate. <i>Cleft Palate J.</i> 27:169-173.	
Wirt A. Wyatt R. Sell D. Grunwell P. and Mars M. (1990a) Training counterparts in cleft palate speech therapy in the developing world:a report. <i>Cleft Palate J.</i> 27:169-173.	
Wirt A. Wyatt R. Sell D. Grunwell P. and Mars M. (1990b) Training counterparts in cleft palate speech therapy in the developing world:an extended report. <i>Brit. J. Dis. of Commun.</i> 25:355-367.	

# Abstract

This investigation was undertaken within the context of the Sri Lankan Cleft Lip and Palate Project, probably the largest surgical and research programme to date concerned with the late operated cleft lip and/or palate subject (Mars et al., 1990).

This study examines the speech results of 88 patients who received palatal surgery by a visiting British surgical team. The main cohort, consisting of 67 nonsyndromic cleft lip and/or palate Sinhala speaking patients over the age of eight years at palate repair, have been studied longitudinally. All these patients have pre-operative, post-operative, and post-therapy speech recordings. In addition, 21 similar patients below the age of eight years at surgery have been partially examined.

51 patients have further speech recordings at 4 or 5 years post-operatively. Investigations of velopharyngeal function were undertaken using lateral skull X-rays of patients phonating 'ee', nasopharyngoscopy, and a perceptual assessment. Post-operative intra-oral examinations were also carried out.

A unique method of speech analysis has been devised, and is used to describe the speech results.

The results have shown that patients who have established their speech with an unrepaired palate usually have severely disordered speech, with the exception of some patients with less severe clefts.

Post-operatively, many patients retain these poor speech patterns, even with some speech therapy support.

Post-therapy, only one third of the cohort had normal or near-normal speech, none of whom were adults. The value of palatal closure is very limited if regular speech therapy is not available as a follow-up to surgery.

Only 20% of the cohort achieved post-operative velopharyngeal closure, suggesting that palatoplasty is an inadequate surgical procedure for the majority of patients, in particular those who present with major clefts and are older than eight years of age at surgery.

The important variables affecting outcome are palatal repair, speech therapy intervention, age, cleft type, nature of pre-operative speech, and nature of surgery. Structural factors in particular velopharyngeal function and also possibly fistulae, in the adult group, are further relevant variables.

Criteria for selecting patients for surgery within this type of environment are proposed.

# Acknowledgements

My very grateful thanks to Pam Grunwell, whose clear thinking, continued support and friendship have helped me tremendously.

Very special thanks are extended to Mike Mars, without whom I know this project would never have happened. I thank him for instilling in me his enthusiasm for the fascinating subject of cleft lip and palate. He not only gave me the opportunity to develop my ideas in the project, but his encouragement, support and belief in my ability to produce this work has truly sustained me over the years.

I am especially grateful to Dave Rowley for all his time in helping me with the statistical analysis, and results.

My thanks to Lian Ma for her constant encouragement and thought-provoking discussions about this work. I am indebted to her for all she taught me regarding velopharyngeal function, particularly nasopharyngoscopy.

I am also very grateful to all the speech and language therapists associated with the project, in particular Anne Wirt and Rosie Wyatt. I would also like to thank Marion Woodard, for her contribution in the early planning stages of the project. I particularly acknowledge the support of Mary Anne Witzel, who helped me appreciate the value and importance of this work, and gave me the opportunity to observe her nasopharyngoscopy clinics at The Hospital for Sick Children, Toronto and, more recently, the encouragement from my colleague Anne Harding.

I thank Simon Brown, for all his hard work in the production of the figures and the final thesis.

A thank-you to Christine Godber, who reliably has given so freely of her time to help me, not only in Sri Lanka but also in London.

I take this opportunity to acknowledge the late Professor Houston, not only for his statistical support, but also for his continued encouragement over the years.

I acknowledge Professor JB. Dissanayake, Professor C. Reynolds, Rajapaksa and Dr. Wijayawardhane for their time and help with Sinhala.

In Sri Lanka, I thank Professor Sanath Lamabadusuriya for his hard work in the development of the project. Particular thanks are extended to the speech therapy counterparts, and to the medical students. I especially remember Professor Chandrasiri, the former Dean and Vice-Chancellor, and his secretary Pushpa Umagiliya for all their help. I am grateful to the various Directors of Galle General Hospital, and the different Deans of the Medical Faculty, University of Ruhuna. A thank-you is also extended to B.R. Dissanayake and Mohammed Fouz, for the accommodation they provided.

I am grateful to the Board of Governors, The Hospitals for Sick Children, Great Ormond Street, for its generous support of my study leave for my visits to Sri Lanka.

I acknowledge the following for the grants I have received: The College of Speech and Language Therapists, Overseas Development Aid, the Cleft Lip and Palate Association in Great Britain, and the Joint Research Board of the Hospitals for Sick Children and the Institute of Child Health.

Most importantly, however, I must thank my husband Andrew who not only has been so patient and supportive over the years, but without whom my visits to Sri Lanka would not have been possible. My thanks too to my son Jack, and his grandparents: Jack for accommodating a mother who seemingly was always working on the 'pjuter', and his grandparents for helping to look after him, so that this work could be completed.

Finally, but by no means least, I remember my patients in Sri Lanka, from whom I have learnt so much.

# Tables

- Table 1. Speech Therapy Personnel and Purpose of each Visit.
- Table 2. The Four Movement Patterns of the Velopharyngeal Valve.
- Table 3. Distribution of Valving Patterns for Normal and Pathological speakers.
- Table 4. Sample according to Age Range, Mean and Median Age, and Gender.
- Table 5. Patients who had Palate Repair in 1985 and 1986.
- Table 6. Patient Sample according to Age and Cleft Type.
- Table 7. Dates of Speech Recordings.
- Table 8. Patient Recall Rate at Follow-up.
- Table 9. Distribution of Patients according to Year of Surgery.
- Table 10. Number and Percentage of Patients of each Age Category for Lateral Skull X-rays of Patients Phonating 'ee'.
- Table 11. Scale used for rating Lateral X-ray of Patient Phonating 'ee'.
- Table 12. Intra-rater Reliability.
- Table 13. Inter-rater Reliability.
- Table 14. Number of Patients who underwent Nasopharyngoscopy.
- Table 15. Percentage of each Age Category who underwent Nasopharyngoscopy.
- Table 16. Nasopharyngoscopy Reliability Study.
- Table 17. Patients and Percentage of each Age Category who had Intra-oral Examinations in 1988 and/or 1990.
- Table 18. Rating Scale used to describe Size and Location of Fistulae.
- Table 19. Number of Patients, and Duration of Residential Intensive Speech Therapy Courses.
- Table 20. Patient Attendance during the 1988 Courses.
- Table 21. The Original Speech Attainment Scale.
- Table 22. The Revised Speech Attainment Scale.
- Table 23. First Inter-rater and Intra-rater Reliability Study using the Original Rating Scale.
- Table 24. Second Inter-rater Reliability Study
- Table 25. Revised Placement and Manner Scales Reliability Study.
- Table 26. Correlations at the Pre-operative Data Point for Placement, Manner and Voice, and their Aggregate.
- Table 27. The Seventeen Speech Patterns.
- Table 28. Quantitative Characteristics of Place and Manner of the Speech Patterns.
- Table 29. Distribution of Speech Patterns according to Frequency of Occurrence across the Data Points.
- Table 30. Distribution of Speech Categories Pre-operatively, Post-operatively, Post-therapy, and 4/5 years Post-operatively.
- Table 31. Pattern of Downward Trends over Time in Speech Patterns and Speech Categories.
- Table 32. Distribution of Pre-operative Speech Categories according to Age.
- Table 33. Distribution of Post-operative Speech Categories according to Age.
- Table 34. Distribution of Post-therapy Speech Categories according to Age.

- Table 35. Distribution of Speech Categories at 4/5 years Post-operatively according to Age.
- Table 36. Results of Speech Categories between Age Group in the Main Cohort.
- Table 37. Results of Speech Categories within Age Group at the Different Data Points.
- Table 38. Results of Speech Categories for each Cleft Group over Time: \* significant p values.
- Table 39. Correlations between the Three Measures of Velopharyngeal Function.
- Table 40. Results of Post-operative Velopharyngeal Function: A Comparison between the Lesser Cleft Group and Major Clefts.
- Table 41. Correlations between the Speech Categories and Measures of Velopharyngeal Function.
- Table 42. Correlations between the Speech Categories Characterized by Compensatory Articulations and Measures of Velopharyngeal Function.
- Table 43. Correlations between Fistulae and Speech Outcome Measures for the Total Group.
- Table 44. Correlations between Fistulae and Speech Outcome Measures for the Adult Group.
- Table 45. Descriptive Statistics related to Lateral Pharyngeal Wall Movements in the Presence and Absence of Fistulae.
- Table 46. Raw Data relating to Speech, Velopharyngeal Function and Surgical Observations.
- Table 47. Correlations between the Speech Results Pre-operatively, Post-operatively, and Following Therapy, and the Three Different Sections of Surgical Observations.
- Table 48. Correlations between Surgical Observations and the Three Post-operative Measures of Velopharyngeal Function.
- Table 49. Correlations between Selected Features of Palatal Repair and the Three Post-operative Measures of Velopharyngeal Function.
- Table 50. Means and Standard Deviations for Conversation and Articulation Groups.
- Table 51. Means of Imitation of Singletons and Trisyllables at the Pre-operative, Post-operative and Post-therapy Stages.
- Table 52. Post-therapy Speech Categories of Patients who did not return for Follow-up in 1990.
- Table 53. A Comparison of the Results of the Adults and Adolescents, with the Ortiz-Monasterio Findings.

### ***In Appendices***

- Table 54. The Consonant Sound System of Sinhala.
- Table 55. The Sinhalese Vowels in relation to the Cardinal Vowels.
- Table 56. Descriptive Statistics of the Post-operative and Post-therapy Results of each Age Group.
- Table 57. Amount of Change Post-therapy of the Adult and Adolescent Groups
- Table 58. Post-operative Results between Age Categories of the Same Cleft Group.
- Table 59. Post-therapy Results within Age Categories of the Same Cleft Group.

# Figures

- Figure 1. Speech Patterns according to Place and Manner Scores.
- Figure 2. Speech Categories according to Phonetic Criteria.
- Figure 3. Distribution of Patients according to Speech Categories at the Four Data Points.
- Figure 4. Patterns of Change by Pre-operative Speech Category.
- Figure 5. A Comparison of Speech Categories between the Age Groups at the Four Data Points.
- Figure 6. A Comparison of Speech Categories within the Age Groups at the Four Data Points.
- Figure 7. Adults – Speech Categories at the Four Data Points.
- Figure 8. Adolescents – Speech Categories at the Four Data Points.
- Figure 9. Children – Speech Categories at the Four Data Points.
- Figure 10. Degree of Speech Change by Category (pre-op to post-op).
- Figure 11. Degree of Speech Change by Category (pre-op to immediately post-therapy).
- Figure 12. Degree of Speech Change by Category (pre-op to 4/5 years post-op).
- Figure 13. Speech Categories by Cleft Type (pre-op).
- Figure 14. Speech Categories by Cleft Type (post-op).
- Figure 15. Speech Categories by Cleft Type (post-therapy).
- Figure 16. Speech Categories by Cleft Type (4/5 years post-op).
- Figure 17. Bilateral Cleft Lip and Palate: Speech Categories at the Three Data Points.
- Figure 18. Unilateral Cleft Lip and Palate: Speech Categories at the Three Data Points.
- Figure 19. Hard & Soft Cleft Type: Speech Categories at the Three Data Points.
- Figure 20. Lesser Cleft Type: Speech Categories at the Three Data Points.
- Figure 21. Patient Distribution according to Measures of Velopharyngeal Function.
- Figure 22. Patient Distribution by Gap Size.
- Figure 23. Movement Characteristics of Velopharyngeal Sphincter.
- Figure 24. Patient Distribution by Valving Pattern.
- Figure 25. Nasopharyngoscopy by Age.
- Figure 26. Nasality by Age.
- Figure 27. X-ray by Age.
- Figure 28. Nasopharyngoscopy by Cleft Type.
- Figure 29. Nasality by Cleft Type.
- Figure 30. X-ray by Cleft Type.
- Figure 31. Nasopharyngoscopy by Speech Categories.
- Figure 32. Nasality by Speech Categories.
- Figure 33. X-ray by Speech Categories.
- Figure 34. Incidence and Fistula Size.
- Figure 35. Distribution of Patients by Age and Fistula Type.
- Figure 36. Total Sample – Incidence and Fistula Size by Age.
- Figure 37. Fistula Type by Cleft Type.
- Figure 38. Total Sample – Incidence and Fistula Size by Cleft Type.



- Figure 39. Distribution by Location of Fistula.
- Figure 40. Deliberate Fistula – Incidence and Fistula Size by Age.
- Figure 41. Deliberate Fistula – Incidence and Fistula Size by Cleft Type.
- Figure 42. Total Palatal Closure – Incidence and Fistula Size by Age.
- Figure 43. Total Palatal Closure – Incidence and Fistula Size by Cleft Type.
- Figure 44. Patients <26% correct Pre-operatively on Imitation of Singletons — Post-therapy Speech Categories in relation to Pre-operative Speech Categories.
- Figure 45. Years of Education by Age.
- Figure 46. Selected Characteristics of Patients who made Appreciable Changes in Controlled Speech.

# Chapter 1

## Introduction

Cleft lip and/or palate malformations are the most common congenital abnormalities in the craniofacial region. Closure of the cleft palate is advocated, in order to separate the nasal and oral cavities, and to provide a mechanism which would potentially be capable of producing normal speech, hearing, dentition, occlusion, and swallowing. The results of corrective surgery in the West, however, are very variable, leading to a variety of anatomical and functional impairments (Bardach and Kelly, 1991). Possible adverse sequelae include impaired facial growth, dental anomalies, speech disorders, velopharyngeal dysfunction, middle ear problems, poor hearing, and difficulties in psychological well-being and social relationships. Treatment of cleft lip and palate presents a serious problem for health delivery systems throughout the world.

The Sri Lankan Cleft Lip and Palate Project was begun in 1982 by Michael Mars, who has since directed the project. He initiated the project as a means of extending his research into normal and abnormal facial growth. The project has since developed as the largest and most comprehensive surgical and research programme to date concerned with the late operated cleft lip and/or palate subject (Lamabadusuriya et al., 1988; Mars et al., 1990). Shprintzen (1990a, p174: see Appendix VII, Wirt et al., 1990a) describes the data as fascinating, and that several of the papers are,

*“valuable lessons for others who also visit the third world to deliver care.”*

The aim of this chapter is to provide an introduction to some of the general theoretical issues, followed by an explanation of the specific areas of concern addressed in this investigation. The context in which this study takes place is briefly described. The breadth of the speech therapy contribution is reviewed.

### **Background**

Maxillary retrusion, or underdevelopment of the middle third of the face (see Appendix D), is a common characteristic of a large number of patients with repaired clefts of the lip and/or palate in the Western world. The cause of this is unknown, and controversial. Some authorities claim that intrinsic factors are responsible, suggesting that maxillary retrusion is a part of the cleft palate condition (Bill, Moore and Coe, 1956; Pruzansky and Aduss, 1964). In contrast, other authorities, notably orthodontists, regard maxillary retrusion as an iatrogenic deformity (meaning 'caused by the doctor'), with the suggestion that palatal closure in infancy is responsible (Gillies and Fry, 1921; Ortiz-Monasterio et al., 1959, 1966; DeJesus, 1959; Pitanguy and Franco, 1967; Bishara et al., 1986). Yet another school of thought suggests that lip repair and not palatal surgery is responsible for growth disruption (Hagerty and Hill, 1963).

Another controversy centres around the optimum timing of palatal closure, especially with regard to the effects upon speech development and performance, and subsequent facial growth.

Several studies advocate early surgical closure of the palate in order 'to facilitate normal speech development' (Veau, 1931; Jolleys, 1954; McWilliams, 1960; Peet, 1961; Evans and Renfrew, 1974; Dorf and Curtin, 1982). Such findings on the timing of surgery are remarkably consistent, in particular given the differing methodologies and methods of analyses used in these studies. Morris (1990) points out that there is general agreement that surgery should not be delayed beyond three years of age for the acquisition of normal speech. There is, however, a need to identify whether there are important differences in speech outcome at different ages below three years. Although early surgery is advocated for speech purposes, delayed palatal closure is claimed to minimize adverse growth defect (Schweckendiek, 1978; Hotz et al., 1978).

Clearly there is the potential problem of conflicting aims between maximizing facial growth and speech.

Workers in the field, recognizing this problem, have tried to modify surgical protocols to realize these two aims. Delayed hard palate closure was recommended, and is still carried out to the present day in some centres (Hotz et al., 1978; Soderpalm et al., 1991; Honigmann, 1991). In this surgical protocol, early closure of the soft palate is undertaken, but the repair of the hard palate is delayed, on the premise that this avoids subsequent mid-facial growth damage. Although research has shown that there is normal maxillary growth when hard palate closure is delayed beyond twelve years of age (Schweckendiek, 1978), speech is disappointing in this regime (Bardach et al., 1984). As a compromise, some proponents of this surgical protocol advocate closure of the hard palate at four to six years of age (Hotz et al., 1978). However, although there is some conflicting evidence, the majority of the speech results remain disappointing, with no benefits to facial growth (Cosman et al., 1980; Witzel et al., 1984; Henningson et al., 1990; Van Demark et al., 1989).

The investigation of a large group of patients with unrepaired cleft lip and/or palate provides an opportunity to study the natural history of cleft lip and palate in the absence of intervention. This might help to resolve some of the controversies related to the aetiology of facial growth and the timing of surgery. Such patients, however, are not found in the West. A large reservoir of unoperated cleft lip and/or palate subjects of all ages was available in Sri Lanka. This population, therefore, provided an ideal cohort for studies of surgical outcome, especially as Sri Lanka is a small island with a large population. Furthermore, a reasonable transport system facilitates long-term follow-up (Mars et al., 1990: see Appendix II).

### ***Reasons for Speech Investigation***

In recent years, authorities have recognized the importance of studying the effects of palatoplasty on both facial growth and speech in a surgical series (Morris and Bardach, 1990). McWilliams et al. (1990, p.62) write,

*"There would be special relevance to data that examine speech variables and growth variables simultaneously as a function of age at palate surgery."*

They quote only one such report, that of Jolleys (1954).

Morris and Bardach (1989) also recommend the study of the timing of primary palatoplasty in relation to both

speech development and mid-facial growth. Furthermore, they specifically identify,

*"...the effect of untreated clefts on both speech and language development, and facial growth and development"* (op. cit. p.142) as priority areas of future research.

The literature review (see Chapter 2) demonstrates how previous speech reports of similar unoperated patients have flawed methodologies. Studies have been characterized by poorly designed frameworks of speech analysis, using parameters of speech that were ill-defined and non-comparable (see Chapter 2: Part B). Furthermore, in some reports, professionals other than speech therapists have reported the speech results, resulting in subjective and inadequate studies (Jackson et al., 1983).

Trost-Cardamone (1986) states that there are no prospective longitudinal data on the timing of initial palatoplasty. The present study represents a unique opportunity for a prospective longitudinal study of speech and velopharyngeal function in a group of patients who have palatoplasty after their speech has been acquired.

It is generally assumed that normal speech is more often associated with earlier surgery than later surgery, yet McWilliams et al. (1990) recommend that this assumption should be investigated.

With regards to speech production skills, they hypothesize that,

*"...when palatoplasty and hence any possibility of normal velopharyngeal functioning is delayed until after the child has begun to talk, the resulting speech patterns are apt to be defective because of the abnormal velopharyngeal anatomy and physiology. The hypothesis to be tested is whether early palatoplasty results in normal patterns of speech more frequently than does later palatoplasty."* (McWilliams et al., 1990, p.62)

Secondly, with regard to velopharyngeal function, they suggest that,

*"...the physiologic potential of the muscles comprising the velopharyngeal valving mechanism may be irretrievably lost by delay in moving them into a normal relationship. This hypothesis can be tested by determining whether early palatoplasty results in physiological velopharyngeal competence more frequently than later palatoplasty."* (McWilliams et al., 1990, p.62)

The study of a population who have established their speech in the presence of an unoperated palate, and have subsequently had surgery, permits the investigation of the relationship of both speech acquisition and velopharyngeal function to age at palatoplasty.

It has become common for surgical teams from developed nations to travel to developing countries in order to perform surgery on previously unoperated patients, usually without the collection of pre-operative and post-operative records (Law and Fulton, 1959; Keunen, 1966; Boo-Chai, 1971). Teams sponsored by charity organizations from Europe, South and North America, Africa and Australasia are currently involved in such projects.

The benefits of surgery to speech are assumed, but have not been scientifically investigated. This is especially

important given that 80% of the world's population have no access to elective surgical care (Mahler, 1981). Large groups of unoperated patients still exist. If an adequate investigation is performed, it might even be possible to predict which patients might benefit from delayed surgery in order to make the best use of resources in the developing world, and visiting teams.

### ***The Sri Lankan Cleft Lip and Palate Project***

Following the initial visit to Sri Lanka in 1984 by the Project Director and a surgical colleague, the project was established with three principal objectives:

- ❑ to provide surgical treatment for patients in Sri Lanka with clefts of the lip and/or palate.
- ❑ to provide training for Sri Lankan surgeons and professional staff.
- ❑ to collect scientific records of cleft lip and palate for the study of the natural history of the condition.

Mars et al. (1990) have written a detailed description of the project (see Appendix II).

Speech therapists were included in the pre-operative and post-operative assessment team. All patients were seen by the pre-operative team: the exact nature of the assessments undertaken depended on age, timing of the assessment and extent of the cleft.

The pre-operative assessments included dental impressions, clinical photographs, lateral skull radiographs, both a still and of the patient phonating 'ee', speech assessments involving simultaneous audio and video recordings, nasopharyngoscopy, audiometric recordings, ENT examination, social histories, psychosocial questionnaires and attitudes ratings.

The purpose and description of the pre-operative and post-operative assessments related to other areas of research are briefly described. This is in order that the breadth of the assessments undertaken is fully appreciated, in particular those referred to within this study.

Dental impressions were taken to make plaster models of the mouth, in order to demonstrate the relationship of the upper and lower jaws. Precise arch dimensions can be measured and compared between the different cleft types and normal healthy subjects. Lateral skull radiographs were taken to measure the skeletal and dental relationships of the mandible and maxilla in the anterior-posterior plane in relation to the cranial base. Based on these measures, facial growth studies have been undertaken (Mars and Houston, 1990).

Hearing tests were undertaken in 1985; however, their reliability was later questioned. Sri Lankan medical students performed the tests, unfortunately with limited training and monitoring of the procedure. Subsequently, however, hearing has been assessed by British trained audiologists (in 1986 by an Educational Audiologist, and in 1990 by a Consultant Audiological Physician). Distraction testing, conditioning and free field audiometry were used in younger children. In older patients, full pure tone audiometry was employed, with bone conduction and masking if screening at twenty decibels was not satisfactory. At the same time, an Otolaryngologist's opinion on the nature of any ear disease was undertaken (Albert et al., 1990). Therefore

for the majority of the main cohort in this study, reliable information on hearing and an opinion on middle ear disease has been gained at two points in time: viz. November 1986 and August 1991.

A social history, a questionnaire, and an attitudes rating scale were administered. These were aimed at systematically detecting the social and emotional effects of facial deformity and/or severe speech difficulties (see Appendix Vd). The social history included information about the patient's family, type and duration of schooling and further education, feeding habits and social lifestyle. Two methods of investigating the way in which patients viewed their world and circumstances were attempted: a questionnaire and an attitudes rating. The psychosocial questionnaire provided information on how the patients perceived themselves, the effect the cleft had had on their lives, their expectations of surgery and their understanding of the condition. The attitudes ratings provided a less direct but more objective technique than questioning in an interview situation.

Ward and James (1990) have described in detail the surgical aspects of the project. In total, ten surgeons have been associated with it.

### ***Achievements***

630 operations have been performed, with an age range of three months to seventy years. Pre-operative records have been obtained on 741 subjects, with selected records on 130 healthy control subjects from the same racial group. Selected records have also been collected on a group who have been operated on at conventional ages by Sri Lankan surgeons.

### ***The Speech Therapy Component of the Project***

The initial aim of the speech therapists' contribution was confined to the collection of pre-operative records, but following the experience of the first visit this was expanded into the provision of post-operative intensive residential speech therapy courses, counterpart training (1988), and nasopharyngoscopy investigations in 1990.

Table 1 illustrates the chronological development of the speech therapy input to the project. Six speech therapists have been associated with the project since 1985.

### ***Speech Audio and Video Recordings***

The collection of speech audio and video recordings is described in detail in Chapter 4.

*Table 1. Speech Therapy Personnel and Purpose of each Visit*

<b>Date</b>	<b>Number of Therapists</b>	<b>Purpose</b>
November 1985	2 in Sri Lanka	Pre-operative records
July 1986	2 in Sri Lanka	10 day therapy course Post-operative records Post-course records
November 1986	3 in Sri Lanka	14 day course Pre-operative records on 1986 surgical cohort Pre- and post-course records
Summer 1988	2 in Sri Lanka 1 in England	4 month series of courses Counterpart training Post-operative records Pre- and post-therapy course records
August 1990	3 in Sri Lanka	Post-operative records Nasopharyngoscopy Counterpart training
November 1990	3 in Sri Lanka	14 day course Counterpart training Pre-operative records Post-course records Pre-operative Nasopharyngoscopy

### ***Speech Therapy Courses***

It was evident even before surgery that the level of speech performance could have been higher in some patients if they had had the opportunity of receiving speech therapy. It was also anticipated on the basis of clinical experience of the population and a review of the literature (Morris, 1979), that even in the context of highly successful surgery, speech therapy would be needed to change habitual deviant articulatory patterns (Dorf and Curtin, 1982; Trost-Cardamone, 1986). Van Demark (1974b) found that there was no improvement in the speech of individuals who had post-operative velopharyngeal incompetence unless they received supportive speech therapy. In this situation, Trost (1981) maintained that it was possible to change selected components of articulation, particularly place deviations. Furthermore, many patients were at a disadvantage on account of age. Speech therapy would probably be needed as a result of this factor alone (Bzoch, 1979; McWilliams et al., 1990).

There is only one speech therapist in Sri Lanka for a population of sixteen million. In view of this, the British team of speech therapists organized intensive speech therapy courses for all patients over the age of six years at the time of surgery, on whom the British surgeons had performed palatal repair.

Four courses have been run to date, and details of attendance are shown in Table 8 (Chapter 4). The recall rate was high in 1986, and in 1990, but was lower in 1988. This was probably because the 1988 programme took place against a background of worsening political violence in the country.

### ***Counterpart Training***

The counterpart training developed from our experience of the residential speech therapy courses. It was recognized that patients would benefit from continued speech therapy support when the Western team was not visiting the country. As there was only one speech therapist in Sri Lanka, it was decided to follow the lead of a growing number of western health care professionals who spend time in the developing world by training local individuals as health care workers. Five local individuals have received training in facilitating basic articulation skills in patients with cleft palates. Details of this training, and the clinical, political and cultural issues that arose have been described elsewhere (Wirt et al. 1990a, 1990b: see Appendix VII).

### ***Nasopharyngoscopy***

Although the importance of objective data on post-operative velopharyngeal function was appreciated, it only became possible to collect nasopharyngoscopy data in the later stages of the study. Nasopharyngoscopy provides a view of the velopharyngeal valve from above, without disturbing the normal flow of speech production. It is possible to observe the complete anatomy and function of the component parts of the velopharyngeal sphincter – i.e. the soft palate, the lateral pharyngeal walls, and the posterior pharyngeal wall – both at rest and in motion during uninhibited speech.

Loney and Bloem (1987) found that the terms velopharyngeal incompetence, velopharyngeal inadequacy, and velopharyngeal insufficiency were often used interchangeably. Evidence for this terminological confusion is found in the literature review (Chapter 2). In order to clarify this situation, Trost-Cardamone (1989) proposed a recent classification based on aetiology, which is followed in this study. The category of velopharyngeal insufficiency includes any velopharyngeal dysfunction associated with structural aetiologies, such as cleft palate.

### ***Outline of Thesis***

The structure of each chapter of the thesis is now outlined.

Chapter 2 consists of a survey of the literature and is divided into two parts. Part A is a review of aspects of speech associated with cleft palate. Part B is a review of speech in patients with unoperated palates

Part A is subdivided into seven sections. Section I is concerned with historical aspects, providing an overview of the evolution of the study of speech in cleft lip and palate disorders.

Section II consists of a review of the generally accepted findings regarding 'cleft palate speech'. It should be stated here that the use of the term 'cleft palate speech' has become an accepted shorthand in the literature, a practice that will be followed. It is recognized, in this study, however, that it is an inaccurate and misleading term, which fails to reflect the heterogeneity of cleft palate speakers. This concept is given further consideration in this section.



Section III reviews the findings related to the primary parameters of speech associated with the cleft palate condition.

Section IV continues with a critique of speech research, in particular with regard to methodological issues and frameworks of speech analyses.

Sections V and VI review research related to structural issues. Section V examines velopharyngeal function, given its importance in determining whether surgery has achieved its aims. Section VI reviews the literature associated with one of the known surgical complications of palate repair, the development of oronasal fistulae.

Section VII consists of a review of speech therapy treatment associated with cleft palate.

Part B is a critical review of previous studies of speech in patients with unoperated cleft palates.

Chapter 3 is a consideration of the issues and hypotheses that are to be addressed in this study.

Chapter 4 describes the methodology, and includes a detailed description of the subjects included. The procedures employed in this investigation are outlined, followed by a description of the intensive speech therapy courses.

Chapter 5 traces the development of the method of speech analysis, with a description of the reliability studies.

Chapter 6 consists of a presentation of the results, with some preliminary interpretation.

Chapter 7 is an in depth interpretation of the results, with cross-referencing of the results of different variables. The discussion also contains a critical review of the study, relates the findings to previous work, and examines the implication of these results in relation to the theory of cleft palate speech.

Chapter 8 is a summary of the conclusions, with a discussion of the theoretical contribution provided by this study.

# Chapter 2

## Literature Review

### **Part A –**

### ***A review of aspects of speech associated with cleft palate***

#### ***I. Historical Aspects***

This section provides an overview of the evolution of the study of speech in cleft lip and palate disorders. It demonstrates how the term 'cleft palate speech' has been used to describe an increasing range of phenomena, as our understanding of the speech characteristics associated with this condition has grown.

Individuals with cleft palate are considered at risk for phonetic, phonological, resonance and phonatory disorders (McWilliams et al., 1984, 1990; Stengelhofen, 1989). These disorders may be associated with velopharyngeal inadequacy or other structural conditions which may result from cleft palate, such as intermittent hearing loss, dental or occlusal factors, or oro-nasal fistulae. Equally, persistent speech disorders are found where the aetiology is unclear, but may be influenced by the nature of surgery, timing of palate repair, extent of original cleft, surgical skill, psychosocial and learning factors, or the amount of speech therapy.

The primary aim of palate repair is to ensure the potentiality of normal speech development. In the Western world early infancy is generally considered to be the conventional time for palatal closure. Under this surgical timing, Spreistersbach et al. (1973) estimated that 50% of children develop normal speech spontaneously, another 25% of patients achieve acceptable speech with speech therapy support and 25% require secondary surgery for velopharyngeal incompetence. McWilliams et al. (1984, 1990) stated that between 70% to 95% of children with cleft palate do not require secondary surgery for velopharyngeal incompetency. Studies cited in support of this observation include Riski and Delong (1984) who reported that 78% of their sample developed velopharyngeal adequacy. Stengelhofen (1989), on the other hand, estimated that there are around 40% of cleft palate patients who have long-standing problems leading to deficits in their communication skills.

The reason for such differing findings may in part be explained by the fact that McWilliams et al. and Stengelhofen are considering different aspects of speech. McWilliams et al. (1984) appeared to be restricting their figures to the incidence of disorders of resonance requiring secondary surgical intervention. Stengelhofen (1989), in contrast, probably included any difficulty related to any of the areas of communication, such as language development, phonation, resonance, or the sound system. Although Spreistersbach et al. (1973) does appear to take into account speech sound difficulties in contrast to resonance disorders, his term "acceptable speech" is ambiguous and ill-defined, with the result that it is difficult to interpret the statements and meaningfully compare the figures of these authorities.

Initial attempts at cleft palate closure concentrated on the anatomical closure of the cleft, with very unsatisfactory results in terms of facial growth, dentition, and speech. Many patients had a severe degree of maxillary collapse, severe dental abnormalities, articulation disorders and hypernasality. From 1925, surgeons turned their attention to improving the speech result. This was possible, as their understanding of the anatomical and functional requirements for speech increased, and the risks of surgery decreased with the advent of antibiotics, transfusions and anaesthesia. Speech performance then became the criterion by which the operative procedure was judged, leading to an upsurge of interest in the speech characteristics associated with cleft palate in this century. In fact, even as early as 1862, Passavant and Shoenborn (Yules et al., 1971) introduced procedures with the definite aim of improving the speech result.

In 1928, Berry described the characteristics of speech associated with cleft palate as,

*“...nasal emission, lack of intra-oral air pressure, misarticulation of /s, z/ and especially severe hypernasality on the high vowels /i/ and /u/.”*

Although this set of properties showed considerable insight, it was not a comprehensive description.

Since World War Two, there have been attempts to describe speech following surgery, but frequently these judgements were made by surgeons using very simple frameworks of speech analysis (section IV: see below). Moll (1968) reviewed speech studies between 1931–1962 and found the incidence of normal speech varied from 0–90%. The variability in these results could be explained by flawed methodological designs, different methods of measuring speech, and as previously referred to, professionals other than speech therapists reporting speech results.

In the 1950s and 1960s American speech pathologists began to contribute significantly to the literature on the nature of speech disorders in cleft palate speakers. They studied the general characteristics of cleft palate speakers (section II: see below). Speech was primarily studied from a phonetic perspective frequently employing the traditional framework of error analysis of distortions, substitutions, and omissions which had disadvantages (section IV: see below). Researchers also studied in detail error types, the phonetic categories of manner, place and voice, singleton consonants, clusters and vowels.

One particular drawback of studies during this period was a tendency to attribute all articulatory disturbances to velopharyngeal incompetency. Insufficient account was taken of the potential effects of other aspects of speech disorders on speech results, in particular developmental aspects (Bzoch, 1965; Bzoch, 1979; Philips and Harrison; 1969: section III, see below). However, Morris (1981) reported that since 1960 there had been better identification and appreciation of the range of aetiological factors that may account for a speech disorder.

In 1968, Moll wrote that the speech sound articulation of individuals with cleft palate was often briefly described by nasal distortions of fricatives and plosives, the frequent use of glottal stop substitutions, and general inaccuracy of sound articulation. He drew attention to the fact that such a description was an oversimplification, which did not take into account variability within or between patients.

In 1970, Morley, a British speech therapist made a notably valuable contribution. She described two types of speech pattern typical of cleft palate individuals. The first was identified as an intelligible speech pattern characterized by correct place of articulation, with nasal emission and consonant weakness resulting from lack of intra-oral air pressure. The second pattern, though usually unintelligible, was characterized by nasal escape, nasal snort, glottal stops, pharyngeal fricatives, nasal grimace, and other articulatory substitutions. In practice, speech disorders are not as clear cut as this framework might suggest, although this was a useful description for the time.

In 1972, Subtelny et al. described 'cleft palate speech' as being made up of various attributes: articulation errors, nasal air escape, intelligibility, nasality, and phonation. Nasal grimace might also occur. These attributes were all related but intercorrelations reported in the literature varied greatly (Moll, 1968). Subtelny et al. (1972) stated that since it was not possible to establish predictable correlations, each parameter must be separately assessed.

Much of the research has concentrated on the velopharyngeal mechanism, so writers have tended to concentrate on the nasality aspect of the speech disorder. For example, Edwards (1980) wrote that 'cleft palate speech' provided a shorthand term that implied a syndrome of speech disability characterized by hypernasal resonance with pharyngeal and glottal realizations of many sounds. The concept of a syndrome of possibilities is useful, but her description does not include the whole range of problems, focusing as it does largely on the velopharyngeal mechanism.

Bzoch (1979) described the characteristics of 'cleft palate speech' in a traditional error framework but also described the aetiological factors that accounted for them. The characteristics that he listed include:

1. laryngeal and pharyngeal gross substitution errors of articulation for consonant sounds.
2. distortion of consonant sounds due to audible nasal emission.
3. lisping and other articulatory distortions related directly to dental or occlusal abnormalities.
4. articulatory deviations related to loss of hearing acuity.

He also observed:

- distortion of voice quality for vowel and syllabic sound elements due to hypernasal resonance.
- distortion of voice quality, affecting vowels or nasal consonants or both due to hyponasal (denasal) resonance.
- dysphonia characterized by a rough or uneven fundamental laryngeal vibration resulting in hoarseness.
- communication problems from visual distraction of the listener due to nasal and facial grimace.

In this description, Bzoch emphasized the concept of gross substitutions, first described by Morley (1970) as 'compensatory adjustments'. Trost (1981) has since described these as compensatory articulations (section III: see below). These are a distinctive category of errors of place of articulation in patients who do not or

cannot close the velopharyngeal sphincter during speech.

An exciting development during the eighties was the contribution of phonology to the study of cleft palate speech (Lynch et al., 1983; Hodson et al., 1983; Grunwell and Russell, 1987). Phonological principles have only been applied to the study of disordered speech since the seventies. Previously, cleft palate speech was largely discussed from an articulatory and phonetic perspective. Crystal (1981, p.193) underlined how important it was to use both phonetic and phonological principles in the study of the speech of cleft palate children,

*"... it is required in order to determine the extent to which an adequate phonological system is being obscured by purely phonetic deviance, or whether there is in addition an underlying disturbance of a phonological type; if the latter, whether it is something unique to the cleft palate condition, or a manifestation of some general pattern of delay."*

A child with a phonetic deviance or delay has difficulty in physically articulating certain sounds in the language. He/she is unable to, or does not, articulate certain sounds. This may be due to abnormal articulatory structures, hearing impairment, or abnormal learned neuromotor patterns as a result of the cleft (Bzoch, 1979), or may be developmental in origin (Grunwell, 1987). A phonetic deviance affecting the child's ability to signal meaning differences results in a phonological deficit. An exact diagnosis of phonetic, and phonological delay or deviance, and their relationship to each other should be attempted. Investigation of developmental characteristics of a child's speech is advocated using phonological principles.

Recently Stengelhofen (1989) summarized the potential range of phonetic problems associated with cleft palate as:

- 1 Changes in breath direction.
- 2 Inadequacy of breath support because of air waste.
- 3 Weakened fricatives, plosives and affricates.
- 4 Audible nasal emission.
- 5 Tendency for contacts to be towards the back of the oral cavity.
- 6 Preponderance of laminal contacts and imprecise tongue tip movements.
- 7 Use of double articulations.
- 8 Secondary articulations such as pharyngealization, and velarization.
- 9 Frequent use of glottal stop.
- 10 Fricatives may be retracted in place to become velar, pharyngeal or glottal.

Summarizing only the characteristics of speech associated with velopharyngeal dysfunction due to clefting, Trost-Cardamone (1990a) described four "stigmata", resulting in perceptually deviant and phonologically distinctive speech.

These were:

1. hypernasal resonance distortions of vowels in non-nasal contexts, and of glides and liquids.
2. nasal air emission: the nasal airflow that accompanies production of plosives, fricatives and affricates.
3. weak pressure consonants due to reduced intra-oral air pressure.
4. compensatory articulatory gestures.

Later she also included "atypical backed articulations" in which the place of articulation tends to be posterior to that found in standard English.

She categorized cleft palate misarticulations into two categories with respect to underlying causes. Category 1 misarticulations are structurally based and include such features as audible nasal emission and weakness of manner of plosives, fricatives and affricates, and excessive hypernasality of vowels and liquids and glides. Category 2 misarticulations are compensatory substitutions, coarticulations, and atypical backed articulations. Category 1 and 2 misarticulations can coexist.

Hoch et al. (1986) described three types of "speech development" in children who are unable to achieve velopharyngeal closure:

1. Hypernasality without oral articulation abnormalities. The normal patterns of oral articulation acquisition occur despite velopharyngeal inadequacy. The only abnormalities noted are hypernasality, possible nasal turbulence, or other manifestations of an airleak through the velopharyngeal valve.
2. Hypernasality with weak oral pressure consonants. The correct placement of oral articulators occurs, but the stop/fricative manner of articulation is affected by failure to channel and impound sufficient airflow through the oral cavity.
3. Hypernasality with compensatory articulations.

In view of the nature of speech of the population in the present study, these two latter descriptions were likely to be particularly applicable.

## ***II. General Characteristics of Cleft Palate Speakers***

This section reviews the generally accepted findings regarding cleft palate speech.

During the 1950s and 1960s, there were a number of unrelated studies primarily conducted by speech pathologists in North America, which taken together present an overview of the nature of 'cleft palate speech' in individuals with 'early repair'.

Before reviewing these studies, the term 'cleft palate speech' needs further consideration. The use of the term 'cleft palate speech' encourages the view that it is a single entity and that cleft palate speakers form a homogeneous group. The cleft palate population, however, is a heterogeneous group in speech, just as it

is in other areas such as extent and presentation of the cleft, facial growth characteristics, hearing ability, intelligence, velopharyngeal function, and associated congenital abnormalities (Spreistersbach et al., 1964). Therefore the term 'cleft palate speech' is inaccurate and misleading, and is described by Moll (1968) as "a meaningless simplification".

The only group that can be considered as an homogeneous speaking group is the group of patients with cleft lip only (Spreistersbach and Powers, 1959; Spreistersbach et al., 1961; Riski and Delong, 1984). They form a group which is characterized by normal articulation, and which is not at risk for the speech characteristics that have been described above.

In view of the early recognized heterogeneity of cleft palate speakers, researchers have tried to establish the effects of different variables on speech. The most commonly addressed variables have been type of cleft, age at palatal surgery, type of surgical management, and the presence or absence of velopharyngeal incompetency. Moll (1968) stated how important it is to discuss speech results whilst these variables are controlled.

With reference to cleft type, Spreistersbach et al. (1964) reviewed the differences in cleft type groups in their discussion of heterogeneity in the 'cleft palate population'. Differences had been reported in articulation skills, the ability to "impound intra-oral breath pressure", incidence of hearing loss, intellectual functioning, and associated congenital anomalies. On all of these variables, the cleft palate only group compared less favourably than the complete cleft lip and palate group. Spreistersbach et al. (1964, p.212) described it as,

*"...imperative that the subgroup or subgroups of cleft type be specified when studying speech or velopharyngeal competence in individuals with clefts."*

Therefore, there is evidence to suggest that differences between cleft type groups is not restricted simply to the extent of the cleft, but that differences in other parameters exist too.

Spreistersbach et al. (1961) reported that the palate only subgroup exhibited a lower mean score on articulation tests than the lip and palate subgroup. Their explanation was two-fold: firstly, patients with extensive horseshoe-shaped clefts of the hard and soft palates presented with significant tissue deficiency, and the condition of cleft palate only was more often associated with other congenital deformities.

Moll (1968) and McWilliams et al. (1990) reviewed the evidence which showed that the severity of speech problems increased with cleft type severity, using a classification of soft palate only, hard and soft palate (H&S), unilateral complete clefts (UCLP), and bilateral complete clefts (BCLP). McWilliams et al. (1990) attributed the differences between the group with complete cleft lip and palate and the group with cleft palate only to dental problems, maxillary collapse, and protrusion of the premaxilla associated with clefting.

Using speech therapy as an index of articulation severity, Morley (1970) found that the percentage of children requiring speech therapy differed according to cleft type severity: 42% of the BCLP group, 23% of the UCLP group, and 18% of the postalveolar cleft group.

Fletcher (1978) reported the percentages of correct articulation responses according to cleft type, and a similar trend was seen: BCLP – 49% correct, UCLP – 64% correct, soft and hard palate – 72% correct, soft palate only – 91% correct. He, however, did report important individual differences which did not conform to this systematic pattern.

Riski and Delong (1984) also found a trend for articulation proficiency to decrease with increased severity of clefting.

These two most recent studies, however, have not described the level of velopharyngeal adequacy/inadequacy according to cleft type, using objective methods of assessment, such as nasopharyngoscopy and multi-view videofluoroscopy.

More recently, differences between the UCLP and BCLP groups have been described. Karling (1989) compared the speech of 84 unilateral cleft lip and palate patients (UCLP) with 19 bilateral cleft lip and palate (BCLP) Swedish speaking patients at a mean age of 14 years. The BCLP group was significantly less intelligible, and had significantly more retro-positioned dental articulation than the UCLP group. Other differences were found which were not statistically significant. For example, 42% of the BCLP group underwent pharyngeal flap surgery compared with 24% of the UCLP group, indicating a higher degree of hypernasality in the BCLP group. The mean frequency of nasalized fricatives was higher in the BCLP group. The BCLP group required more speech therapy than the UCLP group. Interestingly, glottal and pharyngeal articulation was only found in a limited number of patients in both groups, which Karling attributed to speech therapy remediation.

The heterogeneous nature of 'cleft palate speech' naturally leads to the finding that there is a very wide range of ability in articulation skills. Moll (1968) emphasized the great variation from child to child. Spreistersbach et al. (1961) reported the articulation test scores for a group of 114 cleft patients, over an age range of 3.6 – 16.11 years, with a mean of 9.1 years. These ranged from 6–100% correct. Riski and Delong (1984) provided more recent support for this observation, when they concluded that the large standard deviations in their population also reflected heterogeneity of articulation skills. In addition they found there was considerable variability in articulation within a speaker, dependant on factors such as context, or rate of speech. They concluded that it was necessary to sub-classify speakers with cleft palate when studying articulation skills, in particular adequacy of velopharyngeal function.

Individuals with cleft palate are at high risk of disordered articulation. In cleft palate individuals, the level of articulatory attainment is lower than average (Spreistersbach et al., 1956; Counihan, 1960; Morris, 1962; Bzoch, 1965; Philips and Harrison, 1969; Fletcher, 1978).

Spreistersbach et al. (1956) found that the 3–8 year old cleft palate children consistently demonstrated lower levels of articulatory proficiency, when comparing the results of the experimental group to the Templin-Darley norms.

Bzoch (1965) studied 60 cleft palate children aged from 3–7 years. He reported that 45% had speech that was



difficult to understand, and 45% had speech that was occasionally difficult to understand. He described how the five year old cleft palate children had not developed articulation skills equivalent to the normal three year old controls. However Bzoch failed to take into account the developmental dimension of a child's phonology, which may have influenced these results.

Philips and Harrison (1969) studied 74 pre-school cleft palate patients matched with an age equivalent control group. 94% of the experimental group were inferior to the mean articulation scores of the control group. They also made observations on the qualitative differences between the two groups. The experimental group had more difficulty with medial sounds, their substitutions did not decrease with age, and only omissions were corrected or changed to other error types. They concluded that cleft palate speakers have a "generalized" speech delay, characterized by a high occurrence of omissions and substitutions, and surprisingly a difficulty with nasal consonants not associated with the structural problem of velopharyngeal incompetency. This implies that their articulation problems had other aetiologies, quite possibly developmental in nature. The authors acknowledged that the design of the study did not allow for determining the extent to which hearing loss, adequacy of velopharyngeal function, age at time of palatal repair contributed to these results.

Counihan (1960) studied the articulation skills of 55 cleft palate adolescents and adults with an age range of 13–23 years, and an average age of 16.6 years. He compared the group with the norms on the Templin-Darley test and found that more than half had poorer articulation than the average five year old. In order to control for the effects of velopharyngeal incompetency he also evaluated the results removing the errors that had been classed as distortions as a result of nasal emission. He reported that there were still errors due to other factors, such as disturbances in the peripheral speech mechanism, but did not expand on this.

Fletcher (1978) compared 5–8 year old children with repaired clefts of the palate with an age equivalent group on the Templin-Darley norms. The performance of the experimental group was in general much lower than that of the normal group.

In a longitudinal study by Van Demark et al. (1979), 351 cleft palate subjects with an age range of 2.6 – 18.0 years were shown in general to be below average in articulation skills. The authors concluded that when group data is considered, individuals with cleft palate did not achieve the articulatory proficiency of normal eight year old children, even by early adulthood.

Therefore, despite the disadvantages of early studies (section III: see below), it is clear that cleft palate individuals consistently show poorer articulatory attainment than the average.

There have been some cross-sectional studies which show improvement in articulation as they get older. Van Demark (1969, 1979) reported the percentage of correctly articulated sounds in four different manner categories. The results showed that cleft palate speakers, assessed in three age groups, improve with advancing age, especially for plosives, and fricatives.

Van Demark (1974a) emphasized the importance of velopharyngeal adequacy. He found that children who subsequently needed secondary management (with the implication therefore of velopharyngeal inadequacy)

improved less than 5% in consonant articulation over a three year period.

Van Demark et al. (1979) found that while their cleft palate subjects did improve in their articulation after 10 years of age, the rate of improvement slowed. Approximately, 80% of the items tested were produced correctly by age 16 years. Speech therapy was available to the patients but its effects were not specifically evaluated. Van Demark et al. concluded that cleft palate patients can continue to improve in their articulation skills past the age at which normal speakers have achieved articulatory maturation.

### ***III. Review of Speech Characteristics***

This section reviews the findings related to the primary parameters of speech associated with the cleft palate condition.

#### ***Hypernasality***

One of the most complex resonance disorders, that of excessive nasal resonance, or hypernasality, is commonly associated with cleft palate. This is an attribute of voice quality which occurs primarily in the production of vowels and diphthongs.

Curtis (1968) wrote that the primary cause of excessive nasalization or nasal resonance is inadequate velopharyngeal function, a mechanism at considerable risk in cleft palate patients. Since valving integrity is essential for normal speech, speech itself is an indicator of valvular integrity (McWilliams et al., 1984, 1990). Unfortunately, not only have the terms 'nasality' and 'hypernasality' been used synonymously, but these terms have been misused as a description of velopharyngeal function, and have not been restricted to perceptual judgements of resonance.

The judgement of the degree of hypernasality is influenced by other characteristics of the vocal tract, and not just the velopharyngeal mechanism. For example, the following factors can all affect nasality: the position of the tongue in the oral cavity, the extent of mouth opening, phonatory variations, certain distortions of voice quality from pharyngeal and/or oral cavity variation, vocal intensity, pitch, phonetic factors, standard of articulation, intelligibility, or characteristics of the hard and soft palate, such as an open anterior palate or oronasal fistulae. Therefore a problem in nasality is not necessarily a consequence of, or entirely attributable to velopharyngeal function. The assessment of hypernasality is further complicated by the possibility of other nasality types occurring. Although hypernasality is the most usual type of nasality associated with cleft palate, hyponasality and cul-de-sac resonance (McWilliams et al., 1984, 1990) may also be found. Moreover, nasality types are not necessarily mutually exclusive.

The exact incidence of hypernasality is highly variable across studies, and is related to multiple factors, such as different study design, subject selection, lack of control for cleft type, lack of attention to issues of reliability and validity, and the difficulty of assessing nasality in the presence of other speech disorders. Other coexisting speech disorders may mask or confuse the perception of hypernasality.

Researchers have found that articulation disorders, especially glottal and pharyngeal compensatory articulations, tend to enhance the perception of hypernasality, and consequently velopharyngeal incompetence (Henningsson and Isberg, 1986; Hoch et al., 1986). Henningsson and Isberg (1986) asked listeners to mark every glottal stop or glottally coarticulated stop, and the most hypernasal words in the speech samples of their study group. They found that there was a higher degree of hypernasality in words with glottal stops than with oral stops. Bzoch (1979) maintained, in fact, that hypernasality can only be reliably rated when phonation and articulation are within normal limits.

Research into hypernasality has been concerned with ensuring that the method of assessment is reliable and valid. Individual listener judgements have been found to be unreliable. Although it is evident that groups of trained listeners are the optimum, this is not a practical method as it is cumbersome, expensive, and time-consuming (McWilliams et al., 1984, 1990). It has been found, however, that pre-trained judges can rate nasality reliably on an individual basis, provided there is frequent re-establishment of reliability using recorded speech samples.

Sherman (1954), in an attempt to eliminate the distracting effects of other variables on the rating of nasality, found that playing tapes backwards to raters increased the validity of the assessments, and so this method became popular until Fletcher (1978) produced definitive evidence to the contrary.

In terms of measurement, McWilliams et al. (1984, 1990) described rating scales as an appropriate and useful device for assessing nasality, provided that reliability is attended to, and that a range of speech contexts is judged. Moll (1968) pointed out the importance of subjective methods, with Kantner's (1948) dictum "the human ear is the final detector and arbiter". However as Shprintzen (1986) pointed out, no standards have been set which make listener judgements a uniform diagnostic test.

A number of instrumental measurement techniques have been developed to measure nasal airflow, and nasal resonance objectively, or nasal/oral pressure. These include the Exeter nasal anemometry system (Ellis, 1979), Tonar II (Fletcher, 1978), and Perci (Warren, 1979). However, no instrumentation for measuring nasal airflow and resonance was used in the present study, and therefore further discussion of these techniques is not appropriate.

Inability to prevent the airstream passing into the nose causes extreme difficulty in building up sufficient intra-oral air pressure for the production of fricatives, plosives, and affricates. This results in weakness of manner of production, and audible nasal symptoms.

A high relationship between hypernasality and articulatory ability has been found in speakers with cleft palate (Van Hattum, 1958; McWilliams, 1958). Judgements of the degree of nasality vary with accuracy of articulation. Better articulation is associated with judgements of less nasality.

Individuals who fail to achieve velopharyngeal closure articulate less well than persons who do achieve it (Van Demark, 1964, 1974a). Those with larger openings generally articulate more poorly than individuals with smaller openings (McWilliams et al., 1984, 1990; Van Demark, 1974b). Relatively small openings may

be associated with reduced intra-oral pressure on only some fricatives e.g. /s, z/ but as the opening increases, plosives and other consonants may also be affected (Subtelny et al., 1961). There is however no simple one-to-one relationship between speech adequacy and velopharyngeal deficiencies. In borderline velopharyngeal closure in particular, it is possible to find mild or gross articulation problems. Morris (1968) found that velopharyngeal function accounts for only 25% of the variance in articulation. This implied that many other variables account for the remaining 75% of the variance in the articulation of speakers with cleft palate.

Associated with nasal resonance, but differing from it, is nasal air emission, often a significant feature of the speech of cleft palate patients (Counihan, 1960). Air that would normally be directed through the mouth during the production of plosives, fricatives, or affricates escapes from the oral cavity into the nasal cavity. It does so either through the velopharyngeal port and/or through palatal fistulae, with several possible different effects on speech.

One effect of nasal air emission is the nasal distortions of phonemes, such as the sounds /s, z/ being produced with nasal friction [s̥z̥]. When nasal emission is due to consistent velopharyngeal insufficiency, there is concurrent nasal emission during the production of plosives, fricatives, and affricates, and hypernasality on vowels, glides and liquids.

Investigators have used differing terminology to describe nasal air emission e.g. "nasal snort" (Backus et al., 1943), "distortion-nasal and substitution-nasal" (Van Demark, 1964). McWilliams et al. (1984, 1990) differentiated between several different types and degrees of nasal air emission: inaudible nasal emission, audible nasal emission, and nasal turbulence. Audible nasal air emission refers to audible air escaping through the nostrils; nasal turbulence is a more severe form of this. Nasal air emission is classified as a nasal snort, where there is forceful shunting of air through the nasal airways, and oral airflow is absent or minimal.

There is considerable variation between speakers in the amount of nasal air emission. There is less variation within a speaker, although variance has been observed in relation to such factors as phonetic context, and rate of speech. The variation within a speaker is likely to be greater for the group of individuals with small velopharyngeal openings than for the group with large velopharyngeal openings (Morris, 1979). Where a speaker has a large velopharyngeal opening, the port is consistently open and so there will probably be a constant amount of nasal air escape. Selley et al. (1987), however, concluded that the dynamics of nasal airflow in the vocal tract are highly complex, related to the position of the tongue, resistance due to the lips, and nasal airways resistance. They argued that the amount of nasal escape cannot simply be related to the observed size of the velopharyngeal defect.

Unfortunately, there has been confusion as to how nasal air emission should be classified. Hoch et al. (1986) regarded nasal air emission as a secondary manifestation of velopharyngeal inadequacy. Trost-Cardamone (1989), however, differentiated phoneme-specific nasal emission, which may occur in the absence of clefting or velopharyngeal impairment. This disorder is not associated with hypernasality, and usually affects targets /s,z/ but sometimes also targets /ʃ,ʒ/. Trost-Cardamone maintained that the problem is a result of learning, as opposed to structural abnormalities. The problem does not require a surgical solution, but can

usually be remediated with speech therapy.

Nasal or facial grimace is a speech related behaviour frequently observed in speakers who demonstrate nasal emission. Speakers attempt to inhibit air flow through the nose by constricting the nares and sometimes other facial muscles. This is viewed as unconscious compensatory behaviour developed to prevent the nasal emission of air, possibly indicative of anatomical limitations. Although grimace has no direct effect on speech production, this speech related behaviour may adversely affect the communication process. The listener may be visually distracted from attending to the speaker's message by the grimacing behaviour.

### ***Articulation Characteristics***

One approach to the study of cleft palate speech has been to use the phonetic categories of place, manner and voice.

#### ***Manner***

Moll (1968) concluded that classification of articulation in terms of the manner of consonant production revealed some trends that are commonly observed in the speech of cleft palate speakers.

The manner categories of fricative, plosive and affricate were found to be more often defective than the other phonetic classes of nasals and glides (Bzoch, 1965; Spreistersbach et al., 1956; Counihan, 1960; Moll, 1968; Van Demark, 1969; Philips and Harrison, 1969).

Morris et al. (1961) found in descending order the best discriminators between speakers with adequate and inadequate velopharyngeal mechanisms were the fricatives and plosives, followed by the affricates, and then nasals and glides. This paper supported the work of Subtelny and Subtelny (1959) who reported that the fricatives were most sensitive to inadequate velopharyngeal closure. Plosives could be produced with a small opening as shown on lateral skull X-rays.

Fletcher (1978) analysed his articulation data in terms of a sibilant and non-sibilant contrast – that of sibilants /s,z,ʒ/, nonsibilants /θ,ð,v,f/ and plosives /p b,t d,k g/. He reported mean error percentages of 47.4 for sibilants, 24.0 for nonsibilants, and 17.3 for plosives. He concluded that the sibilants were the most meaningful differentiator of articulation skills in cleft palate speakers. These data supported the findings of McWilliams (1958), and Spreistersbach et al. (1956).

Investigators have also examined the liquid /l/ and /r/ sounds. Van Demark (1979) suggested that cleft palate individuals with poor velopharyngeal function displayed poorer articulation skills not only on plosives, fricatives and affricates, but also on the liquids and glides.

## ***Place***

A number of investigators have assessed articulation in relation to the place in the vocal tract at which the sound is articulated. Spreistersbach et al. (1956) reported that the eight most defective consonants were linguadentals and postdentals. They concluded that since "these sounds are all fricatives", it was probable that the defectiveness of these consonants was related to their manner of production rather than place. Similarly, Counihan (1960) found that manner confounded the study of place of production.

Moll (1968) recommended examining place of articulation separately for each manner of consonant production. In his review of five studies, the only conclusions he drew were that sounds with bilabial place of articulation were less defective than lingual sounds, a finding that was consistent across all manner categories. He concluded that place was less important than manner of articulation.

On the other hand, Morley (1970) identified the tendency towards backward displacement of anterior sounds resulting in sounds made at the alveolar ridge being substituted by sounds made further back in the oral cavity. Findings from studies employing cineradiographic and videofluoroscopic procedures also revealed a consistent tendency for lingual place targets to be shifted backwards in speakers with cleft palate (Brooks et al. 1965, 1966; Lawrence and Philips, 1975; Trost, 1981). The majority of the deviant articulations known as "compensatory articulations" (Morris, 1968, Trost, 1981) involve posterior tongue placements relative to normal targets (see below). Stengelhofen (1989) also described articulation as characterized by,

*"maintenance of manner but a shift of place is frequently observed" (op. cit. p. 15)*

McWilliams et al. (1984, 1990) argued that defects associated with cleft palate may influence both manner and place of articulation. For example, these are particularly observed in relation to alveolar targets produced in a retracted place of articulation with incorrect manner, resulting in characteristics of palatalization and lateralization (Albery, 1991). Should there be velopharyngeal inadequacy, manner of production will be further distorted. Another example is that of speakers who use glottal stops to replace all or most of the plosives, fricatives and affricates. Although glottal stops are usually viewed as a defect in place of articulation, manner classes are also reduced when this occurs (Trost-Cardamone, 1986). However, Trost-Cardamone views place knowledge and place learning as the major areas of speech learning.

## ***Compensatory Articulation***

Due to the distinctive nature of these errors of place of articulation, it is intended to discuss them separately. They occur in patients who do not, or cannot, close the velopharyngeal sphincter during speech. They tend to occur consistently across a variety of phonetic contexts.

The classic compensatory articulation associated with cleft palate is the glottal stop. Sherman et al. (1959) studied glottal stops in the speech of cleft palate children, age range 4–10 years, and found that the cleft palate group had more severe ratings for glottal stops than their matched control group, who were described as

having functional misarticulation. Sherman et al. (1959) and Trost (1981) described how glottal stops usually are an error of place, but correct manner is preserved. Glottal stops are frequently substituted for voiceless cognates, usually plosives. Glottal stops rarely replace fricatives, when a change in manner of production would result. Interestingly, although glottal stops still occur in the speech of cleft palate speakers, there appears to be a recent trend towards a decrease in this behaviour (Greene and Canning, 1959; Cohn and McWilliams, 1983). In the latter study only 5.5% of a sample of 204 children had glottal errors. This trend is interpreted as a reflection of improved surgical management during the last twenty to thirty years.

Like glottal stops, pharyngeal fricatives are also substitutions that have been described as "compensatory" for poor velopharyngeal function (Morris, 1968; Van Demark, 1979; Bzoch, 1979; Trost, 1981). Bzoch (1979) used the term "gross substitutions" to describe these articulatory behaviours, and included the velar fricative in this category. Trost (1981), basing her observations on auditory perception and cephalometrics, added the pharyngeal stop, the dorsum palatal stop, and the posterior nasal fricative to the glottal stop and pharyngeal fricative. When subjects attempt an oral placement simultaneously with pharyngeal fricatives and glottal stops, the process of coarticulation occurs. Hoch et al. (1986) preferred to consider compensatory articulations in terms of the relative anatomical position in which they occur. Thus, palatal consonants which are anterior to the velopharyngeal valve form one group, and those compensations occurring below the level of the velopharyngeal valve form the second group.

Kawano et al. (1985) found that the diagnosis of pharyngeal fricatives was often reclassified as laryngeal fricatives when speech was analysed using multi-view videofluoroscopy and nasopharyngoscopy. They reported observation of a narrowing of the vocal tract, by the posterior positioning of the epiglottis, and elevation of the arytenoid cartilages. Frication was produced in the constriction between the epiglottis and the arytenoids, resulting in the laryngeal place of articulation. They discussed the difficulty of differentiating the pharyngeal and laryngeal fricative on the basis of auditory impression alone.

Brown et al. (1990) made similar observations. During fricative production, the base of the tongue was found to move posteriorly and inferiorly, making contact with the epiglottis, and causing the epiglottis to move posteriorly. Frication occurred between the epiglottis and the elevated arytenoid cartilages. They also observed similar articulatory gestures at the level of the larynx during affricate and plosive production. This resulted in the new categories of laryngeal affricate and laryngeal plosive. The articulatory posture for the laryngeal plosive involved posterior-inferior lingual movement against the epiglottis, which in turn contacted the posterior pharyngeal wall and the elevated arytenoids in a stopping manner. Brown et al. (1990) also concluded that the laryngeal fricative was difficult to distinguish perceptually from the pharyngeal fricative.

The relationship between the development of glottal and pharyngeal compensations and structure are not completely understood (McWilliams et al., 1984, 1990). Trost-Cardamone (1990c) proposed the theory that in attempting to match perceptual speech models, two options were available to a speaker with velopharyngeal dysfunction. The first was to accept the inability to produce high-pressure sounds and display a restricted phonetic inventory limited to nasals, glides and liquids. The second was to reject the inability

to produce high-pressure sounds and develop compensatory or "adaptive" strategies in order to accomplish speech pressure-valving (Warren, 1986). In effect, compensatory articulations develop out of the speaker's attempts to valve the articulation where success is more likely. This may be either below the level of the defective velopharyngeal valve (Lawrence and Philips, 1975), or in the area of the palatal defect so that the tongue is used to occlude the cleft or fistula (Trost-Cardamone, 1986), or alternatively, the tongue is used as a "lingual assist" to occlude the velopharyngeal port, causing inevitable backing for many speech sounds.

Hutters and Bronsted (1987) hypothesized that the speech characteristics associated with velopharyngeal dysfunction are dependent on the strategy adopted by each individual speaker. For example, the speaker who adopts a passive strategy makes no attempt to reduce the unavoidable speech consequences caused by velopharyngeal insufficiency, resulting in speech characterized by nasalization and nasal friction. An individual with an active strategy attempts to reduce the effect of velopharyngeal insufficiency by developing compensatory articulations. Hutters and Bronsted argue that these strategies are universal rather than language dependant, related to the organic condition.

Despite these studies, the nature of the relationship between structure and function remains complex. Although compensatory articulation is sometimes a consequence of velopharyngeal inadequacy, the reverse is also true: velopharyngeal inadequacy may be a consequence of compensatory articulation.

Hoch et al. (1986) described how velopharyngeal inadequacy leads to compensatory errors that subsequently reinforce and exacerbate velopharyngeal inadequacy. Limited movements of the velopharyngeal valve occur during production of these sounds resulting in or contributing to velopharyngeal inadequacy (Kawano et al. 1985; Henningsson and Isberg, 1986; Hoch et al., 1986; Shprintzen, 1990c). Henningsson and Isberg (1986) demonstrated cineradiographically that velopharyngeal incompetence is greater during glottal stops than during oral stops. Reports by these authors have described increased movements of the components of the velopharyngeal valve, especially the lateral pharyngeal walls, after therapeutic correction of compensatory articulation.

## ***Voice***

In the study of voiced–voiceless cognate pairs of fricatives, plosives and affricates, it has been consistently found that cleft palate speakers make more articulation errors with the voiceless sounds than with their voiced cognates (Spreistersbach et al., 1956, 1961; McWilliams, 1958; Counihan, 1960; Moll, 1968). This is explained by the need for greater air pressure for the voiceless sounds in the presence of velopharyngeal incompetency.

An example of this is illustrated in Sherman et al.'s study (1959) which found that glottal stops were used more frequently to replace voiceless than voiced consonants. The work of Philips and Harrison (1969) suggested that the reverse is true for the fricatives in a maturing sound system. However these authors suggested that given the high number of errors, associated with delayed maturation, the study of voicing was almost meaningless. They suggested, therefore, that when developmental issues are no longer operating the



reported trend in voicing does occur.

The majority of speech characteristics associated with cleft palate have been described according to a traditional framework of error analysis, that of distortions, omissions, and substitutions. The common findings will now be reviewed.

### ***Distortions***

The type of articulatory errors that cleft palate speakers make vary with age. Distortions are the most frequently occurring errors once maturation is completed (McWilliams, 1958).

Investigators have found that when maturation of the child's developing sound system is incomplete, other error types of substitution and omission predominate.

In the studies of children in the age range of 3–8 years by Philips and Harrison (1969) and Noordhoff et al. (1987), the investigators found that substitutions are the most frequent error type. In contrast, Spreistersbach et al. (1956), in a similar age group, found omissions occurred most frequently, followed by substitutions and distortions.

Such confused and conflicting findings serve to highlight the importance of the phonological and phonetic approach to the study of cleft palate speakers, in order to distinguish between developmental characteristics of speech and cleft palate related features (Harding, Sell and Grunwell, 1990). Researchers have attempted to distinguish between oral and nasal distortions. Oral distortions are usually related to dental disturbances or maxillary collapse. Indeed, lateralized articulation was described by Greene and Canning (1959, p. 212) as increasing,

*"...on account of the provision of a competent palatal mechanism, which enables patients to use the oral cavity in articulation."*

Nasal distortions are closely related to velopharyngeal function, in that excessive nasal air flow accompanies speech sounds, resulting in nasal air emission (see above).

### ***Substitutions***

Substitutions refer to incorrect sounds substituted for target sounds. For example, nasal consonants may be substituted for the equivalent plosive, when place of articulation is correct but the manner and voicing contrast is lost. Morris (1979) argued that these should be viewed as nasal distortions, an illustration of one of the weaknesses of the framework of substitutions, distortions and omissions (see below).

The relationship between velopharyngeal function and weak articulation has not been studied in detail. Henningson and Isberg (1991) recently compared velopharyngeal movements using cineradiography in five

patients who had glottal stop compensations, normal speech, and correct articulatory placement, but weak manner of production. The results showed that velopharyngeal movements were impaired during consonants with weak manner. This was even more pronounced in the presence of glottal stops, but movements were maximized during correct articulation.

### ***Omissions***

Omission is the third category of classification of speech errors. There has been some suggestion that omissions are difficult to distinguish from glottal stop substitutions (Noordhoff et al., 1987). This was supported by Bernthal and Weiner (1976) who demonstrated that acoustic energy is often present where an error has been assessed as an omission.

### ***Sound Position in Word***

Data about articulation in the initial, medial and final positions in words are also available. Counihan (1960) found no relationship between misarticulation and sound position in his study group, where the age range was 13–23 years. Bzoch (1965), in contrast, studied 3–6 year old cleft palate speakers and found a trend towards more frequent misarticulation of sounds in the medial position compared to the normal subjects in whom the final consonants were more difficult. The absolute difference between the medial and final position was however very small. In addition, as described previously, the contribution of developmental overlay in the experimental group was not adequately dealt with in this study.

### ***Clusters***

Moll (1968) concluded that misarticulated consonants in clusters were usually errors of omission, whereas the error types on singleton fricatives and affricates tended to be distortions.

Nevertheless, these statements need to be related to age. Cluster reduction is a normal process in phonological development, and therefore this process is likely to be operative in children who are developing their phonology. In contrast, older speakers rarely present with this feature but instead present with a “distortion” according to the traditional framework of analysis. Fletcher (1978) provided evidence that speakers more frequently misarticulate a given speech sound when it occurs in a cluster than when it occurs singly.

Studies show that consonant articulation errors are frequently inconsistent and that this depends on factors such as phonetic context, manner category, and velopharyngeal function.

## **Vowels**

Although nasalization affects the perceptual characteristics of vowels, they usually retain enough of their elements to be recognizable at least in contextualized speech (Moll, 1968). Moll noted that cleft palate speakers articulated vowels adequately as nasalization is not phonemic in English.

This contrasts with the findings of Cullihan and Counihan (1971) and Fletcher (1978). Cullihan and Counihan studied the ability of listeners to identify the vowels /i, u, ae/. Vowels produced by normal speakers were correctly identified 79% of the time whereas vowels were recognized in only 53% of the utterances of the cleft palate subjects. They concluded that loss of vowel intelligibility in cleft palate speakers does occur and may be related to tongue height and mouth opening when adjustments are made to compensate for velopharyngeal incompetency.

Fletcher (1978) concluded that persons with cleft palate show "considerable variability" in tongue placement for vowels. Different vowels are more vulnerable to oral-nasal coupling. Moore and Sommers (1975) found tongue height to be a more critical variable than front or back vowel position. They judged nasality as less severe in low vowel contexts as compared to high vowels, such as /i, u/. Curtis (1968) described the velum as higher and achieving a tighter contact for vowels produced with a high tongue position and close jaw position. For this reason, high vowels are more vulnerable to distortion than low vowels (Spreistersbach and Powers, 1959).

## **IV. A Critique of Approaches in 'Cleft Palate Speech' Research**

In earlier sections of this review there have been references to the drawbacks of previous research. This section aims to describe some of these problems in detail.

The nature of the patients included in studies has varied. At the extreme, for example, unrepaired and repaired subjects have been studied as one group (Spreistersbach et al., 1956; Spreistersbach and Powers, 1959; Byrne et al., 1961; Skoog, 1965).

In some studies all patients that attended a centre were included, even patients who had normal speech. In other studies, however, only patients who attended for regular follow-up were included, for example in the study by Takagi et al. (1971). It is predictable that the group which regularly attends is likely to have persistent problems, and so this inherent selection factor has led to a skewing of results. Morris (1973) pointed out that studies should consist of a consecutive series of subjects in order to avoid selection bias.

Another problem has been the lack of specification of age at palatoplasty or at the time of speech assessment (Morris, 1973). There has been poor control over cleft type of the subjects studied. The research design of studies has usually been cross-sectional.

One fundamental problem has been the lack of an acceptable framework for measuring speech, such that no single framework has been agreed and used across studies (McComb, 1989). The Eurocleft speech group

(1991) has however recently reported on their detailed framework of assessment, which was shown to be reliable when used by trained speech pathologists with different linguistic backgrounds.

There are variations in the sounds and contexts studied. Different stimuli have been used to elicit responses and different criteria to score the responses. Historically, the judgement of speech has been made by a non-speech pathologist, such as the surgeon, with no evidence of inter- and intra-assessor reliability. Even when the speech pathologist was involved, reliability studies were frequently not carried out, as found in the study by Greene (1960). Moll (1968) commented how easy it was for the therapist to show observer bias due to his/her loyalty to the team with whom he/she was working.

One of the early methods of studying speech was the classification of speech into gross categories (McWilliams, 1960). One study which adopted this approach was that of O'Riain and Hammond (1972). Their framework of gross classification involved four categories: perfect, acceptable (defined as nasality primarily), unacceptable (defined as articulation primarily), and grossly defective. Moll (1968) concluded, however, that this general rating of speech had limited validity and usefulness. The framework that Peet (1961) used to describe his results was that of the presence or absence of nasal escape. This completely ignored the articulatory aspects of speech production, or a judgement of the overall aspect of speech adequacy. On the basis of these results, he did however advocate early palate repair. It has already been shown above that there are different components to 'cleft palate speech' which must all be separately rated, and so the inadequacy of these types of frameworks will be appreciated.

The main procedures that speech therapists have used to measure speech are judgements of the overall rating of articulatory ability, a quantitative approach detailing the correct number of responses (Riski and DeLong, 1984), and the articulation test.

There is evidence to support the validity of ratings of articulation. Moll (1968) and Van Demark (1974a) have shown that there is a positive and significant relationship between ratings of overall articulatory performance and the number of errors of articulation. Nevertheless, a rating scale, does not always provide information on patterns of misarticulation. It is not necessarily both qualitative and quantitative, and does not reflect how improvement occurs, or its detail.

Other approaches to analysis have been to compare the number of correct responses with normative data or the performance of a control group on the same test. These methods provide information about the severity of the speech problem, but give no indication about the nature or patterning of the errors, or the nature of the speech disorder. This type of assessment does not help to make decisions regarding speech therapy or surgery. In addition, the results may be skewed by extreme individual results.

In an attempt to describe the pattern of sounds, and regularities in types of errors, a number of articulation tests have been designed to assess the speech of children with cleft palate. The Iowa Pressure Test (Morris et al., 1961) and the Bzoch Error Pattern Diagnostic Articulation Test (Bzoch, 1979) are two examples that have been widely used in North American research. Each requires single word elicitation and a traditional

type of error analysis based on the criteria of distortion, substitution, and omission. The Bzoch Error Pattern Test describes five categories of articulation error types on a continuum. They range from least severe error to most severe: nasal emission, distortion, substitution, and gross substitution to omission.

These types of tests do not require the examiner to transcribe responses phonetically. Such procedures have examined single naming responses, in which the listener is usually interested in the consonant targets only.

This traditional framework of analysis has serious disadvantages. Grunwell (1987) pointed out the lack of information regarding the nature of a sound's misarticulation using this approach. Each target is viewed as an independent unit, such that speech is viewed as a series of separate articulatory gestures. It is known, however, that speech is affected by assimilation and coarticulation. Speech is therefore made up of interdependent units that are sensitive to a particular context. The same target may be produced differently as a result of the surrounding phonetic structure. This was recognized by McWilliams (1958), who urged that a sound be sampled more than once in a test.

The whole issue of using a one word naming response as the basis of assessing speech needs to be questioned. This approach is artificial, and does not accurately reflect the patient's conversational speech, nor the effects of linguistic stress.

A major difficulty of the traditional framework has been the inter-assessor reliability of examiners deciding the exact nature of an error. The same standards have not always been used for making articulatory judgements (Morris, 1979). This was observed at an early stage by McWilliams (1958). She commented on how difficult it was to measure the degree of distortion. The range of distortion was extremely variable, approaching substitution in some cases. In contrast, Van Demark (1971) described how a distortion can be graded on a continuum of mild to severe, but this framework has not been taken up by other researchers. Morris (1979) observed that sound errors did not always fall into neat categories. Philips and Bzoch (1969b) demonstrated insufficient inter-judge reliability for ten experienced speech pathologists when identifying type of error. They concluded that a satisfactory level of reliability was only achieved in calculations of the mean or averaged articulation scores. The Eurocleft study (1990) also reported similar difficulties of inter-judge reliability in the identification of error type. Consequently, it would be difficult to accurately detect the rate of speech improvement using a framework that does not permit a grading of severity.

The results of an articulation test depend on the possibility of representing stimuli as pictures, and the familiarity of stimuli (Grunwell, 1987). She urged that conversational speech should be assessed. Shriberg and Kwiatkowski (1982) found that articulation tests were not representative of articulation in spontaneous speech. In a review of five articulation tests, they found that there was inadequate sampling of syllabic shapes, parts of speech, or morpho-phonemic markers such as /s,z/ when used, for example, to signal plurals. Therefore, it is important to supplement test results with assessments of a patient's spontaneous speech.

The careful articulation of single words may not be possible under the demands of connected speech; in other cases, improved articulation is possible in conversational contexts but has not become automatic. Van

Demark (1964) recognized the importance of sampling conversational speech, and gained a correlation of 0.93 between ratings of articulation on a repeated sentences task and spontaneous speech.

Furthermore, by studying individual phonemes, overall phonological patterns are not detected. No information on systematic patterns is given, nor is guidance regarding intervention. This lack of phonological analysis has meant that there is a dearth of information in studies generally on the extent and nature of deviance or delay in the sound system. There is also a lack of information as to whether the speech disorder is purely phonetic, related to structural limitations, or whether there is in addition a secondary phonological disorder.

## **V. Structural Issues**

### **a. Velopharyngeal Function**

This section reviews velopharyngeal function, since this is considered of primary importance when determining whether surgery has achieved its aims. As McWilliams et al. (1990, p.60) pointed out,

*"The major reason for performing surgery to close a cleft palate is to create a velopharyngeal valving mechanism that is capable of separating the oral from the nasal cavities during speech."*

Morris (1973, p.68) expanded on this, stating that the restoration of velopharyngeal function enables,

*"the articulation of consonant sounds in a normally oral manner, and the achievement of a normal balance of oral-nasal resonance."*

Velopharyngeal closure for speech requires the upward and backward movement of the soft palate, simultaneous with medial movement of the lateral pharyngeal walls, and sometimes movement of the posterior pharyngeal wall. This activity creates a seal that effectively separates the nasal and oral cavities, which facilitates the supraglottal pressure, oral airflow and resonance necessary for adequate speech.

Techniques for assessing this mechanism fall into two broad categories: indirect and direct procedures. Van Demark et al. (1985) stated that no single observation, perceptual or instrumental, is sufficient alone to evaluate velopharyngeal function.

Indirect techniques are those that attempt to quantitatively or qualitatively describe the sequelae of abnormal velopharyngeal function. The primary sequela of this is abnormal speech, in particular hypernasal resonance and/or nasal air escape. These features may therefore be indicative of velopharyngeal insufficiency. However, there are limitations to a perceptual assessment of nasal resonance and/or nasal air escape, in particular the complexity of the types of speech disorders with which velopharyngeal inadequacy is associated (see Chapter 2: section III). Shprintzen and Golding-Kushner (1989) recommended that perceptual assessment is not regarded as the definitive diagnosis of velopharyngeal insufficiency.

Researchers have therefore looked to other means to assess velopharyngeal function. Techniques have been developed which involve direct observation of the pharynx, and the velopharyngeal sphincter. The two most

sophisticated diagnostic procedures of this type are currently multi-view videofluoroscopy (Skolnick, 1969) and nasopharyngoscopy.

Speech has been investigated by means of X-ray images since the beginning of this century. Lateral X-ray cephalograms can be used to assess the depth of the velopharyngeal sphincter and approximation of the soft palate and the pharynx during the production of a vowel or fricative. This is a simple, rapid procedure, which is amenable to measurement. Studies have found that the lateral skull X-rays taken during the production of /i/ agreed better with presumed velopharyngeal incompetence than when taken during the production of /s/ (Calnan, 1953; Bowman and Shanks, 1978). Van Demark (1974b) found that lateral radiographs clearly predict subjects with an obviously incompetent mechanism, and recommended their use with other measures.

During the last twenty years, however, several investigators have pointed out the disadvantages of using lateral skull X-rays as a diagnostic procedure for assessing velopharyngeal insufficiency (Croft et al., 1981; Glaser et al., 1979a; Williams and Eisenbach, 1981). False information can be obtained. For example, there may be apparent midline contact between the velum and posterior pharyngeal wall, but with lateral openings of the port on one or both sides. Alternatively, there may appear to be a gap when, in fact, closure is effected by the lateral pharyngeal walls.

Witzel and Stringer (1990) highlighted how a lateral skull X-ray is unable to confirm closure of the valve along its width. Irregularities in the border of the soft palate or the adenoid tissue may cause small gaps, creating velopharyngeal insufficiency. Such gaps would not be detected on a lateral skull X-ray.

Williams and Eisenbach (1981), in comparing the lateral skull X-ray with cinefluorography, found that a misdiagnosis of velopharyngeal function occurred approximately 30% of the time when relying on lateral radiographs alone. Shprintzen (1986) pointed out that lateral skull X-rays fail to view the velopharyngeal valve in motion, do not provide observation of the lateral pharyngeal walls, nor do they provide a complete view of the valve during connected speech.

The results of the survey by Pannbacker et al. (1984) were therefore surprising. They showed that this technique was still being used by as many as 50% of 128 professionals (dentists, plastic surgeons, and speech pathologists) in cleft palate teams belonging to the American Cleft Palate Association.

Despite all the recognised disadvantages, and in the absence of any other objective measure in 1986, it was considered valuable to undertake lateral skull X-rays of patients phonating 'ee' in the context of the facilities available in a Third World environment, and therefore these were collected in 1986 and in 1990. It was recognised, however, that there was value in a procedure that would be capable of observing the anatomy and function of the component parts of the velopharyngeal sphincter – i.e. the soft palate, the lateral pharyngeal walls, and the posterior pharyngeal wall, – both at rest and in motion during uninhibited speech. Two techniques were considered; that of nasopharyngoscopy and multi-view videofluoroscopy. Unfortunately, there were no facilities to undertake multi-view videofluoroscopy in Sri Lanka and nasopharyngoscopy only

became possible in 1990.

The technique of nasopharyngoscopy was first described in the late 1960s by Piggott et al. (1969). The basic concept behind nasopharyngoscopy is to be able to view the velopharyngeal valve from above, without disturbing the normal flow of speech production. It is then possible to see the complete in vivo structure of the nasopharynx, oropharynx and hypopharynx.

Three types of endoscopes are currently available: a side-viewing rigid endoscope, a side-viewing flexible endoscope, and an end-viewing flexible endoscope. The end-viewing flexible endoscope is generally preferred, as the endoscope can be passed through the velopharyngeal valve (Shprintzen, 1986). In addition, compliance with the end-viewing flexible endoscope is considerably higher than with the rigid endoscope (Shprintzen, 1989). Under the former conditions, Shprintzen reports near total compliance in children over six years of age, and 90% compliance for children ranging in age from four to six years. A detailed description of the technique is provided by Shprintzen (1989).

Information is gained from this diagnostic procedure about size, location, consistency/inconsistency and shape of any gap, and the movements of the velum, lateral pharyngeal walls and posterior pharyngeal wall.

Velopharyngeal closure is effected by several different movements. The velum moves in a posterosuperior direction towards the posterior pharyngeal wall in adults, and towards the adenoid in children. The lateral pharyngeal walls move medially, and the posterior pharyngeal wall moves forwards.

Speakers vary in the component of the valve which is most active in velopharyngeal closure. In some individuals the velum is the most active component of closure, in contrast to other speakers, in whom it is the lateral walls. In another group of speakers, equal contribution by both the velum and the lateral walls can be observed. Therefore, variability in valving patterns is primarily related to differences in lateral wall movement between individuals. This has led to the identification of four distinct movement patterns (Table 2) of the components of the valve both in the normal population and in those with incomplete closure (Croft et al., 1981).

*Table 2. The Four Movement Patterns of the Velopharyngeal Valve*

1. **Coronal:** The velum approximates to the posterior pharyngeal wall, which remains immobile. The lateral pharyngeal walls move medially to approximate the lateral edges of the velum. The major component of velopharyngeal valving occurs in the anteroposterior direction.
2. **Sagittal:** There is marked movement of the lateral pharyngeal walls occurring posterior to the velum, which moves posteriorly only slightly, approximating to the posterior edge of the abutted lateral walls.
3. **Circular:** There is an equal amount of movement in the velum and lateral pharyngeal walls, creating a circular closure pattern.
4. **Circular with Passavant's Ridge:** As in the circular pattern, there is equal contribution to closure of the velum and lateral pharyngeal walls, but there is also anterior movement in the posterior pharyngeal wall (Passavant's Ridge) resulting in a truly sphincteric pattern.



Croft et al. (1981) studied 80 normal speakers, and 500 pathological cases. Table 3 shows the distribution of speakers according to the different patterns for each group.

*Table 3. Distribution of Valving Patterns for Normal and Pathological speakers*

	<b>Normal speakers</b>		<b>Pathological speakers</b>	
Coronal	N=44	55%	N=225	45%
Sagittal	N=13	16%	N=55	11%
Circular	N=8	10%	N=100	20%
Circular with Passavant's Ridge.	N=15	19%	N=120	24%

Many studies have used these velopharyngeal closure patterns to describe results, with no quantitative measures (Croft et al., 1981; Siegel-Sadewitz and Shprintzen, 1982, 1986; Witzel and Posnick, 1989). Other investigators have used equal interval scales to show the degree of velopharyngeal closure or movement (Shprintzen et al., 1979; Karnell et al., 1983; Henningsson and Isberg, 1986; Isberg and Henningsson, 1987). Consequently, reports have relied on descriptions of velopharyngeal closure and velopharyngeal gaps, or descriptions of direct tracings of velar and pharyngeal wall motion (Croft et al., 1981; Witzel and Posnick, 1989; Isberg and Williams, 1990). More recently, Golding-Kushner et al. (1990) have developed a system for quantifying, recording and describing movements of the velum, lateral pharyngeal walls, and posterior pharyngeal wall. It also describes the size, shape, symmetry, and location of velopharyngeal gaps. However, reliability and validity studies have not yet been thoroughly investigated.

There have been very few reports on the reliability of endoscopic examinations. The major work in this area has been conducted by D'Antonio et al. (1989), who demonstrated that videotaped nasopharyngoscopy examinations are most reliably rated by a panel of experienced raters of different professions, using equal interval scales to describe the degree of velopharyngeal closure or movement.

The relationship between compensatory articulation and the velopharyngeal sphincter has been described above (see section III). Henningsson (1988) found that glottal stops and glottal coarticulation are consistently associated with impaired velopharyngeal movement, especially those of the lateral pharyngeal walls. In her view the compensatory articulation pattern contributed to velopharyngeal insufficiency. She concluded that patients with consistent use of glottal stops should be trained in the speech clinic to produce some oral stops before investigations of velopharyngeal function are undertaken.

### **b. Fistulae**

One of the known surgical complications of palate repair is the development of oronasal fistulae. A fistula may occur anywhere along the midline of the former cleft, from the buccal sulcus through the alveolar ridge into the hard palate, or through to the junction of the hard and soft palate. The most frequent location is the

area of the incisive foramen, and at the junction of the hard and soft palate (Henningsson and Isberg, 1990).

Henningsson and Isberg (1990) extensively reviewed the literature on oronasal fistulae and speech production. Their review showed that the incidence in studies of post-operative fistulae for cleft lip and palate patients varies between 9% and 47%. The cause of fistulae has been at least partly attributed to the surgical technique used (Abyholm et al., 1979; Peer et al., 1954; Van Demark, 1974a). For example, Abyholm et al. does not repair buccal fistulae in unilateral or bilateral cleft lip and palate cases at primary surgery. Researchers have found that fistulae occur more frequently in patients with cleft lip and palate than in those with a cleft palate only. Peer et al. (1954) found no fistulae associated with soft palate repair. Similarly, Abyholm et al. (1979) found that the lowest occurrence rate of fistulae in his large series (N=1108) was associated with incomplete palatal clefts (3.5%), in contrast to 18% for the whole series.

The general view held is that the combined effects of surgical technique and the severity of the original defect are important in the aetiology of a palatal fistula (McWilliams et al., 1990).

Not all fistulae are problematic. This will depend on the origin, size, and location of the fistula (Reid, 1962; Abyholm et al., 1979). Regurgitation of food or liquids into the nasal cavity has been well-documented. The literature with regard to the effects of the fistulae on speech has been more controversial.

Some authors believe that a small palatal fistula has no effect on resonance (Krause et al., 1976). Henningsson and Isberg (1990, p.791) suggested that there are three characteristics of speech that may occur,

*"...an extra, whistling component associated with a speech sound, weak pressure consonants in patients with large fistulae (Morley, 1970), and audible nasal escape (Jackson, 1972; Jackson et al., 1976)."*

Such characteristics are a result of air escaping through the fistula. Henningsson and Isberg (1987) compared the effect of an open fistula versus a covered fistula on speech and resonance in the same patients. They showed that when the fistula was covered, speech and resonance improved in all patients (N=10).

Isberg and Henningsson (1987) were the first researchers to describe the effect of fistulae on velopharyngeal function. They found that both small and large oronasal fistulae can impair velopharyngeal function, especially lateral wall movements, causing velopharyngeal insufficiency. They found a significant correlation between fistula size and the degree of lateral wall movement. Increased lateral pharyngeal wall movement was consistently found in all ten patients in their study during articulation anterior to a covered fistula, as compared to the same fistula when open. They concluded that there is a relationship between velopharyngeal function and the presence or absence of fistulae. Before this it was generally accepted that a fistula and velopharyngeal incompetence were two independent factors causing speech and resonance disorders (Krause et al., 1976). Since the same speech symptoms (loss of intra-oral air pressure, hypernasality and nasal escape) can be associated with either velopharyngeal insufficiency, an oronasal fistula, or both, it is important to separate any fistular contribution to deviant speech from effects caused by velopharyngeal activity. Henningsson and Isberg (1987) consequently advise performing the speech examination with the fistula first

open and then temporarily closed, using speech samples containing consonants produced anterior to the fistula. They advocate using chewing gum for temporary fistula obturation.

The critical limit for fistula size for influencing speech quality has also been discussed. In an aerodynamic study, Shelton and Blank (1984) noted a loss of intra-oral air pressure for large fistulae but not systematically for small or moderate sized fistulae. Abyholm et al. (1979) also discussed large fistulae in connection with nasal air escape and hypernasality. Morley (1970), however, observed that even small fistulae could prevent the buildup of intra-oral pressure in pressure consonants articulated anterior to the fistula. Henningsson and Isberg (1987) found that a fistula of 4.5 square millimetres resulted in hypernasality, audible nasal escape, and weakness of pressure consonants.

Different speech symptoms may be related to differences in fistula location (Henningsson and Isberg, 1990). A prealveolar fistula is rarely associated with abnormal speech or resonance, as the upper lip usually covers any fistula satisfactorily. When the fistula is located in the hard palate, both speech and resonance are likely to be affected, even when the fistula is small.

## ***VI. Speech Therapy***

Spreistersbach et al. (1973) stated that research into therapy is difficult to execute and complicated by many known and unknown variables. Much of the research has been aimed at examining the relationship between behavioural management and changes in speech production. Few systematic investigations have been undertaken, however, which examine the effectiveness of speech therapy with children with cleft palate. Indeed, Witzel (1990) judged the effectiveness of studies of articulation intervention therapy in craniofacial anomalies to be low when using a quality of evidence scale.

Studies of the effectiveness of articulation therapy for patients with cleft palate are limited in both quantity and design. There has frequently been no control group (Schendel and Bzoch, 1970; McWilliams et al., 1990). Subjects have been included who are heterogeneous in their velopharyngeal function for example (Van Demark and Hardin, 1990).

Studies have concentrated on the effects of therapy in children. Variables, such as age at therapy, adequacy of the speech mechanism, dentition, motivation, the clinician's experience, and the content of the therapy programme have often been examined when assessing a child's response to therapy. Nevertheless, little is known about the influence of many variables in therapy. Identifying the primary contributory factors has been difficult because of the interaction between variables. Furthermore, reliably determining the type and frequency of therapy is often difficult.

The literature suggests from its descriptive accounts that cleft palate children who have received traditional articulation therapy tend to speak better than those who have not (Chisum et al., 1969). Schendel and Bzoch (1970) found that even children with velopharyngeal inadequacy improved.

Van Demark and Hardin (1986) compared the speech results of thirteen subjects before and after an intensive

six week residential course with results following an additional nine month period, during which some children received therapy in school. All subjects were considered to have velopharyngeal competency, or marginal competency. Patients were categorized as having marginal incompetence, if they demonstrated the speech characteristics associated with velopharyngeal incompetency (Morris, 1978) but the degree of incompetence was so slight, that secondary physical management would not be advised. Changes in articulation proficiency, before and after the intensive treatment period, and between the end of the intensive therapy period and the nine-month period, were not significantly different. There was, however, a significant difference between the pre-therapy recordings and those taken at the end of the nine-month period. These authors concluded that even in an optimally therapeutic environment progress was slow and less than they expected. They found that modification of speech was not necessarily difficult but problems occurred in maintaining progress. Subsequently, Van Demark and Hardin (1990) reported that children with velopharyngeal competence found it easy to modify compensatory articulation patterns but maintenance of the correct patterns in conversational speech was not easily accomplished.

In contrast, Albery and Enderby (1984) found that children who were given six weeks' intensive articulation therapy made greater improvements than children attending weekly therapy, and maintained a higher level of speech performance over a two year follow-up period. They also reported, however, that one of the most difficult tasks was the generalization of consonants into everyday speech.

Interestingly, Van Demark and Hardin (1986) had intended to use control subjects to determine the difference between two groups, but then judged that it was impossible to match subjects adequately.

There has been some controversy about speech therapy treatment in the presence of velopharyngeal inadequacy. It is frequently stressed in the literature that articulation therapy is most effective once velopharyngeal inadequacy is eliminated completely, or at least decreased to a marginal level. Van Demark (1974c) found that the amount of improvement was related to the adequacy of the velopharyngeal mechanism. Where velopharyngeal closure was achieved, more progress was made in therapy than for subjects with a marginal or inadequate mechanism. Subjects with marginal velopharyngeal adequacy demonstrated no improvement in articulation skills where they did not receive therapy. Subjects who achieved velopharyngeal closure made some articulation gains without therapy. For subjects who received therapy and exhibited either velopharyngeal competency or marginal competency, improvement in articulation skills was demonstrated. However, no information regarding the nature of the pre-operative speech disorder, or post-operative investigations of nasopharyngoscopy and multi-view videofluoroscopy were undertaken in this study.

McWilliams et al. (1984, 1990) indicated that articulation improvement is possible without secondary pharyngeal surgery. They advise that therapy should only be attempted if surgery is not feasible. Trost (1981) stated that an inadequate velopharyngeal valving mechanism does not preclude working on selected components of articulation, particularly place deviations.

Hoch et al. (1986) recommended that attempts should be made to correct all articulation errors that occur

below the velopharyngeal valve in the presence of velopharyngeal inadequacy, especially before secondary surgery. They argued that, since the airstream is being modified below the velopharyngeal valve, this effectively deprives the velopharyngeal valve of the opportunity and potential ability to modify the airstream. On the basis of the operant principle of non-reinforcement, it was hypothesized that the velopharyngeal valve stops functioning if the airflow is effectively being cut off below it (Shprintzen, 1990c). He provided evidence that articulation therapy can influence the movement of the velopharyngeal sphincter before secondary pharyngeal surgery. He reported a strong correlation between glottal stop substitutions and gross velopharyngeal inadequacy, which he described as near or total absence of velar and lateral pharyngeal wall movement. In 86 subjects with glottal stop substitutions, 72 had constant gross velopharyngeal inadequacy. 14 had gross velopharyngeal inadequacy with inconsistent movement of the velopharyngeal sphincter during the production of phonemes that were correctly articulated. Of the 72 patients with consistently gross velopharyngeal inadequacy, 34 were able to improve the degree of velopharyngeal movement when the glottal stop substitutions were corrected. No information was provided on the length of time required for this therapeutic change to occur.

Coston (1986) reported excellent success in correcting articulatory errors, including compensatory articulations, before secondary surgery.

Trost-Cardamone (1986) stated that compensatory articulations usually persist even when adequate velopharyngeal closure can be achieved. Since these articulation errors are a learned behaviour, therapy is based on traditional operant learning theory and modifications of the techniques described in the literature (Morley 1970; Trost, 1981). Trost-Cardamone (1990b) stated that there are no data to suggest that secondary pharyngeal surgery can eliminate or correct compensatory articulations. Van Demark and Hardin (1990) concluded that the promotion of correct articulatory placement may decrease hypernasality and audible nasal escape.

The effectiveness of therapy in relation to age is now considered. McWilliams et al. (1990) described how patients in the West who present with persistent speech disorders into adolescence, are probably characterized by a severe cleft, velopharyngeal inadequacy, poor facial growth, and occlusal disorders. They concluded that they are likely to respond poorly to speech therapy. They attributed this to the fact that their abnormal speech patterns were so well learned and automatic that to modify them was difficult. McWilliams et al. (1990, p.394) stated,

*"For patients who do not achieve velopharyngeal adequacy or borderline closure until adolescence or adulthood, the task of acquiring and automating satisfactory articulatory placement is arduous, time-consuming and expensive."*

McWilliams et al. (1990) also wrote that the speech patterns of adults are resistant to change. They therefore frequently require more assistance and more practice, but even with such attention change is difficult to achieve. McWilliams et al. (1990) described their experience of treating adult speakers as "unsuccessful", particularly when patients habitually used glottal stops.

Bzoch (1979) wrote that the effectiveness of therapy for persons with clefts is reduced if the service is offered too late.

An approach to therapy that has been advocated is that of intensive group therapy. In the Albery and Enderby (1984) study, parents reported that children in the intensive group "blossomed", becoming more confident and verbal. All the patients within this study were aged between six and twelve years, with adequate velopharyngeal sufficiency on the basis of perceptual assessment. Huskie (1979) pointed out the value of shared learning, and Bzoch (1979) also expounded the socio-psychological benefits of group learning. Morley (1970) advocated group therapy to allow the child to realize that he or she was not the only person with cleft palate and disordered speech. This form of therapy permits the child to learn that speech can be unintelligible, and hence in need of change, and to observe that persons with speech disorders do improve.

## **Part B – Speech in patients with unoperated palates**

The first properly documented successful repair of a cleft of the soft palate was performed on an adult – a medical student – in 1819 (Watson, 1980). The patient had established his speech in the presence of an unoperated palate. His MD thesis on the operation included insightful comments regarding his speech,

*"All my medical friends now tell me that my voice is clearer, stronger, and free from distortion... It must be admitted that some of the nasal effect persists to this day. Long sustained habit... now militates greatly against me... If bad habits in which we persist almost mechanically are so hard to cure, it is certainly much more difficult to avoid habit lying beyond our voluntary control. However I hope I can achieve a great deal". (op. cit. p.428)*

It is presumed he did achieve considerable speech improvements, as he became a Professor of Anatomy and a popular lecturer.

In highly developed Western countries, the unoperated cleft is nowadays rarely seen after early infancy. However, in some areas of developing countries groups of older patients with unoperated cleft lip and palate do still exist. Boo-Chai (1971) maintained that they are gradually diminishing in numbers as the availability of surgical care increases. This has occurred partly as a result of surgical teams from the west travelling to developing countries in order to perform surgery (Boo-Chai, 1971; Keunen, 1966; Law and Fulton, 1959; Buck, 1960).

These expeditions have been one of the sources of information on large groups of these patients. Unfortunately in some studies (Innis, 1962; Boo-Chai, 1971) the opportunity to report on speech has been lost.

In other studies, descriptive impressionistic comments on speech have been made by non speech therapists with no attempt to systematically measure speech.

For example, Davis (1951) presented a case report of a 49 year old adult with an unrepaired bilateral cleft lip and palate. The only comment on speech at the pre-operative stage was that speech was no worse than in some of the cases who were considered surgical failures.

Similarly, Law and Fulton (1959) reported on growth, hearing, speech and psychosocial aspects in 88 Puerto Ricans. Fifty-one patients, the majority of whom were aged between 15 and 34 years, had unrepaired palates. The authors made the general observation that individuals with open palates frequently exhibited good speech and voice quality, and that adults with unrepaired clefts of the palate had consonant articulation superior to many patients with surgical closure of the cleft. They described intelligibility and nasality in relation to the type of cleft, and reported that adults with unrepaired clefts of the lip and palate seemed to have near normal voice quality, while patients with unrepaired, isolated clefts of the soft palate exhibited greater nasality. The observation was made that individuals who had complete and wide clefts produced all of the speech sounds except /k/ and /g/. They attributed this to the normal facial growth found in this group,

in that the relationship between the maxilla and mandible facilitated anterior speech sound production. Pitanguy and Franco (1967) studied the growth, speech, hearing and psychosocial aspects of 40 Brazilian patients with unoperated palates, with an age range 10–51 years and an average age of 18.5 years. They concluded that,

*"...the phonation in many of the patients was good, principally in those who had some re-education." (op. cit. p.575)*

It is unclear whether this statement describes pre-operative or post-operative speech, nor does it describe the nature and timing of re-education or who provided it. Pitanguy and Franco (1967) recommended a simultaneous pharyngeal flap when there was a distinct tissue deficiency, or in patients with,

*"...dubious palates whose particular situations prevented a phoniatric re-education."*

In patients where there was sufficient tissue not to warrant a pharyngeal flap,

*"...satisfactory phoniatric results were obtained without phoniatric re-education."*

No information was provided on how the judgements of sufficient tissue were made.

Ehmann and Schonenberger (1991) have recently described the surgical details of 71 juvenile (age unspecified) and adult patients with unoperated clefts of the lip, alveolus and palate, operated upon in Northern Cameroon between 1973 and 1986. No speech pathologist was involved in this project, and only anecdotal comments were made. At the pre-operative stage, the nasal speech was described as,

*"...well-understood by the persons accompanying the patient".*

Post-operatively,

*"...despite the lack of speech therapy, the nasal speech had definitely improved". (op. cit. p.471)*

These four anecdotal studies tended to report positive findings, in contrast to those of Ortiz-Monasterio et al. (1959, 1966, 1971, 1974): the group of studies which are generally regarded as the classic studies on the older patient with unoperated cleft lip and/or palate. In the early paper (1959, p.60) on cephalometric measurements related to facial growth, Ortiz-Monasterio and his associates concluded,

*"...a proper speech training programme is compatible with late palate surgery (5 years of age) and that speech defects can be corrected under these circumstances. This naturally is not true concerning adults in whom good surgery and speech therapy are followed by very little improvement in speech".*

There were no data to substantiate these statements.

In their 1966 paper, they reported on the physical characteristics, speech, growth and audiometric results of 63 unoperated patients, with an age range of 14–52 years and a mean age of 28 years. The speech results were reported in a framework of classification of gross categories of poor, fair, good, excellent. Based on this framework, they reported that speech results were consistently poor in individuals with closure of their



palates in adulthood. They stated, however, that simultaneous closure of the palate with a pharyngeal flap resulted in a definite improvement in speech results, despite only a minimum of speech therapy.

In their final paper (1974) a speech pathologist was involved in the assessment and therapy programme. The speech results of 220 patients, operated on after the age of 12 years, were reported. Simultaneous palatoplasty and pharyngeal flap were performed on 140 patients of this group.

The speech results were based on the following rating scale.

1. Excellent – Language perfectly intelligible with minimum nasality.
2. Good – Language perfectly intelligible with moderate nasality.
3. Fair – Language intelligible with severe nasality.
4. Poor – Language with poor intelligibility with severe nasality.

This rating scale was developed by the speech pathologist in the team. However, its validity is questionable. No definitions of the parameters were given – what is the difference, for example, between intelligible and perfectly intelligible? No information is given on the method of measurement. Moreover, the difficulties in assessing intelligibility are now recognized. It can be affected by many factors, including listener variables, speaker variables and external factors. Witzel et al. (1989) stated that intelligibility alone should not be used to report speech results. Moll (1968) maintained that general ratings of speech, such as a measure of intelligibility, are of little value. In his view, it is important to consider individual speech dimensions separately, which Subtelny et al. (1972) also advocated. In addition, there are known difficulties of rating nasality in the presence of other aspects of speech disorders: nasality is a parameter which must be rated separately. It cannot be combined with other aspects of speech. By combining the parameters of nasality and intelligibility, the list of possibilities in this rating scale are not exhaustive. For example, there is no provision for rating poor intelligibility with minimum nasality. Furthermore, no information is given in the Ortiz-Monasterio studies about inter- and intra-rater reliability. It can also be argued that this rating scale is not sufficiently detailed to describe speech change.

Based on this scale, Ortiz-Monasterio et al. (1974) reported that there were neither normal speakers nor even speakers classified as excellent (language perfectly intelligible with minimum nasality) in this series of 220 patients. This is despite the fact that over 140 of these patients had had a pharyngeal flap procedure. Of the group who had palate closure only, 84% of the patients were rated as poor (language with poor intelligibility with severe nasality). Of the group who had a pharyngeal flap, 91% patients were described as fair (language intelligible with severe nasality), 8% were classified as good (language perfectly intelligible with moderate nasality).

Ortiz-Monasterio et al. (1966) advocated pharyngeal flap procedure on the basis of these results. In fact, these results show that in no case was the pharyngeal flap effective in eliminating nasality, and therefore cast some doubt on the conclusions of the 1966 study. The pharyngeal flap apparently did make differences to

intelligibility, a result which is difficult to understand. For example, Trost-Cardamone (1986) stated how compensatory articulations usually persist following pharyngeal flap surgery, even when it leads to velopharyngeal closure. In the Ortiz-Monasterio series, however, no patient gained velopharyngeal adequacy.

Since no information was provided on the pre-operative level of speech attainment, it is unclear if the different post-operative results were attributable to the surgery, or to differences in pre-operative speech attainment. Ortiz-Monasterio et al. (1974) described a fistula rate of 14%, most frequently at the junction of the hard and soft palate, and at the posterior border of the premaxilla. Unfortunately, it is unclear how this figure has been arrived at, about which group of patients this information is given, and whether this reflects post-surgical breakdown.

Information regarding the selection criteria for pharyngeal flap procedure was given in their 1971 paper on the cultural aspects of cleft lip and palate treatment. The recommendation for pharyngeal flap procedure was determined by ability to easily return to the clinic, high or average intelligence, learning level, patient and family motivation, and where patients lived. Occasionally the procedure was provided for those patients categorized as having the best potential, although judged to have a short palate or very wide cleft.

Ortiz-Monasterio et al. (1974) also reported on the results of speech therapy treatment. They divided the patient cohort into three groups: a group which received therapy, a group which received advice only, and a group which received no intervention at all. Factors similar to those used in decisions about pharyngeal flaps were operative in the selection criteria used to determine which patients received therapy (Ortiz-Monasterio and Serrano, 1971). Because of these selection factors, there was no control group to evaluate the benefits of therapy.

The group which received therapy had an average age of 27.5 years; the youngest patient was aged 12 years but the age range was not specified. No information was provided on the type and amount of therapy. No details were given of the differential effects of therapy on members of this group in respect of their age or cleft type.

No information was given about the results of the group who did not receive therapy, or who received advice only, or on the speech results of the group aged 6–12 years. It is somewhat surprising therefore that Ortiz-Monasterio et al. (1974, p.114) concluded,

*"Phoniatric training can be very helpful for the group operated between 6–12 years of age but that speech therapy has little effect in teenagers and none in adults with a well established speech pattern."*

Another major comparable study is on a series of Vietnamese patients with unoperated cleft lip and palate carried out by Landis, an American speech pathologist, and Cuc, a counterpart trainee, in 1972.

They reported on 54 patients with unoperated cleft palate, with an age range of 3–24 years, a mean age of 11.8 years, and a median age of 12 years. They reported on the pre-operative speech characteristics related to type of cleft, using the traditional framework of analysis of correct number of approximations, substitutions, omissions, and distortions. They defined correct approximations as "consonants produced with correct phonemic placement and lacking only adequate intra-oral air pressure." Voice quality and speech intelligibility were also rated.

They studied three groups of patients: unrepaired cleft lip and palate (group 1), repaired cleft lip but unrepaired palate (group 2), and unrepaired post alveolar isolated clefts of the palate (group 3).

They found that there was variability in the pre-operative speech skills of the three groups. Group 3 demonstrated superior articulation skills and intelligibility ratings compared with the other two groups. Interestingly they did not find that the glottal stop and the pharyngeal fricative were features of the speech of this group. They had the highest percentage of correct approximations, and had fewer omissions than the other two groups. This group demonstrated close to normal phonemic placement for consonants. Groups 1 and 2 achieved poor phonemic placement. Group 2 attained superior articulation scores compared with Group 1. This was attributed to their greater success in the approximation of the bilabial sounds. The rating of intelligibility was similar for both groups 1 and 2. The rating of nasality was similar for groups 2 and 3; that of group 1 being considerably worse. In group 3, a comparison was made of the speech skills of the 4 youngest children (median age 6 years) and the 4 oldest children (median age 18.5 years). They found that the speech of these children improved with maturation. This effect did not occur however, when comparing the speech skills of the 4 youngest children (median age 7 years) and the 4 oldest children (median age 15 years) in group 1. Unfortunately, there was no opportunity to assess speech post-operatively.

The only opportunity they had to study post-operative speech quality was in another group of children who had had previous surgical repair. They compared the speech attainment of these children, with repaired cleft palates of a type similar to group 1 and 3. They found that the speech of group 1 was worse on intelligibility and number of approximations than group 3. However, the groups were not strictly comparable. The average age of the groups at surgery and at assessment was not the same. Those with a history of isolated cleft palate were 11.5 years at surgery and 13 years at assessment compared with the group with unrepaired cleft lip and palate who were 7.5 years at surgery, and 10 years respectively. This is potentially important given that, in the unrepaired population, it was reported that speech in group 3 patients improved with maturation alone. The two groups differed by a year between surgery and the time of follow-up. Group 3 had been repaired for one year longer when post-operative measures were taken, compared with group 1. Group 3 had therefore had longer with a repaired palate, and more opportunity to make changes in speech. Furthermore, it could still be the case that some developmental phonological overlay existed in group 1.

Landis and Cuc concluded that a patient with an isolated cleft of the palate was likely to have a better prognosis for improved speech, without the need for extensive speech remediation. They stated, therefore, that consideration of the type of cleft may be of value in planning late palatal surgery. They also concluded

that the specific kind of articulation errors exhibited by the patient may play a part in decisions regarding surgery. It is unclear, however, how this conclusion was reached from the report.

Unfortunately, the framework used for the assessment of speech in this study does have disadvantages (section IV: see above). The definitions of the different categories are not always explicit, and so different raters may categorize a speech error differently. Indeed, in this study, substitutions and distortions are collapsed and reported as one category. By describing speech in terms of errors in respect of the targets, this method of analysis fails to describe the important abnormal phonetic features of severely disordered speech. Furthermore, as in the Ortiz-Monasterio studies, no information is given about how the material was collected, the manner in which the analysis was performed (live or from audio-tape), and whether attention was paid to issues of intra- and inter-rater reliability.

Unlike in the Ortiz-Monasterio studies, Landis and Cuc described the parameter of nasality separately. Unfortunately, they did not discuss this scale in their text. The results suggested however, that they used a three point scale of severe, moderate and slight. No information is provided on how these judgements were made, or issues of intra- and inter-rater reliability.

The Landis and Cuc results were given using descriptive statistical methods only, with no measures of statistical significance.

The only variable discussed in this paper is cleft type: no attempt was made to determine if there were differences in the nature of speech according to other variables, such as age.

In an unpublished paper (abstract only available), Wu et al. (1990) reported on twenty-five Chinese speaking adults. They were all aged over 20 years, and presented at the modern and well-equipped cleft palate unit in Taiwan (Noordhoff et al., 1990). Pre-operatively, a perceptual speech assessment, nasopharyngoscopy and multi-view videofluoroscopy were undertaken. Patients with glottal and pharyngeal compensatory articulations had poor to fair lateral pharyngeal wall movement. This compared with those patients with hypernasality but no articulation pathology. Despite this variation in pre-operative lateral wall movement, palatoplasty combined with a pharyngeal flap was "usually required" in order to achieve an adequate, or at least marginal, velopharyngeal competence.

Speech assessment and nasopharyngoscopy were conducted three months post-operatively. On average hypernasality was reduced to moderate. Articulation and compensatory patterns of articulation remained unchanged. Speech therapy was implemented using traditional methods. After three months, most patients had slight to moderate hypernasality, but their conversational speech remained in the same habituated compensatory pattern and in need of continuing speech therapy. In contrast to the current study, they used not only traditional therapy techniques, but also more sophisticated treatment methods of biofeedback nasopharyngoscopy (Witzel et al., 1988), and prosthesis (McGrath and Anderson, 1990). Patients were also in therapy for a more intensive period, without the difficulties of cross-language and cross-cultural differences between therapists and patients.

This study is the most detailed in the field of late palate closure. This was partly because a population of older unoperated patients was available to investigators with sophisticated facilities. A detailed analysis of speech was apparently undertaken, although no information is given on inter-rater and intra-rater reliability, and on the nature of the speech sample used for the assessment of speech at each stage. They imply that they assess conversational speech post-therapy, and yet in a chapter describing the protocol of their unit (Noordhoff et al., 1990), speech is assessed using an articulation test. The design of the study did not include a control group in the evaluation of the benefits of therapy.

Although they found a reduction in the degree of hypernasality, the results suggest that even with a pharyngeal flap no patient gained velopharyngeal adequacy. There is no discussion of the influencing variables that may account for speech attainment at the different data points.

Another source of information on the unoperated cleft patient has been the few older patients in the West that have unrepaired palates. This can be traced back to the trend to manage these patients prosthetically when surgical techniques were more risky and less successful. Byrne et al. (1961) and Spriestersbach and Powers (1959) reported that individuals with unrepaired cleft palates showed poorer speech sound articulation than those who have received palatal surgery. However the actual differences reported were not marked.

Spriestersbach and Powers (1959) reported the mean articulation ratios based on the Templin-Darley diagnostic picture test. Each ratio was computed between the individual articulation score and the norm for age and sex, in order to minimize the effects of maturation. The age range for their subjects was 5–15 years. A ratio of 1.00 meant the subject gained a score equivalent to the norm. Their subjects with unrepaired palates gained a ratio of 0.6 and those with repaired palates a ratio of 0.77. They concluded that the unrepaired group had,

*"...appreciable articulation proficiency even though they had a marked lack of structural continuity and also major oral pressure deficiencies." (op. cit. p.324)*

Stengelhofen (1989), too says on the basis of clinical experience,

*"...adults with unrepaired clefts achieve a remarkable standard of speech" (op. cit. p.9)*

These findings support the often mentioned observation that speakers frequently compensate for oral structural deficiencies. Adequacy of articulation skills cannot be predicted on the basis of the structural adequacy of the articulation mechanism.

Byrne et al. (1961) reported correct mean articulation percentages of 77.9% for subjects with unrepaired palates and 81.1% for those with repaired palates. No information was given about the variables that may have influenced these results, such as patients' ages, degree of clefting, or amount of speech therapy received. Furthermore, it would seem that most of the unrepaired group were prosthetically managed. Thus, this group was not directly comparable with patients who had established their speech in the presence of an unoperated palate.

It is important to appreciate the significance of the results of these early studies. At that time, techniques of multi-view videofluoroscopy and nasopharyngoscopy were not developed. These are now recognised as vital procedures in the assessment of patients with persistent velopharyngeal inadequacy following palatal closure. They have led to improvements in treatment in the past twenty-five years (Shprintzen et al., 1979). It is reasonable to presume therefore that there would be a greater difference between patients with repaired and unrepaired palates today (McWilliams et al., 1984, 1990).

In 1965, Skoog (1965) evaluated the relative benefits of the superior and inferior based pharyngeal flap, according to age. The subjects included twenty-four patients with unoperated palates, and fifty-eight patients with persistent velopharyngeal incompetency following primary palatoplasty. The average age of the totally unoperated subgroup was 31.5 years with an age range of 11–59 years. His policy was to combine closure of the palate with pharyngoplasty because,

*"...adults who had palate closure alone using the Veau-Wardill technique always resulted in velopharyngeal incompetence". (op cit. p.266)*

He gave no further detail about this adult group. He also stated that speech was best following primary palate repair at an early age.

He divided the group on the basis of age, and presented the speech results for patients under and over 20 years at the time of pharyngeal flap surgery. On the parameters of consonant articulation and "closed" nasality, the results were the same for both age groups. The older age group however did better on the results of the glottal and pharyngeal sounds and open nasality. The only parameter on which the younger group did better was intelligibility.

He concluded that, as long as a pharyngeal flap did not restrict movements of the soft palate, there was no difference between a superior or inferior pharyngeal flap. He also concluded that patients operated before the age of ten years all demonstrated normal speech; of those below the age of 20 years 97% were rated as having acceptable intelligibility, compared with 77% when the operation had been performed after that age.

There are, unfortunately, several methodological problems with this study. These include the mixture of unoperated and operated subjects, and a lack of discussion of the relative benefits of pharyngeal flaps for these two groups. For the unoperated group, there is no mention of the articulatory pattern which existed pre-operatively. The post-operative follow-up varied widely, between 1 and 13 years with a mean of 4 years 10 months. Once again, no detailed information was provided about the framework of speech analysis, how the parameters were defined or measured, or about inter- and intra-rater reliability. No speech pathologist was involved in this study. Indeed, a framework using 'intelligibility' is not a valid method of determining the success or failure of a pharyngeal flap procedure (Shprintzen, 1990b). It is, therefore, difficult to extrapolate any useful information about pharyngeal flaps in patients with unoperated palates from this study.

Another method used to study speech in the individual with an unoperated palate has been through the use

of single case studies. Fletcher (1985) presented a case study in which he discussed how an adult speaker with an unrepaired cleft of the soft palate, and a partial cleft of the hard palate, achieved pressure consonants. This thirty-eight year old man had received only a brief amount of speech therapy. Fletcher pointed out that despite an unoperated palate this patient's total phoneme intelligibility equalled that found by McWilliams (1958) in her study of adults with repaired palatal clefts. In particular he was intrigued by the high intelligibility of the speaker's sibilant sounds.

Dynamic palatometry was used to document the motor patterns of the stop and sibilant sounds. A thin plastic plate with sixty-four sensors on it was fitted. Fletcher identified that the subject increased his linguapalatal contact for plosives, and had a narrower linguapalatal groove for sibilants from that typically found in normal speakers. He described these findings as a compensatory behaviour occurring where there is reduced air support. Fletcher also observed that there was a relatively low ratio of oral versus nasal resonance in this speaker.

Another study which focused on the oral motor aspects was that of Buck (1960), a speech pathologist involved in the Puerto Rican study. Based on lateral skull X-ray films taken during phonation, he reported that patients with unrepaired palates had a markedly higher tongue position than normal speakers, and that the high point was more posterior than in people with normal or repaired cleft palates.

More recently, based on the babbling characteristics of infants with unrepaired palates, Trost-Cardamone (1990c) maintained that hypernasality, nasal air emission and reduced intra-oral pressures were the obligatory consequences of unoperated cleft palate speech production. Two causes of abnormal place learning were postulated: the absent bony partition, and the constant nasal-oral coupling.

Trost-Cardamone (1990c, p.209) wrote that,

*"Under normal circumstances the hard palate may serve as a phonetic (sensory-motor) field within which lingual articulatory placements are practised, learned, and habituated. Absence of this partition removes this phonetic practice field, altering the learning of the linguapalatal consonant placements."*

The majority of the deviant articulations involved posterior tongue placements relative to normal targets, with the use of pharyngeal and glottal placements (Russell, 1991).

An unrepaired palate also precluded the ability of the velum to valve the velopharyngeal port, to build oral air pressure, and to direct airflow orally.

Trost-Cardamone (1990c) suggested that the degree to which the absent partition guides the cleft palate child into atypical placements might relate to the extent and configuration of the cleft.

In summary, although there have been eight separate studies in the developing world, speech pathologists have only been involved in two of them (Ortiz-Monasterio et al., 1974; Landis and Cuc, 1972). In four anecdotal studies (Law and Fulton, 1959; Davis, 1951; Pitanguy and Franco, 1967; Ehmann and Schonberger,

1991), comments on speech have been made by non speech pathologists. The findings of these latter studies largely contradict those in which there has been a speech pathologist.

The assessment and reporting of speech was more detailed in the two studies in which speech pathologists were involved. However there are disadvantages in the frameworks used to analyse speech, and therefore their validity must be questioned. Both frameworks of speech are patently inadequate to handle the data. Furthermore there was no attempt to address issues of inter-rater and intra-rater reliability.

Flaws can also be identified in the research designs of these two studies. For example, in the Ortiz-Monasterio series, there is no record of cleft type. The speech results are reported for all cleft types combined, and yet other studies have reported differences in articulation skills, and velopharyngeal function related to cleft type (Spreistersbach et al., 1961). Although age was considered in the Ortiz-Monasterio studies, the age ranges were wide. Ortiz-Monasterio reported on a group of 220 patients over the age of 12 years but with an average age of 27.5 years. No attempt was made to relate speech results to age in the Landis and Cuc study.

No information was provided on the phonetic characteristics of the languages rated.

Where speech therapy was provided, there were no attempts to use a control group in the evaluation of the benefits of therapy. The description of speech therapy in the Ortiz-Monasterio studies lacks adequate detail about the content and nature of therapy.

No studies have included post-operative objective assessments of velopharyngeal function, such as multi-view videofluoroscopy and nasopharyngoscopy.

In addition, none of the data on the speech results has been submitted to statistical tests to determine if there are significant differences between speech in the operated and unoperated individual, or when follow-up therapy has been provided.

Many of these limitations were also described by Mars and Houston (1990) as characteristic of facial growth studies in unoperated cleft lip and/or palate patients. They also described other drawbacks such as small sample sizes, mixtures of unoperated and late operated individuals, and few post-operative follow-ups. Such characteristics also pertain to the speech studies described in this review.

With regard to pharyngeal flap, it is a commonly held view of plastic surgeons in the West that older patients require combined palate repair and pharyngeal flaps. This view has arisen from the studies described above, in particular that of Skoog (1965). However, that study has a flawed methodology, reporting on a mixture of unoperated and operated patients, with serious disadvantages in the reporting of the speech results. It has also emerged from this review that the claim regarding pharyngeal flap by Ortiz-Monasterio et al. is based on results that do not support the need for a pharyngeal flap. Three other studies that advocate pharyngeal flap (Keunen, 1966; Law and Fulton, 1959; Pitanguy and Franco, 1967) are based on individual clinical judgement and not scientifically structured investigations. Wu et al. (1990) reported on adults who have had a combined palatoplasty and pharyngoplasty, the results of which suggest that even with pharyngeal flap no patient gained velopharyngeal adequacy. Therefore, the benefit of pharyngeal flaps is in doubt.



Most importantly, however, this review has identified that there have been no longitudinal studies that report on the pre-operative, post-operative and post-therapy speech results of the same group of patients who have had late palate closure only. The present study aims to rectify this situation and achieve this objective.

# Chapter 3

## Issues and Hypotheses

This investigation aims first and foremost to study speech production in individuals under four conditions: with unoperated palates, following palatal closure, immediately following therapeutic intervention, and subsequent to this, following a period of no intervention. The relationship between speech production at each data point will be examined.

Secondly, the aim is to describe the influencing variables that account for speech attainment at the separate data points.

This research seeks answers to the following questions:

1. What are the characteristics of speech in the unoperated cleft palate patient?
2. What are the effects of late palatal repair in patients who have established their speech in the presence of an unoperated cleft palate?
3. What are the effects on speech when surgery is supported by short courses of speech therapy?
4. What are the effects on speech after therapy following a period of no intervention?
5. What are the variables that may account for speech performance at these times?

McWilliams et al. (1990, p.69) stress that when reporting speech results,

*"The important variables that must be considered in the design of an investigation are cleft type, age at surgery, type of surgery, and other forms of intervention being utilised".*

The following series of hypotheses have therefore been devised. The hypotheses with regard to cleft type, surgical and speech therapy intervention, age, structural issues related to velopharyngeal function and fistulae are considered the major hypotheses, whereas hypotheses regarding surgical observations, imitation skills, articulation/conversation therapy and years of education are viewed as minor hypotheses.

### ***1. Surgical and Speech Therapy Intervention***

It was predicted that nasal resonance and nasal escape would change spontaneously with surgery, but in contrast it was felt unlikely that the habitual use of incorrect place and manner of articulation would change with palatal closure alone. It was possible that there would be increased evidence of the individual's ability to achieve intra-oral air pressure revealing a greater differentiation of manner, but it was anticipated that a strong habitual element would be operating. Therefore, it was expected that certain patterns of speech production that had developed in the presence of an unrepaired palate would not spontaneously change with palatal closure. Speech therapy would probably be required.

The hypotheses, therefore, with regard to surgery are:

- (1i) Palatal closure alone may result in positive spontaneous change in nasal resonance and nasal escape, but will not change articulatory skills.
- (1ii) Palatal closure supported by speech therapy may result in positive spontaneous change in articulatory skills, but will not change nasal resonance and nasal escape.

## **2. Age**

It is proposed that with increasing age patients are less likely to benefit from late palatal surgery.

This assumption arose since it was judged that the surgical difficulties found in the older patients (Ward and James, 1990, p.13) might not occur so frequently in the adolescent group and children's groups. They describe the types of problems found in the adults and the older children making reference to earlier similar work. They state that there are characteristic,

*"... wider clefts and more vertically displaced palatal segments, which may have been the result of prolonged tongue interposition in the cleft (Ortiz-Monasterio et al., 1966). There was also marked mucoperiosteal fibrosis, which hampered the dissection of the oral and nasal layers, causing excessive bleeding. The most common site of heavy bleeding was from the alveolar branches of the greater palatine artery in the canine region. Other observations related to the difficulty in dissecting the levator palatini muscle, which had a varying degree of fibrosis and shortening. The difficulties encountered made it difficult to achieve a complete water-tight and tension-free closure of the nasal and oral layers of the palate with separate dissection and union of the levator palatini muscle sling."*

It is quite probable that the repair of such a palate would be characterized by tissue breakdown and velopharyngeal insufficiency.

Therefore, given the learning factors and likely remaining structural difficulties, it might be expected that the adult patient is liable to remain essentially a 'cleft palate speaker' following late palatal closure. Nevertheless, it could be argued that articulatory changes might be achieved, albeit with excessive nasal resonance and nasal escape. It may therefore still be possible to facilitate a limited amount of change in certain adult speakers at this very late stage.

It is also reasonable to hypothesize from the above that surgery in the younger age groups may be technically easier, resulting in less palatal breakdown and a higher rate of velopharyngeal closure across the group. In addition, eradicating established patterns and learning new patterns is recognized as an easier learning process for the child and there is therefore likely to be a greater speech change in the younger age group.

One would predict that the degree of speech change after palatal closure may be related to age at the extremes of the age group. It is particularly interesting to measure the performance of the adolescent who falls between

the child, who can change and adapt easily, and the adult, who is less likely to. However, it is quite probable that the adolescent group would have potential to learn, and in all probability, would be motivated to improve their speech in order to make further gains in educational and social achievement.

It seems likely, therefore, that the factors of age, together with extent of clefting and success of surgery, would have considerable influence on speech attainment at the extremes of the age group, but the influence of these factors is less predictable for the adolescent group.

The hypotheses, therefore, with regard to age are:

- (2i) Adult patients present with disordered articulatory patterns that are more resistant to change than those of adolescents or children with the same cleft type, either spontaneously or with therapy.
- (2ii) Adult patients exhibit a higher incidence of velopharyngeal insufficiency following palate repair than adolescents and children, and as a consequence their ability to improve speech production is severely impaired.
- (2iii) Adult patients exhibit a higher incidence of palatal breakdown following palate closure than adolescents and children, and as a consequence their ability to improve speech production is severely impaired.

### ***3. Cleft Type***

With regard to cleft type, it is a reasonable assumption that the more severe the extent of the cleft of the palate the more severe the speech disorder.

Individuals with lesser clefts are likely to have higher pre-operative speech attainment. In addition, this group of patients is likely to have a more successful surgical repair. Following surgery for palatal closure one could predict a low rate of palatal breakdown resulting in fistulae, and a high rate of effective velopharyngeal closure. This group of speakers is most likely to achieve normal speech, either spontaneously or with articulation therapy.

In contrast, individuals with more major clefts are likely to have worse speech attainment pre-operatively. In addition, this group of patients is likely to have a less successful palatal repair, resulting in the development of fistulae and velopharyngeal insufficiency, and therefore the physical structure will be a limiting factor on speech and response to speech therapy. It is predicted that this group will require the most intervention post-operatively and it is quite probable that the amount of therapy available would be insufficient to realize an individual's full potential, or even to effect any appreciable improvement in speech performance.

The hypotheses, therefore, with regard to cleft type are:

- (3i) Patients with lesser clefts have better articulation and less severe nasality pre-operatively than patients with other cleft types.
- (3ii) Patients with lesser clefts demonstrate a higher incidence of normal or near normal speech than the major cleft types post-operatively, following surgery and therapy.
- (3iii) Patients with lesser clefts demonstrate a higher incidence of velopharyngeal closure following palatal closure than other cleft types.
- (3iv) Patients with lesser clefts demonstrate a lower incidence of palatal breakdown following palatal closure than other cleft types.

#### ***4. Structural Issues: Velopharyngeal Function and Fistulae, and Surgical Characteristics***

In the majority of the palatal closure operations, one surgical technique was used by seven surgeons. It is unknown whether the surgical technique is related to the degree of speech change following late palatal closure. However, previous workers (see Chapter 2: Part B) do suggest that palatoplasty alone is often insufficient, and a combined procedure involving a primary pharyngoplasty is needed.

It is predicted that the degree of speech change will be related to the degree of post-surgical breakdown and the formation of an effective velopharyngeal mechanism. It is probable that the success of surgery is linked to the factors of extent of the original cleft and age at which the palate is closed.

The hypotheses, therefore, with regard to structure are:

- (4i) Notwithstanding the different ages of patients, the degree of articulatory change in controlled speech is related to the degree of palatal post-surgical breakdown.
- (4ii) Notwithstanding the different ages of patients, the degree of articulatory change in controlled speech is related to the formation of an adequate or marginal velopharyngeal mechanism.
- (4iii) The degree of post-operative and post-therapy speech change, and post-operative velopharyngeal function, will be related to characteristics of the repair observed by the surgeon at the time of operating.

#### ***5. Speech Therapy***

It was hypothesized that when surgery was supported by articulation therapy there would be a greater use of oral placement and manner. This would be observed particularly in imitation of sounds and consonant-vowel combinations, at single word level, and perhaps in careful speech, but given the small number of sessions available it was considered unrealistic to expect carryover into spontaneous speech. It was predicted

that therapy sessions would have less effect on excessive nasal resonance, although it may be possible to facilitate a reduction in the occurrence of grimacing, a speech related behaviour, through the therapy sessions.

The observations pre-operatively had revealed that the patients were often shy and reluctant to speak. Therefore it was decided that half the patients would receive conversation therapy to improve their social skills and self-confidence, whilst the other half would receive articulation therapy to improve their articulation. Since it was hypothesized that the former approach may engender an improvement in speech, this form of intervention acted as a control for the effects of the articulation therapy approach. It was predicted, however, that the conversation approach would have no direct effects on articulation, resonance, or grimacing, whereas the articulation therapy approach might have beneficial effects to articulation and communication.

The hypotheses, therefore, with regard to therapy are:

- (5i) Patients who received palatal closure supported by subsequent articulation therapy resulted in positive changes in articulatory skills in imitation and single word utterances compared with patients who received palatal closure supported by conversation therapy.
- (5ii) Patients will improve in articulation skills in imitation and single words as a result of palatal closure and subsequent articulation therapy.
- (5iii) Patients will improve in articulation skills in imitation and single words as a result of palatal closure and subsequent conversation therapy.

### ***6. Imitation of singletons and imitation of trisyllables***

As with hypothesis (5i), it was predicted that the habitual use of incorrect place of articulation on the imitation task of trisyllables and singletons would not change with palatal closure alone; speech therapy would be required.

Experience of the patients' imitation skills suggested that those patients who do not imitate well at all the data points are the patients who make no or minimal changes in speech.

The hypotheses, therefore, with regard to imitation are:

- (6i) Palatal closure alone does not change the ability to copy trisyllables and singletons.
- (6ii) Palatal closure supported by speech therapy does change the ability to copy trisyllables and singletons.
- (6iii) Patients with low imitation scores on singletons at the pre-operative, post-operative, and post-therapy stages do not make significant changes in speech post-therapy.

(6iv) Patients with low imitation scores on singletons at the pre-operative stage do not make significant changes in speech post-therapy.

### **7. Years of education**

In addition to the variables identified by McWilliams et al. (1990) there are other variables that may impinge on speech attainment in an individual, which were judged to be relevant in this population.

There was considerable variation in the number of years of education within the sample with one of the reasons for leaving school frequently given as unintelligible speech. It is predicted that patients who received minimal education may present with a more severe speech disorder pre-operatively and possibly may show less speech change at the two following data points. These patients would be unused to receiving instruction and would be less likely to take full advantage of the therapy courses. Equally there may be a relationship between speech attainment and the individual who has completed his education and even gone onto receive higher education. Such patients may be able to benefit more from therapy intervention being used to receiving instruction from their education. It is possible that the number of years of schooling, and level of speech attainment at the significant data points are related.

The hypotheses, therefore, with regard to years of education are:

- (7i) Patients who received minimal education have the more severe speech disorders pre-operatively.
- (7ii) Patients who received minimal education are less likely to benefit from subsequent therapy.

# Chapter 4

## Methodology

### ***I. Materials***

This report describes the speech results of 88 patients who received palatal surgery by the British surgical team during the 1985 and 1986 expeditions.

The cohort divides into two groups:

67 patients over the age of 8 who had pre-operative, post-operative and post-therapy speech recordings, referred to as the main cohort.

21 patients under the age of 8 at surgery who mainly had only post-operative and post-therapy recordings.

The reason that the children under 8 years of age did not have pre-operative recordings was the difficulty in gaining the standard speech sample in this age group, associated with the children's shyness and immaturity.

The main cohort of 67 patients was divided into three groups according to age:

- Adults >20 years.
- Adolescents 11–19 years.
- Children aged 8 – 10 years at surgery.

This categorization arose because of the commonly held view by surgeons in the West that palatal closure after 10 years of age is of little value to speech (Skoog, 1965). Ortiz-Monasterio et al. (1974) suggested that twelve years is the cut-off point. It has however become the trend for surgical teams that visit the developing world to repair patients of all ages with the assumption that their speech will benefit from palatal repair. It was decided to consider the over 10 year olds as two separate age groups, as shown in Table 4. This describes the sample according to age range, mean and median age, and gender.

*Table 4. Sample according to Age Range, Mean and Median Age, and Gender*

<b>Age category</b>	<b>N</b>	<b>Age range</b>	<b>Mean age</b>	<b>Median age</b>	<b>Sex distribution</b>
Adults	24	20 – 52	26.0	25	17 males; 7 females.
Adolescents	31	11 – 19	13.0	14	15 males; 16 females.
Children aged 8 – 10 years at surgery	12	8 – 10	8.6	8	10 males; 2 females.
Children under the age of 8 at surgery	21	3 – 7	5.6	6	10 males; 11 females.



This represented a sample of the total number of patients who had palate repair carried out by the British team in 1985 and 1986 (Table 5). In the main cohort, 71% of the total number of possible patients were included in the study. The reasons for exclusion included the following: incomplete speech records, Tamil speaking, overlying speech disorders (which could not be accounted for by the cleft palate problem alone), and severe hearing impairment (according to the assessments undertaken in November 1985, and 1986).

*Table 5. Patients who had Palate Repair in 1985 and 1986*

	<b>&lt;8 years at surgery</b>	<b>8 – 10 years</b>	<b>Adolescent</b>	<b>Adult</b>
1985	28	7	32	23
1986	67	5	15	12
<b>Total</b>	<b>95</b>	<b>12</b>	<b>47</b>	<b>35</b>

The group was distributed according to cleft type as shown in Table 6. The hard and soft cleft group consisted of patients with complete clefts of the hard and soft palates. The lesser group consisted of clefts of the posterior third of the hard palate and the soft palate, or the soft palate only.

The groups BCLP, UCLP, and H&S are sometimes referred to below as the major cleft group(s), reflecting the complete cleft of the palate in each of these cleft types.

*Table 6. Patient Sample according to Age and Cleft Type*

	<b>BCLP</b>	<b>UCLP</b>	<b>H&amp;S</b>	<b>LESSER</b>	<b>Total</b>
Adults.	4 (5%)	15 (17%)	5 (6%)	0	24
Adolescents	4 (5%)	12 (14%)	5 (6%)	10 (11%)	31
Chd. 8 – 10.	3 (3%)	6 (7%)	3 (3%)	0	12
Chd. <8	5 (6%)	11 (13%)	2 (2%)	3 (3%)	21
<b>Total:</b>	<b>16 (19%)</b>	<b>44 (51%)</b>	<b>15 (17%)</b>	<b>13 (14%)</b>	<b>88</b>

*Legend: BCLP: Bilateral Cleft Lip and Palate*

*UCLP: Unilateral Cleft Lip and Palate*

*H&S: Cleft of the Hard and Soft Palate*

*Lesser: Clefts of the posterior 1/3 of the hard palate and the soft palate, or the soft palate only*

All the patients were Sinhala-speaking, and spoke no English. In the main cohort, all patients had complete speech records viz. a pre-operative recording, a post-operative recording, and at least one post-therapy course recording. In the group of children below the age of eight years at surgery, all patients had post-operative and post-therapy recordings. Table 7 shows the dates of the speech recordings. All pre-operative speech recordings were undertaken within the two weeks prior to surgery.

*Table 7. Dates of Speech Recordings*

	<b>Nov. 85</b>	<b>July 86</b>	<b>Nov. 86</b>	<b>Summer 1988</b>	<b>Sept.1990</b>
1985 cohort.	pre-op record.	8 mths. post-op and post 10 day course record.	pre and post 14 day course record.	pre and post 14 day course	speech record.
1986 cohort.			pre-op. record.	20 mths. post-op. record. and post course record.	speech record.

The patient recall rate is shown in Table 8.

*Table 8. Recall Rate at Follow-up of Study Patients*

<b>Nov. 1985</b>	<b>July 1986</b>	<b>Nov. 1986</b>	<b>Summer 1988</b>	<b>1990</b>
N=67	N=52 (84%)	N=43 (64%)	N=63 (44%)	N=66 (75%)
		N=21 (pre-op.)		

Patients were either operated in November 1985 (N=67) or November 1986 (N=21) by one of four surgical teams. Table 9 shows the distribution according to year of surgery. The palatal clefts were repaired by one of two standard techniques, the Von Langenbeck two-flap repair or the Wardill three-flap technique, without primary pharyngoplasty. One patient had a combined procedure of lip and palate repair.

*Table 9. Distribution of Patients according to Year of Surgery*

	<b>1985</b>	<b>1986</b>
Adults	18	6
Adolescents	27	4
Children aged 8 – 10 years at surgery	7	5
children below 8 years at surgery.	15	6
<b>TOTAL</b>	<b>67</b>	<b>21</b>

## **II. Procedures**

### **a. Speech**

#### ***Instruments***

The speech assessment consisted of a standard speech sample which was both simultaneously video and audio tape recorded. High quality video (Panasonic M7 and Olympus systems) and audio equipment (Uher CR160 and Sharp tape recorders) were shipped from Britain. Extra lighting facilities were included following the 1985 visit in order to improve the quality of the video recordings. The environment was made as near as possible to soundproof with the imaginative use of heavy curtaining and thick cardboard packaging.

#### ***Data sampling***

The content of the speech sample was the imitation of singletons (single consonants followed by a vowel i.e. CV), the imitation of nonsense trisyllables (CV,CV,CV), counting from 1–20, reciting days, weeks and months of the year, a word list, the repetition of three sentences, and two minutes of spontaneous speech (see Appendix IV).

In order to compile a suitable speech sample, the investigator sought the help of Professor Reynolds at the School of Oriental and African Studies, London University. He gave information on the sound system (see Appendix III) and a short course on Sinhala designed for students preparing to do Voluntary Service Overseas in Sri Lanka.

As a result of this and the literature review of Sinhala (see Appendix III), the word list and sentences were heavily loaded with plosives, fricatives and affricates, which require intra-oral pressure for production, and are therefore particularly sensitive to the effects of velopharyngeal inadequacy.

#### ***Data Collection***

Each patient was seen individually for the speech assessment procedure. All the patients in the main cohort were seen for speech assessment pre-operatively, but at different stages post-operatively. 92% of the 1985 surgical cohort had post-operative speech recordings eight months following surgery. The remaining 8% had these recordings at twelve months post-operatively. The 1986 surgical cohort had post-operative speech recordings twenty months after palatal closure. In addition speech recordings were carried out before and after each therapy course, except for those courses of one week's duration in 1988.

#### ***Footnote:***

In the text of this thesis, symbols from the International Phonetic Alphabet revised to 1979 (IPA, 1979) and from the PRDS set (1983) are used.

In the group of children below the age of eight years at surgery, the same procedure applied, except only four of them had pre-operative speech recordings. Table 7 summarizes the dates at which speech recordings were taken for the two surgical cohorts.

The British Speech Therapists provided the model for the singletons and trisyllables imitation, which the patients were asked to imitate. This was followed by the patients counting from 1–20, and reciting the days of the week and months of the year. In view of the wide ranging reading ability of the group, the translator asked the patient to repeat the word list in groups of three, and the sentences one at a time. The speech sample was completed by the translator engaging the patient in two minutes of spontaneous speech. In 1985 and 1986 medical students acted as translators, but in 1988 and 1990, the counterparts undertook this task.

At the pre-operative stage only, an oral-motor examination was performed, and the patient was asked to complete an oral-motor skills task (see Appendix Va). This section of the assessment was not audio/video recorded.

### ***b. Velopharyngeal Function***

Post-operatively, two direct measures of velopharyngeal function were undertaken: the lateral skull X-ray with the patient phonating 'ee', and nasopharyngoscopy. Details of the indirect measure of velopharyngeal function, (the perceptual rating of nasality) are found in Chapter 5.

#### ***Lateral X-rays of Patients Phonating 'ee'***

It has become common practice to use lateral still radiographs to measure the velopharyngeal mechanism, especially where it is not practical to use more sophisticated methods, such as multi-view videofluoroscopy or nasopharyngoscopy (Morris, 1978; Bardach et al., 1984). Since it was initially not possible to undertake nasopharyngoscopy, lateral skull X-rays of patients phonating 'ee' were viewed as a useful alternative. Even in the West, this procedure is undertaken by some teams.

#### ***Subjects***

Radiographs were taken at two points in time: eight months post-operatively for the 1985 cohort (N=49), and four or five years post-operatively for the whole cohort (N=59). Table 10 shows the number and percentage of each age category of patients who had lateral skull X-rays phonating 'ee'.

*Table 10. Number and Percentage of Patients of each Age Category for Lateral Skull X-rays of Patients Phonating 'ee'*

AGE CATEGORY	X-RAY 'ee' 86		X-RAY 'ee' 90	
	N	% age cat.	N	% age cat
Adults	16	67%	16	67%
Adolescents	23	74%	20	65%
Children aged 8 – 10 years at surgery	7	58%	9	75%
Children below 8 years at surgery	3	14%	14	66%
<b>TOTAL</b>	<b>49</b>		<b>59</b>	

***Instruments***

A cephalogram lateral skull X-ray was taken in a cephalostat. This is a special head holding device which makes certain that the head is held still, with the sagittal plane at right angles to the main X-ray beam. For the purposes of serial study, magnification is made a stable feature by ensuring a constant distance from the midsagittal plane to the X-ray source (ANODE), and a constant distance from the midsagittal plane and the film.

***Procedure***

The patient was placed in the cephalostat, and the film was exposed.

In 1986, the film was exposed as the patient phonated 'ee'. In 1990, 1 ml of barium was inserted in both nostrils. Two films were taken, one where the patients did not phonate, and one where the film was exposed as the patient phonated 'ee'.

***Reliability study***

The series of radiographs taken in 1986 were rated by 3 judges (a radiologist AB, an orthodontist MM, and a speech therapist DS) on a 3 point descriptive rating scale, of closure, marginal closure and no closure (see Table 11).

*Table 11. Scale used for rating Lateral X-ray of Patient Phonating 'ee'*

1. Closure – the soft palate is in definite contact with the posterior pharyngeal wall.
2. Marginal – there is close approximation of the soft palate with the posterior pharyngeal wall.
3. No closure – there is a definite gap between the soft palate and the posterior pharyngeal wall.

Each judge was asked to rate the series twice. The information has been tested for its reliability using the Spearman's rho correlation coefficient (Table 12 and Table 13). Based on 56 observations all correlations were significant at the 0.0001 level.

The radiographs were rated reliably by the two more experienced judges (judges AB and DS), who also showed the highest intrareliability. It is concluded that lateral radiographs can be rated accurately using this three-point descriptive scale when experienced judges are used.

*Table 12. Intra-rater Reliability*

<b>AB1/AB2</b>	<b>MM1/MM2</b>	<b>DS1/DS2</b>
1.000	0.681	0.864

*Table 13. Inter-rater Reliability*

	<b>AB1</b>	<b>MM1</b>	<b>DS1</b>
AB1		0.762	0.824
AB2		0.762	0.825
MM1	0.762		0.705
MM2	0.824		0.687
DS1	0.748	0.705	
DS2	0.888	0.803	

*Spearman's rho correlation coefficient*

The 1990 data were analysed by a panel discussion of three raters using the same rating scale, two of whom were involved in the original reliability study. The third rater, an oral-maxillo-facial surgeon, was experienced in the interpretation of radiographs and speech in cleft palate patients.

***Nasopharyngoscopy***

It was recognised, however, that there was value in a procedure that would be capable of observing the anatomy and function of the component parts of the velopharyngeal sphincter, both at rest and in motion during uninhibited speech. Therefore nasopharyngoscopy was undertaken in 1990. Shprintzen (1989) described how this diagnostic procedure is able to determine gap size, location, shape, consistency/inconsistency of movement, component movements of the velum, lateral pharyngeal walls and posterior pharyngeal wall.

## ***Subjects***

Patients who returned for follow-up in 1990 were seen for nasopharyngoscopy. 70% (N=62) of the patient cohort cooperated for the procedure. Nasopharyngoscopy failed in only 6% of patients for reasons of compliance. This high level of compliance is notable. Table 14 shows the total number of patients who underwent this investigation. Table 15 shows the percentage of patients of each age category in the study who underwent this investigation.

*Table 14. Number of Patients who underwent Nasopharyngoscopy*

<b>AGE CATEGORY</b>	<b>NASOPHARYNGOSCOPY</b>
Adults	19
Adolescents	23
Children aged 8 – 10 years at surgery	9
Children below 8 at surgery	11
<b>TOTAL</b>	<b>62</b>

*Table 15. Percentage of each Age Category who underwent Nasopharyngoscopy*

<b>AGE CATEGORY</b>	<b>NASOPHARYNGOSCOPY</b>
Adults	79%
Adolescents	74%
Children aged 8 – 10 years at surgery	75%
Children below 8 at surgery	52%

## ***Instruments***

Videonasopharyngoscopy recording was performed with an Olympus ENF type P flexible endoscope, which was attached to a microvideo camera system Cmodel DP 102. A Downs high intensity light source (2150) was used for fibre-optic illumination. Recording was performed on a Panasonic VHS NV-J35HQ video cassette recorder, and the images were displayed on a Panasonic 18 inch television. A Uher microphone was used to record the audio signal through a Uher CR160 tape recorder.

## ***Procedure***

This investigation was undertaken by the author and LM, an oral-maxillo-facial surgeon.

The nasal airway of each patient was examined. The larger airway was determined by examination and inspiration (Shprintzen, 1989). A topical anaesthetic was applied. In older patients the nose was twice sprayed

with xylocaine spray. In younger patients three drops of xylocaine 4% topical solution were syringed slowly into the nasal airway. A cotton wool bud soaked in xylocaine 4% topical solution was then gently inserted into the nasal airway and gradually passed back to the nasal septum.

Once fully anaesthetized, the nasopharyngoscope was passed along the inferior or middle meatus of the nasal cavity until the velopharynx was in view. The tip of the scope was manipulated through a 90 degree arc by rotating the control wheel on the eye piece of the scope until optimal views of the sphincter were gained from above. The endoscope was passed through the velopharyngeal valve during the examination (Shprintzen, 1986). All patients recited the same speech sample (see Appendix Vc), which was videorecorded.

### ***Reliability Study***

The framework of analysis is shown in Appendix Vc. A study of inter-rater and intra-rater reliability was undertaken by the two investigators, as advocated by D'Antonio et al. (1989). This was based on a total of 103 examinations performed on a larger patient sample, who had had palate repair by the British team. Thirty samples were discussed and analysed together, followed by separate analyses of twenty five samples, which formed the basis of the inter-rater reliability study. The investigators jointly analysed the remaining sample (N=45), followed by the re-analysis of 25 samples (samples 61–73, and samples 83–96 inclusive), which formed the basis of the intra-rater reliability study. Table 16 shows the results of the nasopharyngoscopy reliability study on those parameters for which we had an appropriate statistical test. The information relating to nasopharyngoscopy discussed in this study is restricted to these parameters.

*Table 16. Nasopharyngoscopy Reliability Study*

	INTER-RATER	INTRA-RATER
	DS & LM	DS & LM,1/DS & LM,2
Adenoid size	0.676	0.745
Gap size	0.894	0.939
Degree of Closure	0.822	1.000
Degree Soft Palate Movement	0.704	0.818
Degree Left Lateral Pharyngeal Wall Movement	0.801	0.753
Degree Right Lateral Pharyngeal Wall Movement	0.840	0.822
Degree Posterior Pharyngeal Wall Movement	0.434	0.835
<i>Spearman's rho correlation coefficient</i>		



### **c. Intra-oral Examination**

#### **Subjects**

Data were collected on subjects who returned for follow-up in 1988 and 1990, as shown in Table 17.

*Table 17. Patients and Percentage of each Age Category who had Intra-oral Examinations in 1988 and/or 1990*

<b>AGE CATEGORY</b>	<b>INTRA-ORAL EXAMINATIONS</b>	
	<b>N</b>	<b>% age category</b>
Adolescents	N=30	96%
Adults	N=22	92%
Children aged 8 – 10 years at surgery	N= 9	75%
Children below 8 at surgery	N=19	86%
<b>Total</b>	<b>N=80</b>	

#### **Instrument**

A rating scale (Table 18) was used to determine the presence or absence of fistulae. When a fistula was present, its size was judged, based on the largest linear dimension of the fistula. Location and patient's awareness of fistulae was also determined.

*Table 18. Rating Scale used to describe Size and Location of Fistulae*

#### **Size**

- 0 absent
- 1 minute (less than 2 mm.)
- 2 small (between 2 and 5 mm.)
- 3 medium (between 5 and 8 mm.)
- 4 large (over 8 mm.)
- 5 complete breakdown.

## **Location**

- 1 uvula
- 2 soft palate
- 3 junction soft/hard palate
- 4 hard palate – postalveolus alveolus
- 5 buccal sulcus
- 6 other (describe)
- 7 hard palate – postalveolus, alveolus, buccal sulcus.

Patient's report : awareness yes/no

does it cause problems? yes/no

if so, what?

## ***Procedure***

In 1988, the intra-oral examinations were undertaken by two speech therapists either twenty months post-operatively (1986 surgical cohort) or thirty-two months post-operatively (1985 surgical cohort). In 1990, they were undertaken by a surgeon and a speech therapist at five years (1985 surgical cohort) or four years (1986 surgical cohort) post-operatively. Where data were available from the two post-operative data points, the data collected by the surgeon and the speech therapist were used, taking account of the more experienced nature of these clinicians. In some patients (N=18) information was also gained from the dental study models.

## ***d. Surgical Observations***

Following their experiences in 1985, the surgeons developed a surgical rating form to record their observations on ten features of the palatal repair at the time of surgery in 1986 (Ward and James, 1990), with a view to gathering data that might reveal the reasons for successful or unsuccessful speech or velopharyngeal function after surgery.

## ***Subjects***

These observations were therefore available for the 1986 surgical cohort, which consisted of 21 patients.

### ***Instrument***

The rating form consisted of ten items divided into three sections for recording observations on either a three or two point scale (see Appendix Vb).

Section 1 was a judgement of the degree of fibrosis. This consisted of three items: the degree of dissection, the degree of bleeding and the nature of the mucosa, all three of which were categorised on a three point scale.

Section 2 was a judgement of the degree of muscle quality of the velum. This consisted of four items: the ease of mobilizing the levator palati muscle, the quality of levator muscle, the mobilization of the tensor palati muscle, an estimate of tension in the velar repair, all four of which were categorised on a three point scale.

Section 3 was a miscellaneous section, consisting of a judgement regarding the need deliberately to leave anterior fistulae, as a result of the characteristics of the unrepaired palate, and the ease of repair. In addition it consisted of three other items: the preservation of the palatine vessels, the degree of closure of the nasal and the oral layer, and an estimate of the tension of the velar repair.

### ***Procedure***

Following palatal closure, the surgeon completed the form.

#### ***e. Other procedures***

Pre-operatively, patients also underwent the following assessments: dental study models, pure tone audiometry, social history, questionnaire, and attitude ratings. The ENT examination was carried out pre-operatively for the 1986 cohort only.

At subsequent follow-ups, these procedures were repeated.

## ***III. Speech Therapy Courses***

### ***Subjects***

All patients over the age of 6 years were invited to attend each course. Table 19 shows the number of patients who attended each course and their duration. In 1988, a further one week's course was also organised subsequent to the fortnight's course. However, the recall rate was very poor with only 26% attendance. This was due to the sudden and serious escalation of political violence in Sri Lanka at that time.

*Table 19. Number of Patients, and Duration of Residential Intensive Speech Therapy Courses*

	<b>Duration</b>	<b>Patients recalled</b>	<b>Completed course</b>
July 1986	10 days	66	71%
Nov. 1986	14 days	66	60%
Summer 1988	14 days	143	44%
Summer 1988	7 days	143	26%

### **Course Organisation**

The first course, in July 1986, was organised differently from the subsequent courses, in that two different intervention programmes were used. One approach was the direct speech/articulation training, and the other approach was that of conversation therapy.

Traditional speech/articulation therapy is usually considered appropriate for speech problems associated with cleft palate and other velopharyngeal problems. The treatment strategies used are designed to achieve the

*"...correct production of deviant consonant sounds in isolation, syllables, single words, sentences and finally in everyday speech." (Albery and Enderby, 1984, p.119)*

Conversation therapy aimed to facilitate social interaction and the promotion of conversation skills. This was deemed necessary since both our experience of the patients pre-operatively and the pre-operative psychological assessments had revealed that these patients not only had severe speech disorders, but were reluctant to speak, and were socially isolated. Therefore not only was their speech disordered but the whole communication process was disordered and impaired.

The total group (N =52) was divided into two groups on the basis of age: the eight to sixteen year olds formed the children's group, and the over sixteen year olds formed the adult group.

The original plan had been to match patients as closely as possible on eight variables – age, type of cleft, sex, speech attainment and imitation, hearing, IQ, appropriate/inappropriate years of schooling. Once in Sri Lanka it was soon realised that this was too ambitious in view of the sample size and time constraints, so patients were only matched on the first three criteria: those of age, cleft type, and sex. The paired patients in each age group were then randomly allocated to one of two possible treatment groups resulting in the formation of 4 groups: a children's articulation group (N=12), a children's conversation group (N=11), an adults' articulation group (N=14) and an adults' conversation group (N=15).

In all the subsequent courses, a combination of these two therapeutic approaches was used.

In November 1986, patients were grouped according to age, and gender. 43 patients attended, 8 of whom had not attended the July course. The groups who had not received any articulation therapy consisted of 7 children who had attended the July conversation group plus an additional 4 new patients, totalling 11

patients. The adult group consisted of 10 adults who had attended the July conversation group, with one new patient. The two July articulation groups were amalgamated and divided by gender into two groups: 10 males and 8 females. 40 patients completed the course.

In the 1988 courses, patients were grouped according to age and amount of therapy. In this programme, patients were invited to attend for a fortnight followed by one week's course approximately six weeks later. The number and percentage of patients who attended is shown in Table 20.

*Table 20. Patient Attendance during the 1988 Courses*

	1985 SURGICAL COHORT		1986 SURGICAL COHORT	
	Adult %	Child %	Adult %	Child %
Invited	27	35	24	57
	N	N	N	N
Fortnight	11 (40%)	12 (19%)	12 (50%)	35 (61%)
Week	5 (18%)	6 (14%)	9 (37%)	13(12%)

Daytime, evening, and weekend sessions were provided. All the courses were based in the Ayurvedic Hospital, where food, residential facilities for the patients, and accommodation for the courses were provided.

### ***Course structure***

Two British speech therapists were responsible for the delivery of therapy at each course. In 1986 medical students acted as translators. In 1988 five local speech therapy assistants not only performed this task, but were also involved in the delivery of therapy (Wirt et al., 1990a; Wirt et al., 1990b: see Appendix VII).

The therapists allocated patients into subgroups according to different criteria which varied with the year of the course. They then remained responsible for their subgroups throughout the particular course. Parents and the extended family were encouraged to be involved in treatment.

### ***Course philosophy***

The philosophy that lay behind the courses was primarily that of the traditional approach to articulation therapy. However, more recent approaches were incorporated where this was possible. Grunwell and Dive (1988) advocated the use of phonological principles and cognitive approaches which are designed to stimulate speech development by the reorganization and expansion of the phonological sound systems. For example, patients were introduced to all the speech sounds rather than concentrating on one erroneous

sound only, a principle usually adhered to in traditional therapy. Bzoch (1979) wrote that the effectiveness of therapy for persons with clefts is reduced if it involves focus on a single sound until that sound is mastered.

The perceptual-motor information processing model described by Shelton and McReynolds (1979) provided an appropriate theoretical framework for this intervention programme making use of both behavioural and cognitive philosophies. It is based on three components: perception, decision and production. In this model the learner is required to make perceptual responses to stimuli, to plan and perform motor speech responses, and then to evaluate them. Emphasis was placed on the learner understanding the task to be learned, and identifying the differences between actual performance and that required.

Articulation therapy involved teaching in the following areas: normal speech and voice production, and how and why their own speech differed from normal speakers. It also involved elicitation and facilitation of speech sounds stressing placement and manner, listening and discrimination work (Huskie, 1979), oral awareness sessions, grading/targeting production work, generalization and discussion/counselling (Grundy, 1989). Use was made of visual and auditory modelling, tactile clues, practice and reinforcement. These are especially pertinent where there are compensatory articulations resulting in a pattern of posterior placement of the target consonants (Trost, 1981). Therapy aimed to change the place of articulation from posterior to anterior (Trost, 1981), based on the concepts described by Hoch et al. (1986).

Patients had their own folder with prepared course handouts. Self-help skills were encouraged.

Articulation work was interspersed with social activities. Use was made of group dynamics, where patients worked as a large group, individually, in pairs or threes. Several authorities have pointed out the social benefits of group treatment (Morley, 1970; Huskie, 1979).

In summary, whilst this methodology draws upon previous studies, the present study is unique in its longitudinal design, and the comprehensive investigation of several different variables which may affect outcome.

# Chapter 5

## Method of Speech Analysis

### ***1. The Rating Scale***

Any system devised for the analysis of disordered speech should meet the following criteria:

1. The system should be capable of handling the range of phonetic possibilities that may occur within the data, and which are relevant to the investigation.
2. The framework should be applicable so that it results in an analysis appropriate to the condition under investigation and the aims of the research.
3. The analysis should be replicable. It needs to be carried out according to an explicitly stated set of procedures. The criteria for classification and analysis of the data should be explicit and non-ambiguous.
4. The analysis should be both qualitative and quantitative. The qualitative analysis should provide a detailed phonetic description. The quantitative analysis should measure the incidence of phonetic characteristics within and across patients.
5. The framework should have a clearly explained theoretical basis. The framework should relate to our knowledge of the speech sound producing potentials of the normal and disordered speech sound producing mechanism, on the theoretical assumption that it is possible to relate the characteristics of the phonetic output to the nature of the mechanism.

If all these criteria are met then the framework of analysis will have validity with regard to the aims of the investigation and results will be gained which will satisfy the objectives outlined.

The initial approach to devising an appropriate framework of analysis is to start from a premise or hypothesis regarding the nature of the data. It was predicted that an individual who has established his speech with an unrepaired palate would present with deviant speech. On the basis of this assumption the possible effects of an unrepaired palate on speech will now be discussed in some detail.

The vocal tract is made up of a series of varying valves or constrictions used for speech production. These constrictions are created by the active articulators, viz. the glottis, velum, lips, and different parts of the active articulator (the tongue), moving into a stricture with the passive articulators such as the alveolar ridge, upper dentition, or hard palate. Patients with an unrepaired palate do not have the structure to effect some of these valves, notably to a greater or lesser extent those involving the hard and soft palate.

It could be anticipated that the full range of articulatory placement for consonants would not be realized, and that there would be a predisposition to develop compensatory behaviours elsewhere in the vocal tract. In addition, patients with velopharyngeal insufficiency are liable to use compensatory articulations – for example, glottal stops, pharyngeal fricatives or plosives – and therefore this pattern may be encountered in

this population. It might also be expected that there may be attempts by speakers to block off the open cavity with the mobile articulator; for example, by pushing the body of the tongue into the cleft. As a result, the range of placement possibilities may be restricted and deviant.

The manner characteristics of consonants are also likely to be affected. Plosives, fricatives and affricates all require the buildup of intra-oral air pressure, in which the hard and soft palates both play an integral role. To achieve intra-oral air pressure there must be an effective means of separating the nasal and oral cavities. This is achieved not only by an intact hard and soft palate, but also by the adequate functioning of the velopharyngeal mechanism, in which the soft palate plays a primary role. Therefore, the patient with an unrepaired palate has an inadequate structure, incapable of producing these manners of production.

It was predicted that patients might have greater difficulty signalling the voiceless cognates, and therefore a loss of voiceless/voiced differentiation might result (see Chapter 2: section III).

The balanced oral-nasal resonance characteristic of normal Sinhala speakers would be lost in a patient with an unrepaired palate. The effective separation of the nasal and oral cavities would not be possible and excessive nasal resonance and nasal air emission is expected in these individuals. Nasal and facial grimace is also likely to occur as a compensatory behaviour developed by the patient in his unconscious efforts to stop the airflow escaping via the nares.

Following palatal surgery it was predicted that nasal resonance and nasal escape would change spontaneously. In contrast, it was felt unlikely that the habitual use of incorrect place and manner of articulation would change with palatal closure alone. It was possible that there would be increased evidence of the individual's ability to achieve intra-oral air pressure, revealing a greater differentiation of manner, but it was anticipated that a strong habitual element would be operating. Consequently, it was expected that certain patterns of speech production that had developed in the presence of an unrepaired palate would not spontaneously change with palatal closure. Speech therapy would probably be required.

When surgery was supported by articulation therapy it was hypothesized that there would be a greater use of oral placement and manner. This would be particularly observed in imitation of sounds and consonant-vowel combinations, at single word level, and perhaps in careful speech, but given the limited amount of therapy intervention it was considered unrealistic to expect carryover into spontaneous speech. It was predicted that therapy sessions would have less effect on excessive nasal resonance, although it may be possible to facilitate a reduction in the occurrence of grimacing.

It is clear from the literature review and the points made above that 'cleft palate speech' consists of different parameters which should each be separately analysed. A rating scale, capable of describing speech performance and speech change, was devised as an initial approach to describing these data (Table 21). The rating scale was composed of separate scales for each speech parameter, so that each could be separately evaluated. This assessment procedure, based on auditory impressionistic descriptions, was devised to be sensitive to the deviancies in speech that had been observed. Following the use of this scale, a revised and



more sensitive version has been developed (Table 22). This resulted from experience in analysing patients' speech after therapy. The differential effects of therapy on speech, which were observed as the patients had the benefit of an increasing amount of therapy could not be adequately evaluated by the first scale.

The original scale was made up of two components: speech performance and speech related behaviour. Speech performance consists of those properties of placement, manner, voice, and nasality that make up articulation. In the original scale placement, manner and voice were graded on a 0–6 point scale, each grade representing a qualitative description. Speech related behaviour consisted of grimace and oral-motor skills scales. This again was rated by a qualitative judgement on a 0–6, and a 0–3 point scale respectively.

The revised scale is made up of the same parameters except the oral-motor skills scale is no longer included. The placement and manner scales are extended to a 0–8 point scale, and the nasality scale is condensed to a four-point scale.

The ratings were based on video recordings and, in a few instances, where this recording was inadequate, the audio recording was used. Van Demark et al. (1989) demonstrated that analysis from video recordings is adequate for general ratings of speech. In this study, the use of the video recording permitted the analysis of grimace and observation of tongue tip and blade movement required to make the judgements for the placement scale.

All ratings were based on the early part of the speech sample – that of the reciting of numbers, days, months and the word list – but not spontaneous speech. It was predicted that if it was possible to detect any speech changes, given the limited amount of speech therapy, it would be in this highly controlled part of the sample.

In conducting these ratings, patients were awarded a point when there was some evidence that they were demonstrating speech behaviours of the type described on the specified targets. The point given for each scale is intended to represent a balanced judgement of the rated speech sample.

In addition, the speech assessment included a task of imitation of singletons and trisyllables. The therapist modelled twelve trisyllables and ten singletons, involving plosives, fricatives and affricates. Patients were asked to copy each in turn.

The following criteria were used to determine if the imitation was a correct or incorrect response:

- a. Placement was correct with the provision that velar plosives were credited if produced as uvular plosives.
- b. Manner was satisfactory. Weakness of manner as a result of nasal air emission and excessive resonance, however, did not constitute an error.
- c. Voicing errors were accepted in view of the lack of aspiration found in Sinhalese voiceless plosives. Therefore, if placement and manner were satisfactory according to this criterion, but voicing was incorrect, the patient was credited with the response.

A rating of grimace was also given for this part of the speech assessment.

TABLE 21

**THE ORIGINAL SPEECH ATTAINMENT SCALE**

**PLACEMENT** : based on targets / t, d, k, g, s, t, d, s, ʃ, ʒ /

- 0 – No attempt at placement.
- 1 – Very limited attempt at oral lingual placement – main place of articulation is glottal and pharyngeal.
- 2 – Attempt made at oral lingual placement – main place of articulation is glottal and pharyngeal.
- 3 – Some glottal/pharyngeal articulation but a substantial number of oral lingual placements.
- 4 – Mainly oral placements, with minimal glottal/pharyngeal placements. The oral articulations may involve errors of intra-oral substitution and distortion type.
- 5 – Full range and correct use of expected placements, e.g. bilabial, alveolar, retroflex, velar, palatoalveolar.

**MANNER** : based on targets: / t, d, k, g, s, p, b, t, d, s, ʃ, ʒ /

- 0 – No supraglottic articulation e.g. no use of oral articulators for consonants.
- 1 – Nasals and approximants only.
- 2 – Minimal modification of the oral airstream. e.g. occasional friction, plosion usually not achieved, usually nasal equivalents, omissions or air stopped at the glottis.
- 3 – More consistent modification of the oral airstream with nasalization, and nasal air escape, and sounds intermediate between oral stops and nasals e.g. some oral plosion and friction, (credit as 3+ if no excess nasality).
- 4 – Plosion, friction and affrication achieved with nasalization and nasal air escape, although not always fully established throughout the possible targets.
- 5 – Normal manner of plosion, friction, and affrication.

**VOICE** : based on targets / p, b, t, d, k, g, t, d, s, ʃ, ʒ /

- 0 – No detectable use of the voiced/voiceless contrast.
- 1 – Occasional voiced/voiceless differentiation.
- 2 – Correct use of voice in some consonants (e.g. p b) but in a limited sound system with many glottals.
- 3 – Only occasional incorrect use of voice.
- 4 – Correct use of voice but in a less limited sound system than 2.
- 5 – Appropriate voicing throughout the fully established sound system.

**NASALITY**

- 0 – severe hypernasality.
- 1 – moderate-severe hypernasality.
- 2 – moderate.
- 3 – mild.
- 4 – inadequate.
- 5 – normal.

**GRIMACE**

- 0 – marked – not restricted to nares – very distracting.
- 1 – slight – not restricted to nares – not unduly distracting.
- 2 – marked – restricted to nares – distracting.
- 3 – slight – restricted to nares – not unduly distracting.
- 4 – inconsistent occasional grimace – barely noticeable.
- 5 – absent.

**ORAL-MOTOR SKILLS**

- 0 – dyspraxia suspected.
- 1 – detectable oral motor difficulties affecting tongue placement.
- 2 – some limitation of lip movement as a result of surgery.
- 3 – satisfactory.

TABLE 22

**THE REVISED SPEECH ATTAINMENT SCALE**

**PLACEMENT** : based on targets / t, d, k, g, s, t, d, s, ʧ, ʒ /

- 0 – No attempt at placement.
- 1 – Very limited attempt at oral lingual placement – main place of articulation is glottal and pharyngeal. 1\* A favourite back place of articulation may also predominate.
- 2 – Attempt made at oral lingual placement – main place of articulation is glottal and pharyngeal.
- 3 – Some glottal/pharyngeal articulation but a substantial number of oral lingual placements. Glottal and oral coarticulations may be characteristic.
- 4 – Mainly oral placements, with minimal glottal/pharyngeal placements. The oral articulations involve errors of distortion, omissions, and intra-oral substitution resulting in restricted use of oral placements.
- 5 – Mainly oral placements, with minimal glottal/pharyngeal placements. No errors of intra-oral substitution and distortion type.
- 6 – Only oral placements with no glottal/pharyngeal placements, but not fully established throughout the possible targets.
- 7 – Full range and correct use of expected placements, e.g. bilabial, alveolar, retroflex, velar, palatoalveolar.

**MANNER** : based on targets / t, d, k, g, s, p, b, t, d, s, ʧ, ʒ /

- 0 – No supraglottic articulation e.g. no use of oral articulators for consonants. Vowel-like approximations only.
- 1 – Nasals and approximants only.
- 2 – Minimal modification of the oral airstream. e.g. occasional friction, plosion usually not achieved, usually nasal equivalents, approximants, omissions or air stopped at the glottis.
- 3 – More consistent modification of the oral airstream with nasalization, and nasal air escape, and sounds intermediate between oral stops and nasals e.g. some heavily nasalized plosion and friction. 3\* Use of one manner type, often plosion, predominates at the favourite place of articulation.
- 4 – Evidence of nasalized oral plosion and oral friction not necessarily established throughout the possible targets. No affrication.
- 5 – Plosion, friction and affrication achieved with/without nasalization and nasal air escape, although not always fully established throughout the possible targets.
- 6 – Plosion, friction and affrication achieved with nasalization and nasal air escape, fully established throughout the possible targets.
- 7 – Normal manner of plosion, friction, and affrication fully established throughout the possible targets.

**VOICE** : based on targets / p, b, t, d, k, g, t, d, s, ʧ, ʒ /

- 0 – No detectable use of the voiced/voiceless contrast.
- 1 – Occasional voiced/voiceless differentiation.
- 2 – Correct use of voice in some consonants, (e.g. p b) but in a limited sound system with many glottals.
- 3 – Only occasional incorrect use of voice in a limited sound system.
- 4 – Correct use of voice but in a less limited sound system than 2.
- 5 – Appropriate voicing throughout the fully established sound system.

## **NASALITY**

- 0 – severe or moderate hypernasality.
- 1 – mild hypernasality.
- 2 – inadequate nasality.
- 3 – normal.

## **GRIMACE**

- 0 – marked – not restricted to nares – very distracting.
- 1 – slight – not restricted to nares – not unduly distracting.
- 2 – marked – restricted to nares – distracting.
- 3 – slight – restricted to nares – not unduly distracting.
- 4 – inconsistent occasional grimace – barely noticeable.
- 5 – absent.

Each of the separate scales will now be discussed, with their revisions.

### ***Placement***

This scale was designed to detect the degree of oral lingual placement on the targets specified (plosives, fricatives and affricates).

The lower end of the scale distinguishes speakers who make no attempt at oral lingual placement from speakers who make a very limited attempt and who use a high degree of pharyngeal and laryngeal compensatory articulations. This latter group is then further distinguished from those with the same characteristic articulatory pattern but who do make a consistent attempt at oral lingual placement.

In the revised scale, the original point 1 is subdivided to include the group of patients where one favourite back place of articulation predominates, often associated with a favourite manner type. The revised scale develops point 3 to identify the occurrence of glottal coarticulation with oral lingual placements, a speech behaviour particularly observed in patients who have had therapy.

The main revisions, however, occurred at the top end of the scale. The original point 4 was subdivided to distinguish patients 'with errors of intra-oral and substitution type' from those without these errors. The original scale is still characterized by compensatory articulations, albeit minimal, to as high as point 4. A point was therefore needed to indicate where there were only oral placements with no glottal/pharyngeal placements, but not fully established throughout all the possible targets (point 6 on the revised scale).

### ***Manner***

The manner scale refers to the degree of stricture that is created in the vocal tract between the passive and active articulators. The manner scale represents a graded progression from no differentiation of the airstream to manner types requiring the most intra-oral air pressure: those of plosion, frication and affrication.

The revised scale redefines the lowest point of the scale by specifying that this refers to vowel-like approximations only. In the original scale the differences between points 3 and 2 and points 3 and 4 were very marked and therefore many patients were credited with point 3. This point needed to be more explicit, and was subdivided, resulting in the expansion of the original point 3 and the insertion of a new grade at point 4. Point 3 in the revised scale is expanded to include the type of pattern where one manner type predominates at the favourite back place of articulation. Point 4 is a new grade inserted for speakers who exhibit more consistent nasalized oral plosion and oral friction than for point 3, but no affrication. Point 6 is another new grade, for speakers who are using all the manner types but accompanied by nasal air escape and excessive nasal resonance, in contrast to point 7, where there is no disorder of resonance.

### ***Voice***

The voicing scale is a scale to detect the degree of voice/voiceless contrast in the targets specified. The only revision which occurred was an expansion of point 3 in order to clarify that this was found in a limited sound system.

### ***Nasality***

Given the assumption about the nasality characteristics of this type of speech, points 0–4 in the original nasality scale describe the amount of hypernasality detected in a speaker. There is provision for describing hyponasality and normal oral resonance at the top end of the scale, since it is possible that either of these characteristics may be found post-operatively.

In the revised scale there is a collapsing of the points 0,1,2 which describe the amount of hypernasality. This occurred as a result of the predicted lower reliability achieved by raters (see below). It was judged that this resulted from the difficulty of assessing nasality in the presence of severe articulatory disorders. The literature review (see Chapter 2: section III) shows that the degree of nasality perceived is confounded by the phonetic characteristics of the sound system.

The revised scale has reduced the possibilities of the degree of hypernasality from a range of four to a range of two.

### ***Grimace***

This scale was based on that of Subtelny et al. (1972) and has not changed in the revised version. Its application has altered as a result of the reliability study. The rating of grimace in the first reliability study was unreliable (see below). It was suspected that the nature of the speech sample involving imitation and rote tasks resulted in variability of grimace behaviour. The imitation task appeared to increase or cause grimace to occur, possibly related to the increased efforts patients made to copy sounds. As a result of this, patients are given two separate ratings for the different types of speech task, that of the imitation of speech sounds and that of rote speech.

### ***Oral-Motor Skills***

This four point scale was designed to detect oral-motor difficulties, which may have indicated another speech disorder or some generalized oral-motor difficulty, which some researchers (e.g. Fletcher, 1978) describe in individuals with cleft palate repair at conventional ages. Since the scale was unreliable in the first reliability study, it was then deleted from the assessment.

### ***Reliability***

Morris (1978) states that when the investigator does not speak the language, it is particularly important to consider reliability and validity. He found in the Bratislava study (1978) that speaking the language of the patient is not essential for making a reliable diagnosis of velopharyngeal competency.

The reliability of the speech rating scale, in its original and revised versions, has been established by the author (DS) and three trained listeners (LY, RW, AW). The four reliability studies described all used Spearman's rho correlation coefficient test to determine the degree of inter-rater and intra-rater reliability.

The first reliability study using the original rating scale involved listeners DS and LY. To evaluate the reliability of the author's speech ratings, forty patients from the whole study group were twice rated by the author on separate occasions. The second trained therapist rated the same forty patients independently. This sample of patients was randomly drawn from the total patient sample at the pre-operative stage, post-operatively, and after the first therapy course in July 1986.

Table 23 shows the intra-rater and inter-rater reliability on the properties of speech performance, speech related behaviour, and the imitation tasks. The different properties of speech can be seen on the vertical axis. Along the horizontal axis, the correlation between the author's two sets of ratings are found, followed by the correlations between the author and those of the second rater LY.

All correlations that were greater than 0.8 are significant at the 0.01 level. As can be seen, the parameters of placement, manner and voice are the most reliable, followed by nasality. The ratings of the speech related behaviour of grimace and oral-motor skills do not reach a satisfactory level of reliability, in contrast to the imitation tasks, which show high reliability. The poor inter-rater and intra-rater reliability of the grimace scale can probably be explained by the different speech tasks on which the judgement was based.

*Table 23. First Inter-rater and Intra-rater Reliability Study using the Original Rating Scale.*

	<b>DS1 DS2</b>	<b>DS1 LY</b>	<b>DS2 LY</b>
IMITATION of TRISYLLABLES	0.79	0.81*	0.86*
IMITATION of SINGLETONS	0.81*	0.82*	0.80*
PLACEMENT	0.93*	0.90*	0.91*
MANNER	0.92*	0.89*	0.86*
VOICE	0.87*	0.83*	0.88*
NASALITY	0.74	0.76	0.68
GRIMACE	0.70	0.65	0.62
ORAL-MOTOR SKILLS	0.60	0.65	0.43

\* significant at the 0.01 level.

A second reliability study was later conducted with two other trained listeners (AW and RW) and the investigator (DS). Twenty three patients from the whole study group were twice rated by all the listeners at two data points: before and after two of the fortnight courses in the summer 1988 project. The investigator performed all the ratings from a video recording. Listeners AW and RW performed the first set of ratings live and listeners DS and RW performed the second set of ratings from video and live recordings respectively. Table 24 shows the results of this study. The different properties of speech can be seen on the vertical axis. Along the horizontal axis, the correlation coefficients between the two sets of ratings from the live judgements are found, followed by the correlations between ratings based on the video recordings and those made from live judgements.

*Table 24. Second Inter-rater Reliability Study.*

	<b>RW/AW Live</b>	<b>DS/RW Video/Live</b>
PLACEMENT	0.8008	0.7383
MANNER	0.8331	0.7798
VOICE	0.8393	0.7906
NASALITY (NB revised scale)	0.7896	0.8695
GRIMACE IMITATION	0.7160	0.3512*
GRIMACE ROTE.	0.7816	0.5610

All correlations significant at the 0.0001 level except that marked \*.

The reliability ratings of the voice and manner scales were highly significant at the 0.01 level, irrespective

of whether the judgements were based on live or on video ratings.

On the placement scale, there was high reliability if rating occurred in the same medium, but the reliability was less consistent across the two media. This suggests either that different information is being used to make the judgements depending on the medium, or the scale is being used differently across the two media with possibly a loss of information. The correlations between the live/video ratings (DS/RW) were however all significant at the 0.05 level, except for that of grimace on the imitation task.

Reliability of the nasality scale was low overall, and no pattern related to medium could be found to account for this. When the correlations were repeated with the collapsed scale, levels of significance were then achieved. However, it should be pointed out that because some of the raters had used hardly any other grade than grade 0 there were several occurrences of a perfect correlation of 1.0, a reflection that only one item on the scale was used.

The rating for grimace during rote speech indicated that reliability was highly significant. The grimace rating on the imitation speech task did not generally achieve such a high level of significance as the grimace rating on rote speech; this is possibly related to increased variability within the task.

The third study was to establish the reliability of the revised scales of placement and manner. This was established by the investigator and one of the trained listeners. Twelve randomly selected patients from the whole study group and representing all the data points were twice rated by the author and once by the other trained listener. Table 25 shows the high correlations achieved, using the Spearman's rho correlation coefficient test. Again the different properties of speech can be seen on the vertical axis. Along the horizontal axis, the correlation between the author's two sets of ratings are found, followed by the correlations between the author and those of the second rater AW.

*Table 25. Revised Placement and Manner Scales Reliability Study.*

	<b>DS1/DS2</b>	<b>DS1/AW</b>	<b>DS2/AW</b>
PLACEMENT	0.91	0.78	0.86
MANNER	0.94	0.79	0.72

The final reliability measure undertaken was to determine how highly correlated the pre-operative ratings on each of the placement, manner and voice scales were with the aggregate of the pre-operative ratings of all the scales. This was based on 57 observations of the adult and adolescent groups at the initial pre-operative data point. It was appropriate to study this data point given that the placement, manner and voice ratings in these age groups were to be used as an overall measure of the baseline articulation. Table 26 shows the high correlations achieved between placement, manner and voice and their aggregate for the pre-operative measures, indicating that the scales were being used reliably.



*Table 26. Correlations at the Pre-operative Data Point for Placement, Manner, and Voice and their Aggregate*

	<b>PLACEMENT</b>	<b>MANNER</b>	<b>VOICE</b>
PLACEMENT			
MANNER	0.76		
VOICE	0.81	0.85	
AGGREGATE	0.91	0.93	0.95

Thus, it has been satisfactorily demonstrated that the revised scales of placement, manner, and nasality, the voice scale, and the grimace scale on two different speech tasks are reliable across trained listeners.

This description of the framework of analysis therefore satisfies the criteria required for the analysis of disordered speech outlined at the beginning of this chapter.

## **II. Speech Patterns**

Although inferential statistics have been used as part of the quantitative analysis, McWilliams et al. (1990) highlight the problem of statistical significance versus clinical relevance. They point out the importance of the relationship between a statistical difference and a perceptual difference. Clinical interpretation of the findings is required in order to give “perspective to the research findings”. They give the example of what a statistically different cephalometric measurement means in terms of facial appearance. The researcher needs to make some interpretation of the clinical importance of findings of statistical significance.

Similarly, significant differences were found in these data: although some quantitative information was available to aid their interpretation, qualitative information was not described. A system was required to describe the amount of qualitative change. Different combinations of placement and manner scores could be identified at the pre-operative, post-operative, and post-therapy data points, resulting in the identification of seventeen different speech patterns (Figure 1). It was anticipated that the study of the speech patterns and the change in those patterns across the data points may provide the qualitative information required.

In addition, experience and examination of the data suggested that there may be recurring relationships between speech patterns across the data points. If any such relationships are identified, this information may contribute to our knowledge and ability to predict, pre-operatively, the possibility and degree of likely change post-operatively.

Fourteen of the seventeen patterns could be arranged as a graded scale using qualitative and quantitative descriptions. Table 27 depicts the seventeen speech patterns. Table 28 and Figure 1 show the quantitative place and manner characteristics of each of the patterns, reflecting the graded nature of the speech patterns.

Three patterns only (4, 8, and 10) do not easily fit into a graded scale. Some patterns covered a range of possibilities, hence the same pattern being represented at different points.

Pattern 4 is characterized by nasalized plosion occurring at one place of articulation only (usually pharyngeal) for many of the targets, even the bilabial targets. This consistent use of nasalized plosion at one back place of articulation distinguishes this pattern from the surrounding Patterns of 3 and 5 where attempts at different oral lingual placements were observed, associated with glottal articulation, and much less evidence of nasalized plosion. Equally it was not justified to allocate this pattern higher up in the hierarchy, due to the few attempts made at oral lingual placement and the frequently favoured pharyngeal place of articulation.

Pattern 8 consists of speech characterized by mainly oral placements with minimal glottal/pharyngeal placements, and with manner characteristics found usually in Pattern 2. Therefore the position of this pattern was determined by the place characteristics. The manner characteristics of the surrounding Patterns of 7 and 9 (that of nasalized oral plosion and friction) demonstrate how this pattern does not easily fit into the hierarchy.

Pattern 10 consists of speech characterized by a substantial number of oral lingual placements, with some glottal/pharyngeal placements, but with plosion friction and affrication achieved with/without nasalization, but not established at all targets. The position of this pattern was determined by the manner characteristics. The place characteristics of the surrounding Patterns 9 and 11 (that of mainly oral placements with minimal glottal/pharyngeal) demonstrate the difficulties of fitting this pattern into the hierarchy.

*Table 27. The Seventeen Speech Patterns*

Placement (or place) based on targets /<sub>n</sub> t d k g s t d s ʃ dʒ/.

Manner based on targets /p b t d k g s t d s ʃ dʒ/.

The numbers following place and manner refer to the points on the speech attainment rating scale.

**Pattern 1. Place 1 or 0 Manner 1 or 0**

Consisted of substitutions involving no attempt or a very limited attempt at oral lingual placement with the main place of articulation as glottal. Manner consisted of vowel-like approximations only, nasals and approximants. There was no detectable use of the voiced/voiceless contrast. It was also useful to include the imitation scores because these patients consistently demonstrated very poor imitation, scoring 0 or 1 only on each of the imitation tasks.

**Pattern 2. Place 2 Manner 0 or 1**

Pattern 2 differed from that of Pattern 1 only in that attempts at oral lingual placement were made especially detectable on targets /<sub>n</sub> t d k/. Otherwise, manner consisted of vowel-like approximations only, nasals and

approximants. There was no detectable use of the voiced/voiceless contrast. It was also useful to include the imitation scores because these patients consistently demonstrated very poor imitation, scoring 0 or 1 only on each of the imitation tasks.

***Pattern 3. Place 1 or 2 Manner 2***

Consisted of variable degrees of attempts at oral lingual placement but the main place of articulation remained glottal and pharyngeal. This pattern differed from Pattern 2 in that there was some modification of the airstream, usually occasional detectable friction. Patients exhibiting this pattern generally showed more accurate attempts at sound imitation than in Patterns 1 and 2.

***Pattern 4. Place 1\* Manner 3\****

Consisted of speech characterized by a favourite back place of articulation, often pharyngeal/uvular, frequently associated with a favourite manner type often nasalized plosion. This occurs where a plosive is accompanied by excessive nasal resonance, usually associated with an open velopharyngeal port.

***Pattern 5. Place 1 or 2 Manner 3***

Consisted of speech usually characterized by attempts made at oral lingual placement, but the main place of articulation remained glottal and pharyngeal. Some modification of the oral airstream with sounds that are intermediate between oral stops and nasals, e.g. heavily nasalized plosion and nasalized friction, could also be detected.

***Pattern 6. Place 3 Manner 2***

Consisted of speech characterized by a substantial number of oral lingual placements, with some glottal/pharyngeal placements. However, there was minimal modification of the airstream resulting in only occasional friction, nasal equivalents or approximants, with many omissions or air stopped at the glottis.

***Pattern 7. Place 3 Manner 3 or 4***

Consisted of speech characterized by a substantial number of oral lingual placements, with some glottal/pharyngeal placements. Nasalized oral plosion and oral friction were detected, but frequently were not fully established throughout the possible targets. No affrication was detected.

***Pattern 8. Place 4 Manner 1 or 2***

Consisted of speech characterized by mainly oral placements with minimal glottal/pharyngeal placements. However there was incorrect manner of articulation resulting mainly in nasals and approximants, with minimal modification of the oral airstream. There was no detectable use of the voiced/voiceless contrast for oral lingual targets.

***Pattern 9. Place 4 Manner 3 or 4***

Consisted of mainly oral placements with minimal glottal pharyngeal placements. Errors of intra-oral substitution, omission and distortion occurred. Varying degrees of nasalized oral plosion and oral friction occurred but there was no affrication.

***Pattern 10. Place 3 or 4 Manner 5***

Consisted of speech characterized by a substantial number of oral lingual placements, with some glottal/pharyngeal placements, but with plosion friction and affrication achieved with/without nasalization, but not established at all targets.

***Pattern 11. Place 5 Manner 4 or 3***

Consisted of speech characterized by mainly oral placements with minimal glottal/pharyngeal placements. No errors of intra-oral substitution and distortion type occurred. Varying degrees of nasalized oral plosion and oral friction occurred but there was no affrication.

***Pattern 12. Place 5 Manner 5***

Consisted of speech characterized by mainly oral placements with minimal glottal/pharyngeal placements. No errors of intra-oral substitution and distortion type occurred. Plosion friction and affrication achieved with/without nasalization and nasal air escape.

***Pattern 13. Place 6 Manner 4***

Consisted of speech characterized by oral placements only. Manner types of nasalized oral plosion, and oral friction were found but neither place or manner characteristics were fully established throughout the possible targets.

***Pattern 14. Place 6 Manner 5 or 6***

Consisted of speech characterized by oral placements only, but not fully established throughout the possible targets. When plosion friction and affrication were achieved without nasalization and nasal air escape, these manner types were not fully established throughout the possible targets. When plosion friction and affrication were achieved with nasalization and nasal air escape, the manner types may or may not have been established throughout the possible targets.

***Pattern 15. Place 7 Manner 5 or 6***

Consisted of speech characterized by the full range and correct use of expected placements. When plosion friction and affrication were achieved without nasalization and nasal air escape, these manner types were

not fully established throughout the possible targets. When plosion friction and affrication were achieved with nasalization and nasal air escape, these three manner types may or may not have been established throughout the possible targets.

***Pattern 16. Place 7 Manner 7***

Consisted of speech characterized by oral placements only, but not fully established throughout the possible targets. Normal manner of plosion, friction and affrication were fully established throughout the possible targets. Appropriate voicing throughout the fully established sound system.

***Pattern 17. Place 6 Manner 7***

Consisted of speech characterized by the full range and correct use of expected placements, with normal manner of plosion, friction and affrication. Appropriate voicing throughout the fully established sound system.

Table 28 shows the quantitative characteristics of place and manner of each of the patterns, with the range of total possible scores when totalled for each pattern. Figure 1 represents this information graphically.

*Table 28. Quantitative Characteristics of Place and Manner for Speech Patterns*

<b>PATTERN</b>	<b>PLACE</b>	<b>MANNER</b>	<b>TOTAL RANGE OF POSSIBLE SCORES</b>
1	0,1	0,1	2,1,0
2	2,	0,1	2,3
3	1,2	2	3,4
4	1*	3*	4
5	1,2	3	4,5
6	3	2	5
7	3	3,4	6,7
8	4	1,2	5,6
9	4	3,4	7,8
10	3	5	8
11	5	3,4	8,9
12	4,5	5	9,10
13	6	4	10
14	6	5,6	11,12
15	7	6	13
16	6	7	13
17	7	7	14

### **III. Speech Categories**

It is neither practical, nor scientifically or clinically necessary to handle seventeen groups. A system was required to categorize and display some of the fundamental groupings that occurred which were nevertheless discrete from one another. A data reduction technique was used to devise such a system and a system of speech categories was developed.

Consideration was given as to how to arrive at groupings of the patterns. Two possible criteria emerged as the basis for identifying groups or categories: distribution across the data points, and phonetic characteristics.

An examination of the distribution of speech patterns at each of the data points revealed some naturally occurring boundaries or divisions in the data (Table 29), and therefore this criterion was considered as a possible legitimate method for grouping the patterns.

*Table 29. Distribution of Speech Patterns according to Frequency of Occurrence across the Data Points*

<b>Pattern</b>	<b>Pre-operative</b>	<b>Post-operative</b>	<b>Post-therapy</b>
1	16	21	10
2	4	5	4
3	18	10	10
4	4	7	6
5	1	2	7
6	0	4	2
7	12	16	13
8	2	2	0
9	3	3	5
10	1	4	3
11	2	1	2
12	2	5	7
13	3	1	1
14	1	4	5
15	1	1	3
16	0	1	1
17	0	2	8

From Table 29, there appeared to be a large number of speakers allocated to Pattern 1 at all data points, in contrast to Pattern 2, therefore band 1 was allocated for Pattern 1 only.

Patterns 2, 3, 4, and 5 were grouped together. At the pre-operative stage there were no speakers with Pattern 6 and therefore a natural junction occurred between Patterns 5 and 6. Post-operatively Pattern 5 represents a trough between Patterns 4 and 6, whereas post-therapy Pattern 5 represents a peak in distribution.

Patterns 6 and 7 were banded together on account of the peak which occurred at Pattern 7.

Patterns 8, 9, 10, 11, 12, 13 and Patterns 14, 15, 16, 17 formed two further groups. A natural division appeared to occur between Patterns 13 and 14 both post-operatively and post-therapy with very few patients represented at Pattern 13 in contrast to Pattern 14.

However, given that the distribution criterion relates to that sample of the population seen, and not to any objective speech criteria, it was decided that it would be more meaningful to develop the categories according to phonetic criteria.

Determining the boundaries according to phonetic characteristics, however, was not without its problems. These related to the interaction between the place and manner categories. A pattern on the basis of place could be allocated to one category, while the manner rating would suggest that the pattern would fit more appropriately in another category and vice versa. However, by taking an overall assessment of the phonetic characteristics, and taking into account the range of raw scores of place and manner, it was possible to reconcile these apparent contradictions, and arrive at six categories (Figure 2).

Interestingly, there is considerable overlap in the definitions of the speech categories according to both the phonetic and distribution criteria. Only two patterns, 2 and 8, were allocated to different categories on the basis of phonetic criteria. The distribution criterion thus appeared to support the classification according to phonetic criteria.

#### ***Category A (Patterns 1 and 2)***

Quantitatively the range of score possibilities on the speech rating scale was from 0–3.

The main place of articulation was glottal and pharyngeal. Manner was characterized by vowel-like approximations only, nasals and approximants. The imitation score was usually very poor, scoring 0/1 only on each of the imitation tasks. Patients in this band made varying attempts at oral lingual placement. Pattern 1 was characterized by no attempts or very limited attempts at oral lingual placements whereas patients with Pattern 2 demonstrated some attempts at oral lingual placements.

#### ***Category B (Patterns 3, 4 and 5)***

Quantitatively the range of score possibilities on the speech rating scale was from 3–5.

The main place of articulation was glottal and pharyngeal with very limited attempts, or attempts made at oral lingual placement. Therefore there is some overlap in place characteristics with Category A. However, this category is distinguishable from Category A in that there were varying degrees of modification to the airstream, such as occasional detectable friction, or heavily nasalized plosion, or in the case of Pattern 4 speakers, nasalized plosion occurring at one place of articulation only.

### ***Category C (Patterns 6, 7 and 8)***

Quantitatively the range of score possibilities on the speech rating scale was from 5–7.

This category was distinguishable from Category B as it was mostly characterized by a substantial number of oral lingual placements with some glottal/pharyngeal placements. Glottal and oral coarticulations were also characteristic. Manner overall was characterized by varying degrees of modification to the airstream, such as occasional detectable friction, or heavily nasalized plosion. Therefore there is some overlap in manner characteristics with Category B.

In the case of some speakers with Pattern 7, there was evidence of limited nasalized oral plosion and oral friction.

This category also includes one pattern characterized by mainly oral placements with minimal glottal/pharyngeal placements (Pattern 8) but in combination with low manner characteristics.

### ***Category D (Patterns 9 and 11 form group D1, and Pattern 10 forms group D2 )***

Given that there is a potential inconsistency with speakers with Pattern 10, this category has been divided into two groups D1 and D2. Quantitatively the range of score possibilities for the whole group on the speech rating scale was from 7–9.

#### ***Group D1. Patterns 9 and 11***

Speech was characterised by mainly oral placements, with minimal glottal/pharyngeal placements. Nasalized plosion and friction occurred to an appreciable extent, but no affrication.

#### ***Group D2. Pattern 10***

The place characteristics of glottal and pharyngeal placements as found in Category C were present. In terms of its manner characteristics, Pattern 10 is similar to the patterns in Categories E and F.

It is therefore difficult to categorize this pattern because of the unusual relationship of plosion, friction, and affrication in combination with persistent glottal and pharyngeal placements for some targets.

This pattern could have been dealt with quite differently: it could have been argued that it was justifiable for it to stand as a single category in its own right.

However, there were reasons for including Pattern 10 in Category D. Firstly, clinical experience suggested that it was closest in clinical terms to Patterns 9 and 11. Primarily, however, had Pattern 10 formed its own category, it would not have fitted into the hierarchical arrangement, which was one of the aims of creating the speech categories. Furthermore, there were few occurrences of Pattern 10. Therefore the category is defined according to D1 criteria. Statistically D1 and D2 will be grouped together: qualitative descriptions however will include separate discussions of each.



### ***Category E (Patterns 12 and 13)***

Quantitatively the range of score possibilities on the speech rating scale was from 10–11.

The characteristics of this category were that each pattern demonstrated either the manner characteristics of Category F (plosion, friction and affrication) in combination with the place characteristics of Category D (mainly oral placements with minimal glottal/pharyngeal placements). Alternatively, patterns demonstrated the place characteristics of Category F (oral placements only) in combination with the manner characteristics of Category D (plosion and friction, with or without nasalization and nasal air escape, but no affrication).

### ***Category F (Patterns 14, 15, 16 and 17)***

Quantitatively the range of score possibilities was from 11–14.

This category was characterized by only oral placements, but with varying degrees of establishment of targets. Plosion, friction and affrication, with or without nasalization, were all in evidence, but may or may not have been established throughout the possible targets.

These categories can be viewed hierarchically in terms of their phonetic characteristics from Category A, the worst, to Category F the highest. Categories A, B and C in particular represent those speakers with the glottal/pharyngeal compensatory articulations described in the literature (Morley, 1970; Bzoch, 1979; Trost, 1981; Kawano et al., 1985; Trost-Cardamone, 1986; Brown et al., 1990).

Finally, it is recognized that the term 'speech categories' actually describe articulation patterns. Nevertheless, the term 'speech categories' is used throughout this work.

### Speech Patterns according to Place and Manner Scores

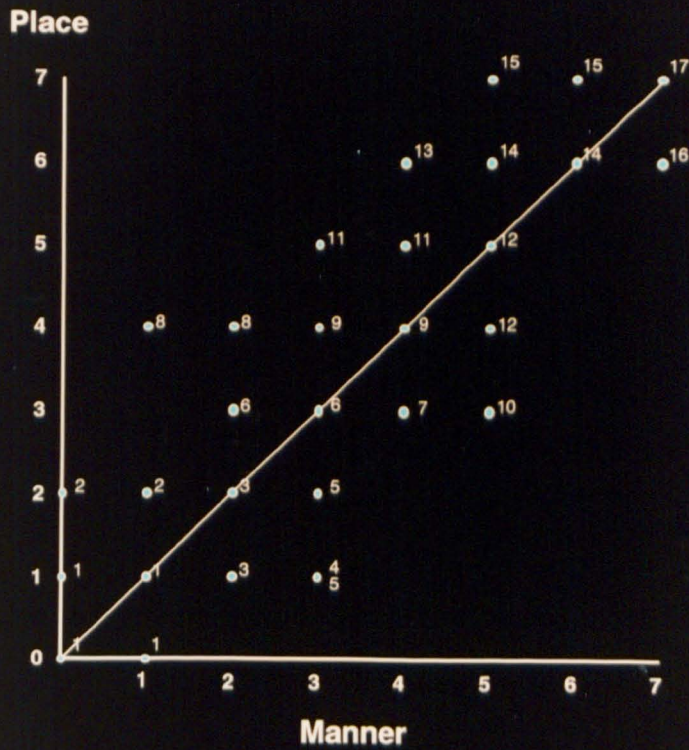


Figure 1

### Speech Categories according to Phonetic Criteria

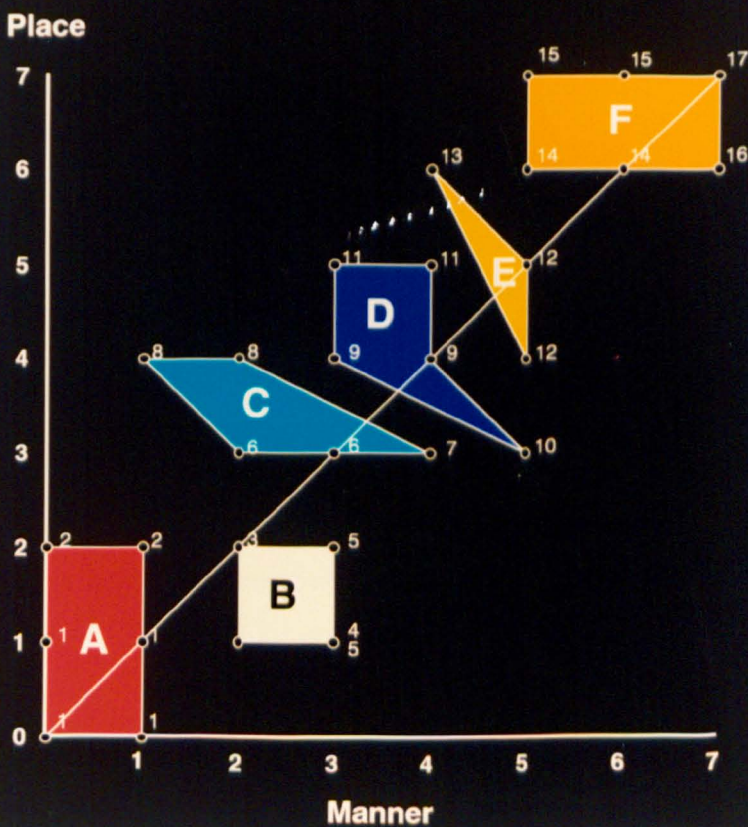


Figure 2

# Chapter 6

## Results

The initial approach to the articulation results was to use the raw scores of the quantitative analysis. However this analysis proved to be inadequate when interpreting the results qualitatively (see Appendix VI). Subsequently, a method using speech patterns and speech categories was developed, as described in Chapter 5. The majority of the results will be presented using the latter approach. There are some results, however, which are presented using the first method. These are the results regarding surgical and therapy intervention, years of education and some results related to cleft type.

### ***I. Overall articulation results***

The overall results of the speech categories for the three older combined age groups (adults, adolescents and children aged 8–10 years at surgery) are presented pre-operatively, post-operatively, and post-therapy. Table 30 gives information on the distribution of the speech categories at each of the data points. This information is displayed in Figure 3.

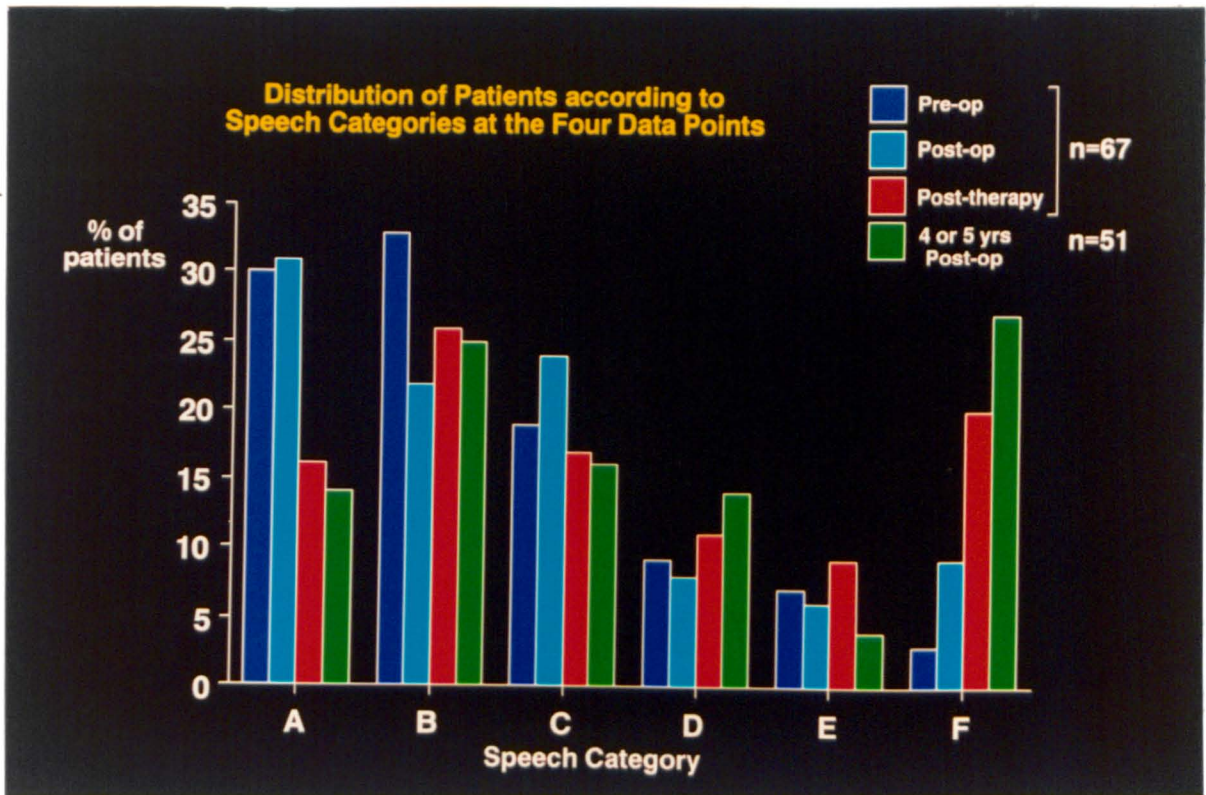
*Table 30. Distribution of Speech Categories Pre-operatively, Post-operatively, Post-therapy, and 4/5 years Post-operatively.*

	<b>Pre-operative stage</b>	<b>Post-operative stage</b>	<b>Post-therapy stage</b>	<b>4/5 years Post-operative follow-up stage</b>
Category A	30% (20)	29% (19)	12% (8)	16% (8)
Category B	32% (22)	22% (15)	25% (17)	24% (12)
Category C	19% (13)	25% (16)	21% (14)	16% (8)
Category D	9% (6)	10% (7)	12% (7)	14% (7)
Category E	7% (5)	4% (3)	9% (6)	4% (2)
Category F	3% (2)	10% (7)	24% (16)	26% (13)
	<b>N-67</b>	<b>N-67</b>	<b>N-67</b>	<b>N-51</b>

It should be recalled that these speech categories are arranged hierarchically, with Speech Category A as the worst speech category and Speech Category F as the best. Table 30 shows clearly how 81% of the patients were classified into speech categories A, B, and C pre-operatively with only 10% in the highest two speech categories E and F. This distribution is similar post-operatively, although there is the suggestion of spontaneous movement into Speech Category F at this data point. Post-therapy, categories A, B, and C still contain 58% of patients, but 33% now fall into the top two speech categories, compared with 10% at the pre-

operative stage and 14% at the post-operative stage. Similar results are found at the 4/5 years post-operative follow-up, when 56% of patients are found in the lowest three speech categories, and 30% in the top two speech categories.

**Figure 3**



A short digression is necessary to explain the apparent deterioration in the speech patterns and speech categories of some speakers, which became apparent in the unexpected downward trends over time in the speech pattern classification of sixteen out of the eighty-seven cases. Table 31 shows the different speech pattern and speech category classifications at the different data points. The numbers in brackets refer to the raw scores of place and manner respectively.

*Table 31. Pattern of Downward Trends over Time in Speech Patterns and Speech Categories.*

Case	Pre-operative Speech		Post-operative Speech		Post-therapy Speech	
	Pattern	Category	Pattern	Category	Pattern	Category
1			10	D	7	C
2			7 (3, 3)	C	3 (2, 2)	B
4	2 (2, 1)	A	1 (1, 1)	A		
5			2 (2, 1)	A	1 (1, 1)	A
6	3 (2, 2)	A	1 (1, 1)	A		
7	7 (3, 3)	C	6 (3, 2)	C		
8			6 (3, 2)	C	5 (2, 3)	B
9	3 (1, 2)	B	1 (1, 1)	A		
10	15 (7, 6)	F	14 (6, 5)	F		
11			2 (2, 1)	A	1 (1, 1)	A
12	3 (2, 2)	B	2 (2, 1)	A		
13	3 (1, 2)	B	1 (1, 1)	A		
14	3 (1, 2)	B	1 (0, 0)	A		
15	11 (5, 3)	D	7 (3, 3)	C		
16	7 (3, 3)	C	3 (2, 2)	B		

The data in these cases were re-examined in order to determine if it was possible to explain this downward trend.

Some of the discrepancy in the results may be due to the technical characteristics of recording. In cases 12 and 13, the soundtrack at one of the data points was noted to be of particularly poor quality. In cases 13 and 15, the post-operative results had to be judged from the audio tape recording due to technical errors in the video recordings at one of the post-operative data points.

Case 1 had no pre-operative records on account of her age. She was noted at the post-operative stage to be very variable in her speech, with possible developmental characteristics.

Case 16 attended two of the therapy groups. The therapists observed that he was an inconsistent and variable speaker. The reason for this remained unknown, but it is possible that there were reasons other than just his cleft palate history that may have contributed to his speech disorder. This variability could be responsible for the differences found in the speech patterns.

In cases 4, 5, 7, 9, 11 there was only one point difference between the combined place and manner scores resulting in the different patterns. For example, cases 4, 5, and 11 all gained a rating of 2 for place followed by a rating of 1 at their subsequent recording and therefore were allocated into different patterns.

In cases 8, 10, and 2, there was one point difference in both place and manner at the two data points on which the patterns were judged.

In case 14, there were real differences in speech performance resulting in the speech patterns shown. Very limited attempts at oral lingual placement were detected pre-operatively, but no attempt post-operatively. Some minimal modification of the airstream was detected at the pre-operative stage, but was not found post-operatively.

In terms of speech categories, seven of the sixteen patients remained in the same speech category. Nine patients dropped down one category.

This discussion helps clarify the reasons for some speakers apparently moving into a worse speech pattern over time. As a general conclusion, it is quite probable that for the majority of cases, speech was not actually worse, but this trend is a reflection of a coarse measuring system.

## ***II. Patterns of Change in relation to Pre-operative Speech***

The next stage in the analysis was to examine the patterns of changes of each category from the pre-operative stage, across the categories post-operatively and post-therapy for the combined adult and adolescent groups and in a few instances for the children's group aged 8–10 years at surgery. This examination was undertaken to determine whether there was a relationship between the pre-operative speech category and the amount of change. This information is displayed in Figure 4.

**SPEECH CATEGORY A** contained twenty patients at the pre-operative stage. Fifteen patients remained in this speech category post-operatively. Five patients changed speech categories spontaneously. Three speakers moved into Speech Category B, and two speakers moved to post-operative Speech Categories C and D respectively.

Post-therapy, eight out of the fifteen patients who remained in Speech Category A post-operatively stayed in this speech category, four moved into Speech Category B, two moved into Speech Category C, and one moved into Speech Category F.

Of those five patients who had moved speech categories spontaneously, only one moved up one category into Speech Category C with therapy. The others remained in their post-operative speech categories.

Therefore 75% patients who began with this pre-operative speech category stayed in this category with surgery alone. Of the total group all except one speaker remained in the lowest three speech categories.

Following therapy, fourteen (70%) of the patients remained in Speech Categories A and B and four (20%) of the patients moved into Speech Category C. Therefore, following therapy, 90% of the patients stayed within the lowest three speech categories. The patient who moved into Speech Category F was one of the children's group, who had post-operative velopharyngeal closure, and gained normal speech.

**SPEECH CATEGORY B** contained twenty-two patients at the pre-operative stage. Post-operatively, eleven (50%) patients remained in this category, and five (23%) patients dropped to Speech Category A, for the reasons outlined above. Therefore, 73% of patients with pre-operative Speech Category B remained within either it or in Speech Category A post-operatively. Five patients (23%) spontaneously moved up to Speech Category C, and one patient moved into Speech Category D.

Following therapy, of the eleven patients who post-operatively were found in Speech Category B, six remained there after therapy. Three moved up to Speech Category C and two moved into Speech Category E.

Of the five patients who dropped to Speech Category A post-operatively, four moved into Speech Category B after therapy, and one patient moved into Speech Category C.

Of the five patients who spontaneously moved up to speech Category C post-operatively, one dropped to Speech Category B post-therapy, three stayed in the same category post-therapy, and one patient moved into Speech Category E post-therapy. One patient spontaneously moved into speech category D post-operatively

and remained there post-therapy.

A summary of these data would therefore suggest that 95% of patients who began in pre-operative Speech Category B stayed within the lowest three bands with surgery alone and 81% (18) stayed within the lowest three categories following therapy. Of the four cases who began in Speech Category B and who changed more than one category post-operatively or post-therapy, none were adult.

**SPEECH CATEGORY C** contained thirteen patients at the pre-operative stage. Post-operatively, ten patients (77%) remained within this category; one patient (7%) dropped to Speech Category B post-operatively. One patient (7%) spontaneously moved up to Speech Category D, and one (7%) to Speech Category F.

Post-therapy, of the ten patients who remained in Speech Category C post-operatively, two patients stayed within the same pre-operative speech category. Five patients moved into Speech Category D, one patient moved to speech category E and two patients moved into Speech Category F. Of those two patients who had spontaneously improved, one moved up a further category with therapy to Speech Category E, and the patient who had moved from pre-operative Speech Category C to Speech Category F post-operatively, remained in that category after therapy.

These data would therefore suggest that there is very little spontaneous change in this speech category, in that eleven (84%) stayed within the category or dropped down a category post-operatively. However, after therapy, five out of thirteen (38%) speakers did improve by at least two categories.

**SPEECH CATEGORY D** contained 6 patients at the pre-operative stage. Five patients were in D1, and one patient was in D2. Post-operatively, one patient dropped to Speech Category C, due to the recording difficulties outlined above. One patient moved into Speech Category E and one patient moved into Speech Category F, where he remained after therapy. The remaining three patients stayed in Speech Category D post-operatively.

Following therapy, these three patients moved into Speech Category F. The patient who had dropped to Speech Category C moved into Speech Category D post-therapy.

In summary, 50% patients who were in Speech Category D pre-operatively stayed in this category post-operatively. Post-therapy, four of the six patients moved up to the highest Speech Category F. These data suggest that patients with pre-operative Speech Category D do well with therapy.

**SPEECH CATEGORY E** contained five patients at the pre-operative stage. Three remained in this speech category post-operatively, and two moved into Speech Category F. All five patients were in Speech Category F after therapy.

**SPEECH CATEGORY F** contained only two patients pre-operatively. They remained in this speech category post-operatively and following therapy.

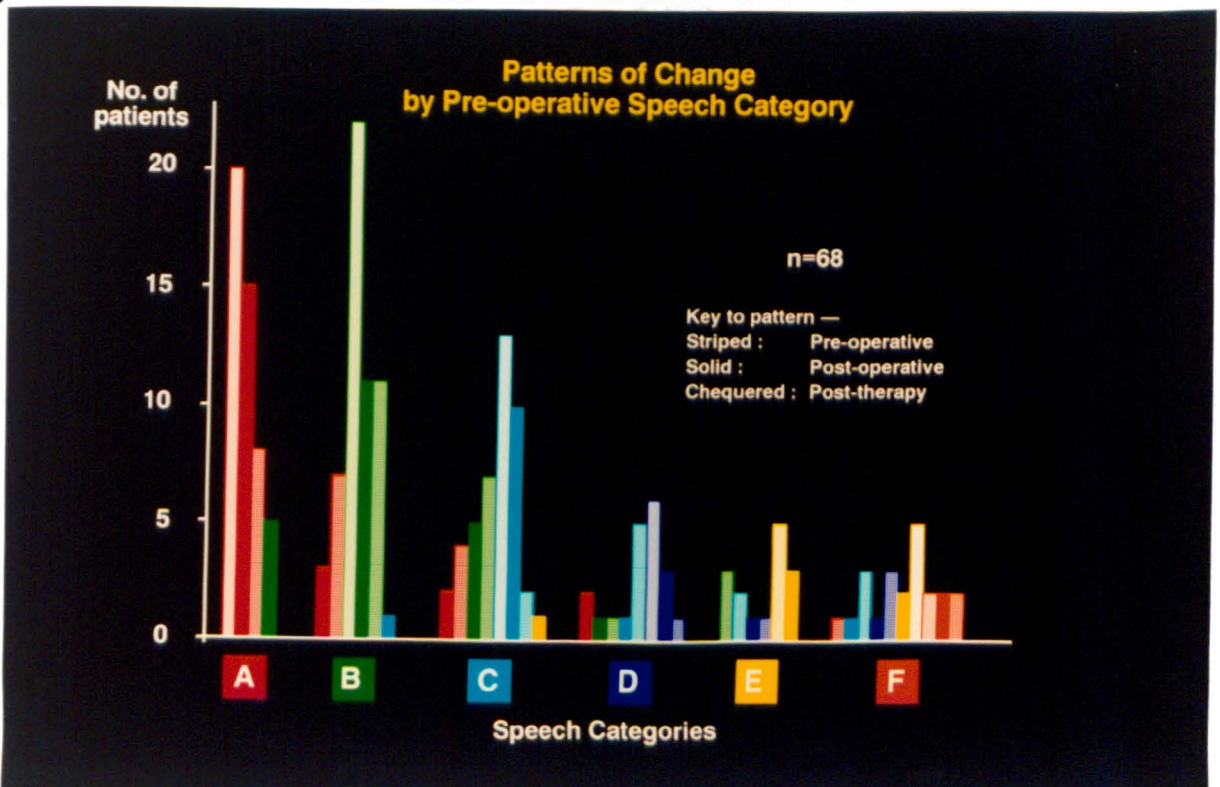


## Summary of Surgical and Speech Therapy Intervention

These data suggest that with surgery alone, the post-operative outcome for pre-operative Speech Categories A and B is rather similar. 75% patients who began in pre-operative Speech Category A stayed in this category with surgery alone, compared with 72% who began in pre-operative Speech Category B, and who remained in the lowest two categories post-operatively. 95% of both groups remained within the lowest three Speech Categories (A, B and C) with surgery alone. There would appear to be some overlap with the behaviour of Speech Category C, since there is again very little spontaneous change in this speech category: 84% stayed within or dropped down a category post-operatively. In contrast to pre-operative Speech Categories A, B and C, a trend for spontaneous improvement in pre-operative Speech Categories D and E speakers was observed. However, this is based on a small sample, as the number of patients represented in the three higher speech categories at the pre-operative stage was small (N=13:19%).

Following therapy, 90% of pre-operative Speech Category A patients stayed within the lowest three speech categories compared with 81% of Speech Category B patients. In other words, only 10% of pre-operative Speech Category A moved up into Speech Categories D, E and F post-therapy. Similarly, only 18% of pre-operative Speech Category B patients were found within the highest three categories post-therapy. In contrast, 76% of pre-operative Speech Category C moved up into Speech Categories D, E or F following therapy and 38% moved up more than one speech category to E and F. Therefore, it appears that pre-operative Speech Category C behaves post-operatively in a similar way to Speech Categories A and B, but the potential for change with therapy is higher. With regard to pre-operative Speech Categories E and F, these data suggest that they behave similarly post-operatively and post-therapy, and that when therapy is provided, pre-operative Speech Category D behaves in a similar way.

**Figure 4**



NB. striped: reproduces as pale colour/columns.

### **III. Surgical and Speech Therapy Intervention**

#### ***Aim***

The aim of this section is to determine the effect of surgery, and surgery supported by therapy, on the speech of the whole cohort.

#### ***Hypotheses***

1. Palatal closure alone may result in positive spontaneous change in nasal resonance and nasal escape, but will not change articulatory skills.
2. Palatal closure supported by speech therapy may result in positive spontaneous change in articulatory skills, but will not change nasal resonance and nasal escape.

#### ***Results***

The effect of surgery on nasality and articulation was examined.

Based on the whole sample, including children below 8 years where data were available, the nasality ratings at the pre-operative stage were compared with those ratings for the 1985 cohort at either 8 or 20 months post-operatively, and for the 1986 surgical cohort at 20 months post-operatively before any speech therapy intervention. Using the Wilcoxon Signed Ranks Test, there was a highly significant difference between the two data points ( $p < 0.001^*$ ). Indeed, when each age group is separately examined, all reached significance: adults  $p = 0.014^*$ , adolescents  $p = 0.007^*$ , children aged 8–10 years at surgery  $p = 0.026^*$ .

The effect of surgery on articulation was examined.

Using the whole sample, the combined place, manner and voice ratings for each patient at the pre-operative stage were compared with those ratings for the 1985 cohort at either 8 or 20 months post-operatively, and for the 1986 surgical cohort at 20 months post-operatively before any speech therapy intervention. Using the Wilcoxon Signed Ranks Test, there was a significant difference between these two data points ( $p = 0.025^*$ ). However, when the children aged 8–10 years were excluded, no significant difference was found for the combined adult and adolescent groups ( $p = 0.398$ ), suggesting that adults and adolescents do not improve their articulation with surgery alone.

The effect of therapy on nasality and articulation was examined.

The nasality ratings at the post-operative stage were compared with those gained after therapy and no significant difference was found (Wilcoxon Signed Ranks Test,  $p = 0.743$ ).

The effect of surgery supported by therapy on articulation was examined. The combined place, manner and

voice ratings at the post-operative data points were compared with those gained after therapy. Using the Wilcoxon Signed Ranks Test, there was a significant difference between these two data points ( $p < 0.001^*$ ) for the whole group, and indeed this difference was still significant when the combined adult and adolescent groups were tested ( $p = 0.002^*$ ).

Therefore, based on the whole sample, there is statistically significant evidence that surgery alone leads to a significant improvement in nasality, but not in articulation. Therapy does not change nasality, but does lead to a statistically significant difference in articulation.

These results provide an overall picture for the whole group; it is well recognized, however, that cleft lip and palate subjects are heterogenous and their progress is affected by many variables. Therefore it is important to examine the effect of specific variables. McWilliams et al. (1990) described the primary ones as age, cleft type, type of surgery and any intervention used.

## **IV. Age**

### **Aim**

The aim of this section is to determine whether age is related to speech results, and if so, in what way.

### **Hypothesis**

Adult patients present with disordered articulatory patterns that are more resistant to change than that of adolescents or children, either spontaneously or with therapy.

### **Results**

Tables 32, 33, 34 and 35 show the distribution of speech categories at the four data points for each of the age groups. Speech Categories A and B have been combined together in view of their close phonetic association and the similar way in which they behave post-operatively and post-therapy, as described above.

*Table 32. Distribution of Pre-operative Speech Categories according to Age.*

	<b>Cat.A. + Cat.B.</b>	<b>Cat.C.</b>	<b>Cat.D.</b>	<b>Cat.E.</b>	<b>Cat.F.</b>
Children aged 8–10 (N=10)	(9) 90%	0%	0%	(1) 10%	0%
Adolescents (N=31)	(17) 54%	(6) 19%	(3) 9%	(4) 12%	(1) 3%
Adults (N=24)	(13) 52%	(7) 28%	(3) 12%	0%	(1) 4%

*Table 33. Distribution of Post-operative Speech Categories according to Age.*

	<b>Cat.A. + Cat.B.</b>	<b>Cat.C.</b>	<b>Cat.D.</b>	<b>Cat.E.</b>	<b>Cat.F.</b>
Children aged 8–10 (N=12)	(8) 66%	(2) 16%	(1) 8%	0%	(1) 8%
Adolescents (N=31)	(14) 45%	(7) 22%	(4) 13%	(3) 10%	(3) 10%
Adults (N=24)	(12) 48%	(9) 32%	(1) 8%	0%	(2) 12%

*Table 34. Distribution of Post-therapy Speech Categories according to Age.*

	<b>Cat.A. + Cat.B.</b>	<b>Cat.C.</b>	<b>Cat.D.</b>	<b>Cat.E.</b>	<b>Cat.F.</b>
Children aged 8–10 (N=12)	(4) 33%	(5) 42%	(1) 9%	0%	(2) 16%
Adolescents (N=31)	(11) 35%	(3) 10%	(3) 10%	(3) 10%	(11)35%
Adults (N=24)	(10) 40%	(5) 20%	(4) 16%	(3) 12%	(2)12%

*Table 35. Distribution of Speech Categories at 4/5 years Post-operatively according to Age.*

	<b>Cat.A. + Cat.B.</b>	<b>Cat.C.</b>	<b>Cat.D.</b>	<b>Cat.E.</b>	<b>Cat.F.</b>
Children aged 8–10 (N=9)	(3) 33%	(1) 11%	(2) 22%	0	(3) 33%
Adolescents (N=23)	(5) 22%	(5) 22%	(2) 9%	(1) 4%	(10) 43%
Adults (N=19)	(12) 63%	(2) 11%	(3) 16%	(1) 5%	(1) 5%

Given the phonetic criteria of Speech Categories A, B, and C the results were:

***Pre-operatively***

90% of the adults were found in the Speech Categories A, B, and C, with 16% in Categories D, E and F.

74% of the adolescents were found in the Speech Categories A, B, C, with 24% in Categories D, E and F.

90% of the children were found in Speech Categories A and B, with 10% in Speech Category E.

***Post-operatively***

80% of the adults were found in the Speech Categories A, B, and C, with 20% in Categories D, E and F.

67% of the adolescents were found in the Speech Categories A, B, C, with 33% in Categories D, E and F.

82% of the children were found in Speech Categories A, B and C, with 16% in Categories D, E, and F.

***Post-therapy***

60% of the adults remained in Speech Categories A, B and C, whereas 40% were classified into Categories D, E and F.

45% of the adolescents remained in Speech Categories A, B and C, compared with 55% appearing in Categories D, E and F.

75% of the children were found in Speech Categories A, B and C, with 25% in Categories D, E and F.

***At 4/5 Years Follow-up:***

76% of the main cohort were represented at this stage.

74% of the adults were found in the Speech Categories A, B, and C, with only 10% in Categories E and F.

44% of the adolescents were found in the Speech Categories A, B, C, with 58% in Categories D, E and F.

44% of the children were found in Speech Categories A, B and C, with 55% in Categories D, E and F.

Inferential statistics were used to determine if there were significant differences in the nature of speech between the age groups, based on a comparison of the speech categories at the four data points. The results are shown in Figure 5.

Using the Kruskal-Wallis one-way analysis of variance, Table 36 shows where the significant differences lie (\*).

*Table 36. Results of Speech Categories between Age Groups in the Main Cohort.*

	<b>Pre-operative</b>	<b>Post-operative</b>	<b>Post-therapy</b>	<b>4/5 years follow-up</b>
	N=65	N=68	N=68	N=51
Children 8–10 yrs.	} H=6.324 p = 0.042*	} H=8.79 p = 0.321	} H=2.572 p = 0.276	} H=7.628 p = 0.022*
Adolescents				
Adults				

In the main cohort, an examination of the pre-operative data revealed major differences occurring between the adolescents and the children aged 8–10 years at surgery. Figures 5 and 9 show that only one case in the children aged 8–10 years at surgery was represented above Speech Category C, in contrast to the adolescents, where eight cases were represented above Speech Category C. There appears to be a pre-operative trend towards the children falling into the lowest two speech categories, in contrast to only approximately 50% of each of the adult and adolescent groups. In contrast, at the post-operative and post-therapy stages, no significant difference was found between the age groups. This possibly suggests that there was some spontaneous change in the children's group aged 8–10 years, so that the three age groups became more similarly distributed across the speech categories following surgery and therapy. At the 4/5 years post-operative follow-up, however, there is a significant difference between the age groups. This is accounted for by the adult group: 74% are now found in the worst three Speech Categories, A, B, and C with only 10% in the top two categories (Figure 7).

The next approach to analysis was to determine if there were significant differences within each age group at the different data points, according to the speech categories, and to examine the qualitative nature of the changes that were found (Figures 6, 7, 8, and 9).

Table 37 shows where the significant differences lie (p values\*). Using the Wilcoxon Signed Ranks Test, at the post-operative stage, a significant difference is found for only the children aged 8–10 years at surgery. All three age groups change significantly at the post-therapy stage. At the 4/5 years post-operative follow-up, the only group which had significantly changed from the post-therapy stage was the adult group.

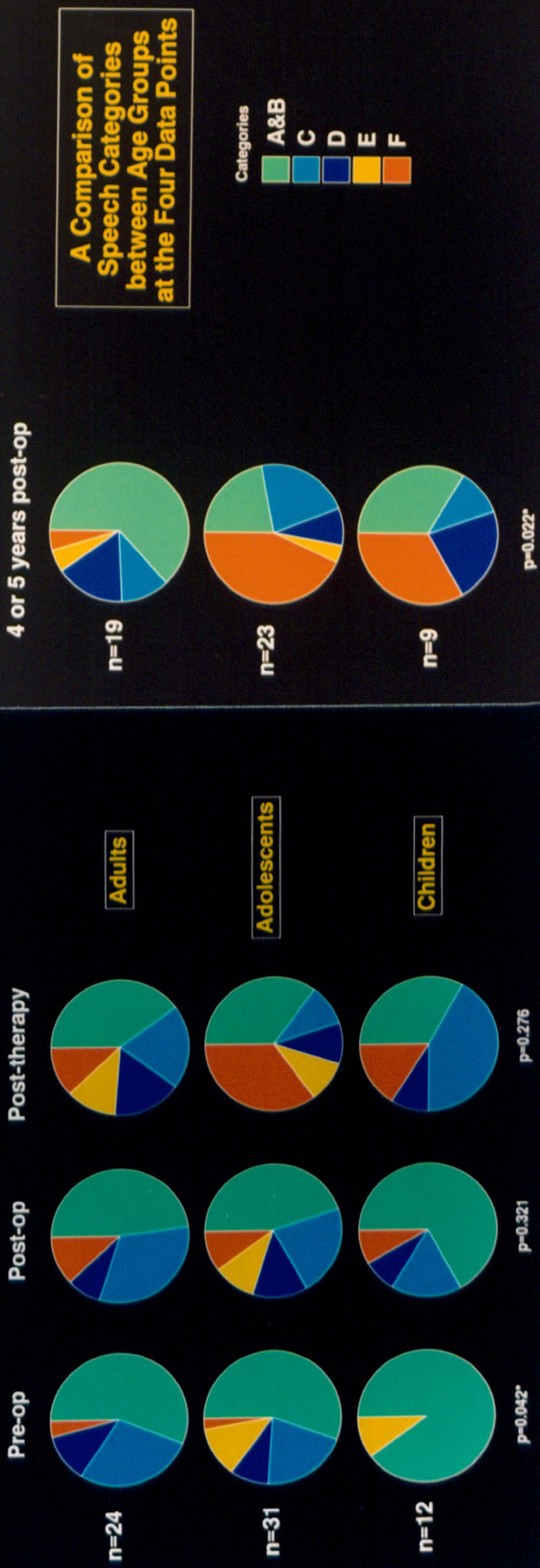


Figure 5

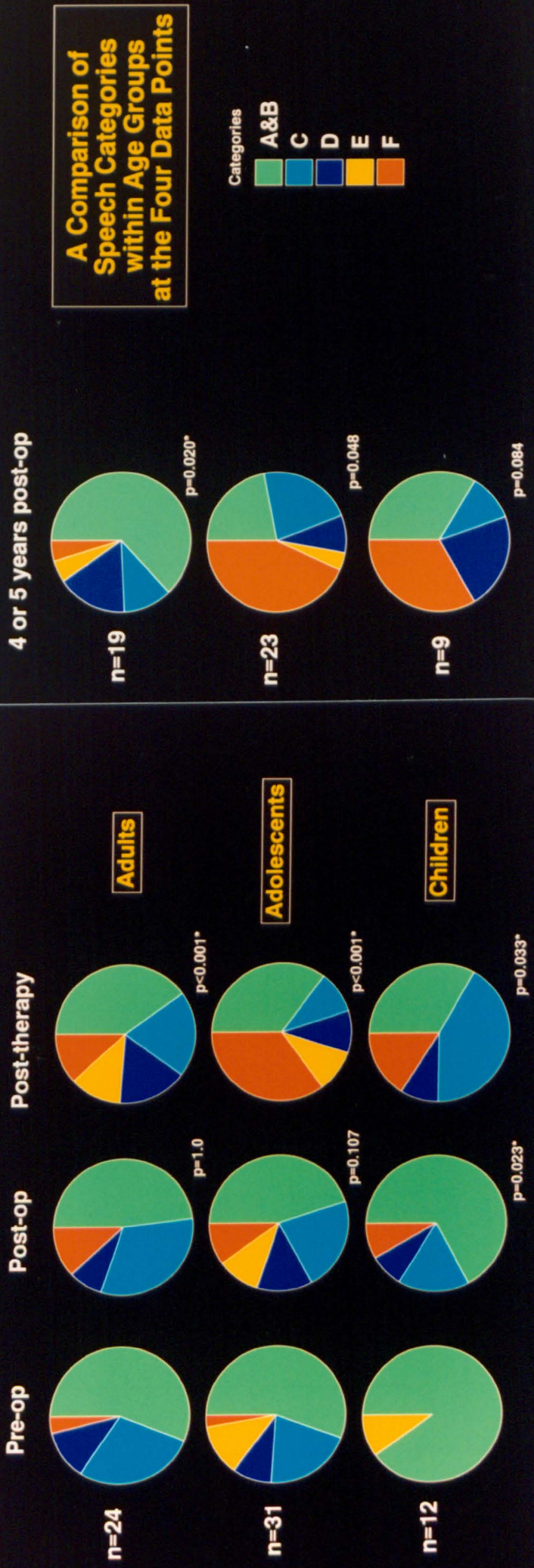


Figure 6



Figure 7

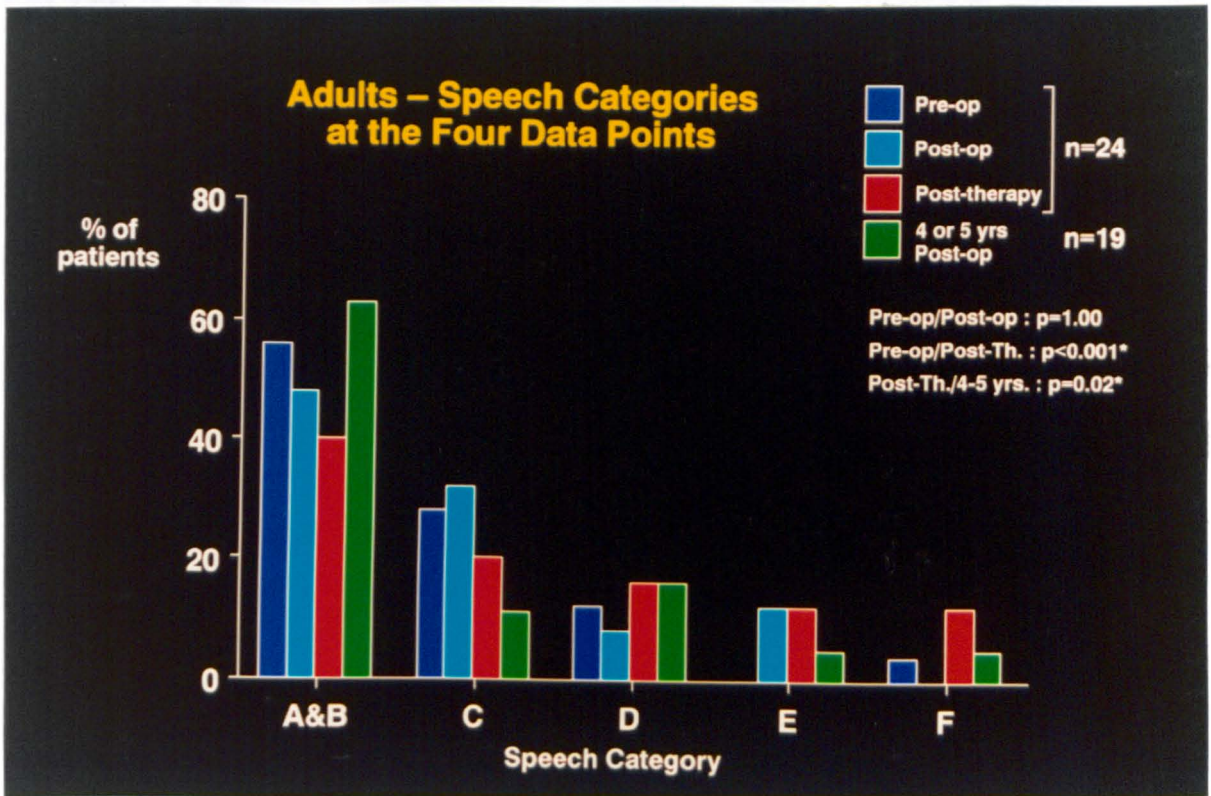
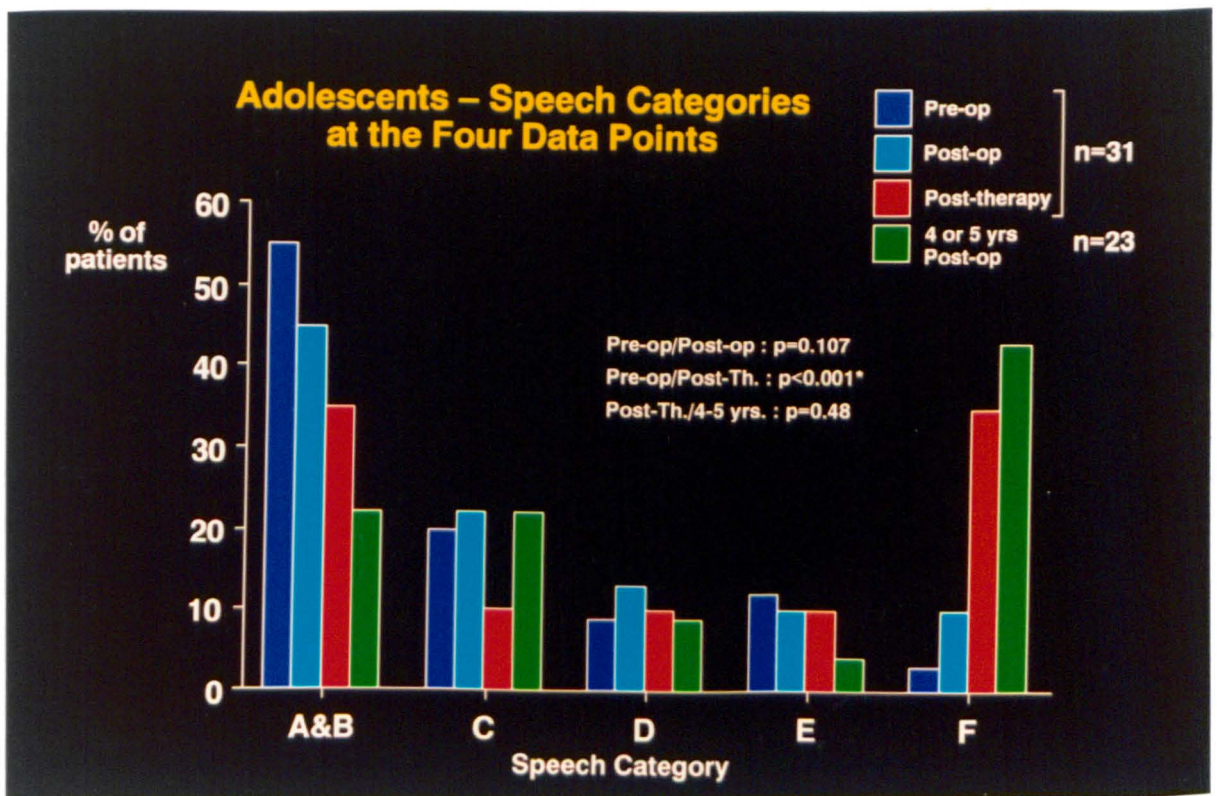
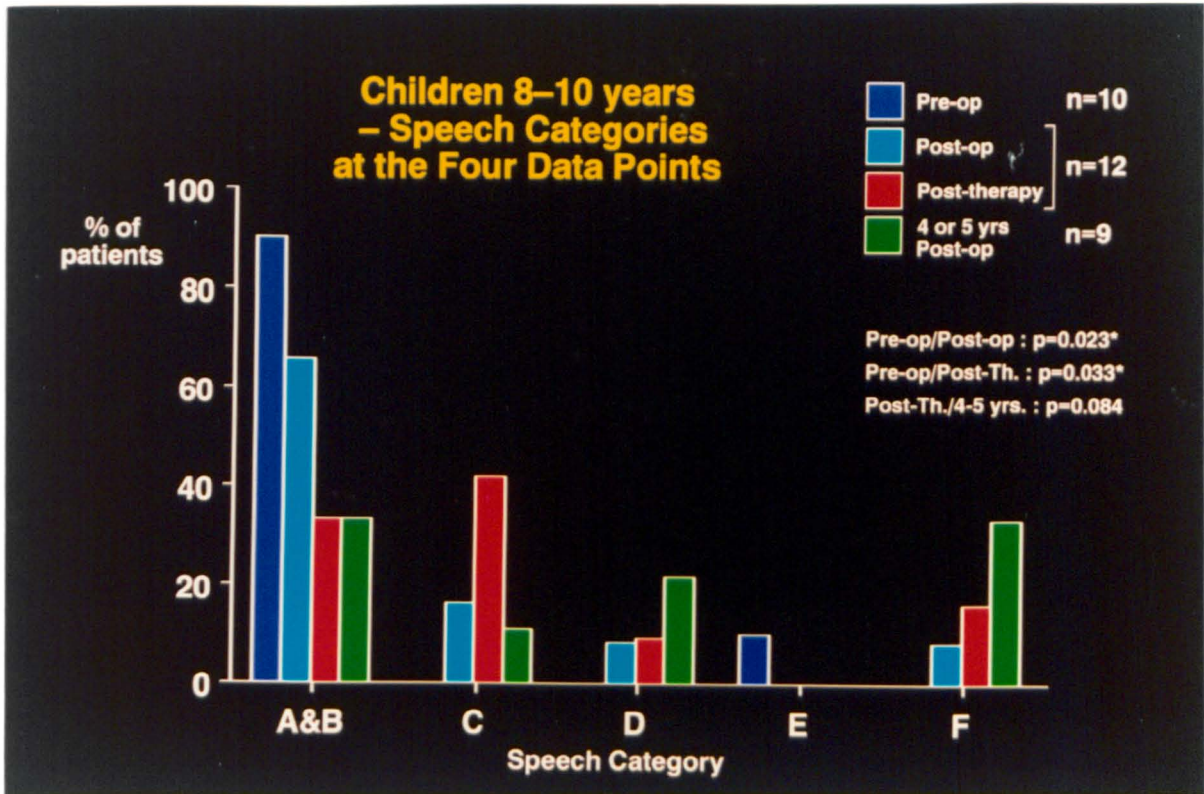


Figure 8



**Figure 9**



*Table 37. Results of Speech Categories within Age Group at the Different Data Points.*

	Pre-op./Post-op.	Post-op./Post-th.	Post-th./4/5 years follow-up
Children 8-10 yrs.	0.023*	0.033* (1 tailed test)	0.084
Adolescents	0.107	0.001*	0.048
Adults	1.0	0.001*	0.020*

These data suggest that spontaneous change only occurred in the group of children aged 8-10 years at surgery. This finding confirms that it is the effect of the children's group which accounts for the overall significant difference which was found between pre-operative and post-operative speech for the main cohort (see section 1 - Overall articulation results).

There appears to be a greater shift out of the Speech Categories A and B both spontaneously and post-therapy for the children's group aged 8-10 years at surgery than for either the adult or adolescent groups.

As previously argued however, inferential statistics do not provide information about the nature of the qualitative change. Although all age groups make significant changes at the post-therapy stage, what is the nature of that change, and are there differences according to age?

McWilliams et al. (1990) have argued the need for researchers to interpret results which are statistically significant from a clinical point of view. A statistically significant difference is not always a clinically significant difference. In the author's view, in order for a finding of statistical significance to be perceptibly different, there must be a change of more than one speech category.

For example, Figure 10 shows the effect of age on the amount of improvement from the pre-operative to the post-operative stage. The majority of adults and adolescents do not move categories, with a few patients moving one category.

Figure 11 shows the effect of age on the amount of improvement from the pre-operative to the immediate post-therapy stage. Only two adults (9%) actually move more than one category. Further examination of the speech patterns themselves reveals some interesting findings. Nine adults (39%) move one category only. In seven of these cases, a study of the speech patterns reveals that there is only one change in either the place or manner characteristics. Eleven patients (50%) stay within the same speech category: indeed, ten of these have exactly the same pre-operative and post-therapy speech patterns. For one case (2%) this is appropriate given the ceiling effect.

In contrast, seven adolescents move across three categories, and four move across two categories, a total of 35% of the group. In terms of speech patterns, out of the nine cases (29%) which move one category only, five changed only one of the place or manner characteristics, and in two cases this was a result of the ceiling effect. Twelve cases (38%) remained in the same speech category pre-operatively and post-therapy. In one case again, this was appropriate given the ceiling effect.

Figure 12 shows the effect of age on the amount of improvement from the pre-operative to 4/5 years post-operative follow-up stage.

Since the post-therapy results were based on recordings immediately post treatment, it was judged appropriate to examine the speech results of patients subsequent to that recording, given that it is recognized that patients may not maintain the benefits of treatment once active intervention has ceased. For the majority of patients this follow-up recording at 4/5 years post-operatively (depending on the year of surgery) occurred two years after the therapeutic intervention. In a few cases therapy had been provided four years previously.

The only group which significantly changed from the previous recording immediately post-therapy was the adult group. Figure 12 reveals how the majority of the adult group made no or minimal changes. Therefore it would appear that a lack of continuing intervention results in a deterioration in this age group. Figure 7 shows that 74% of the adults were found in the Speech Categories A, B, and C, with only 26% in Speech Categories D, E and F. These results are almost identical to those found at the post-operative stage, and represent only a slight marginal improvement on the pre-operative speech results. Indeed, when the pre-operative speech categories of the adult group are compared with those at the 4/5 year post-operative follow-up, no significant difference between the speech categories at these two stages is found (Wilcoxon Signed Ranks Test,  $p = 0.527$ ).

Figure 10

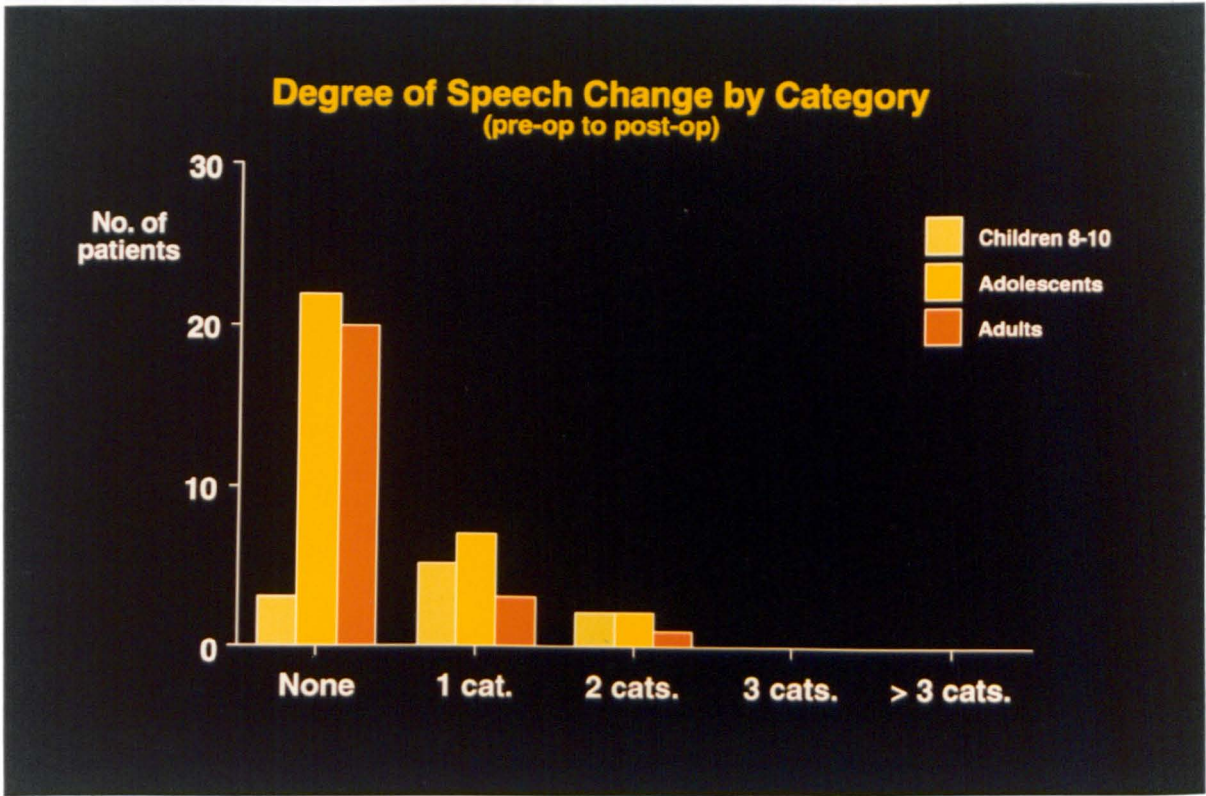
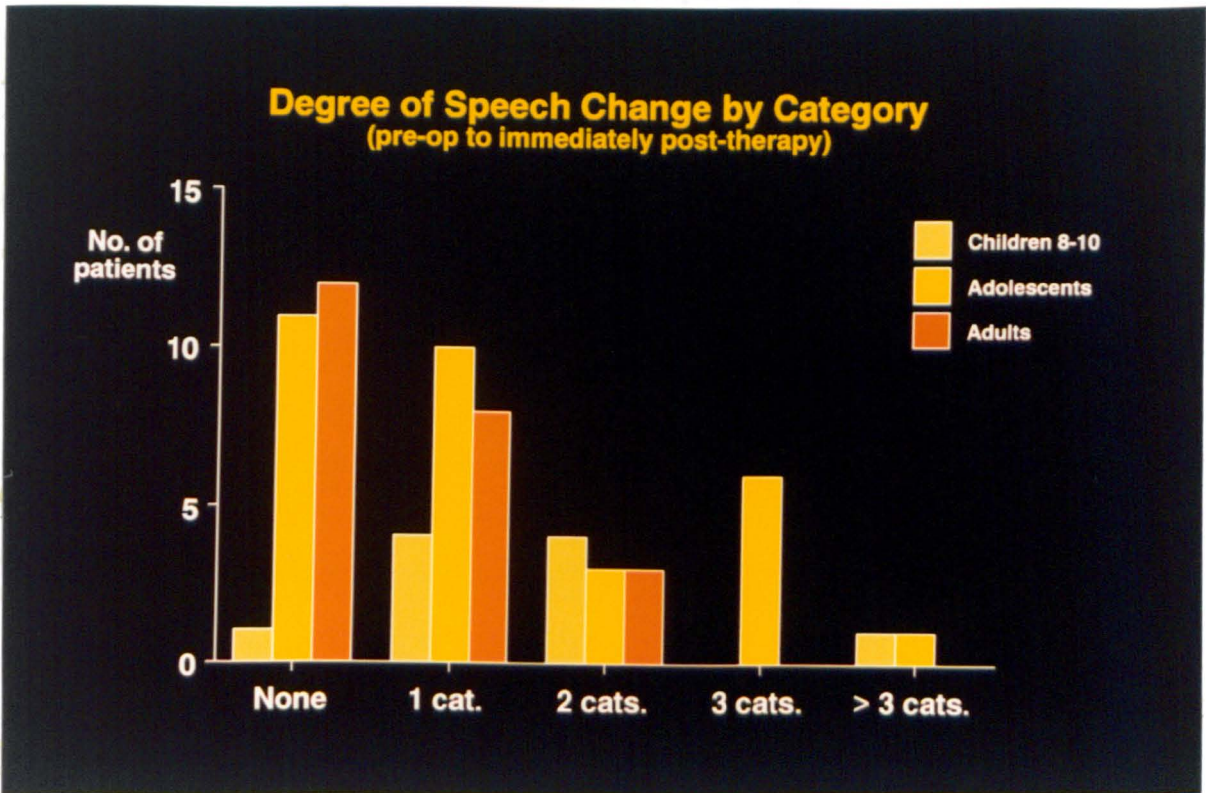
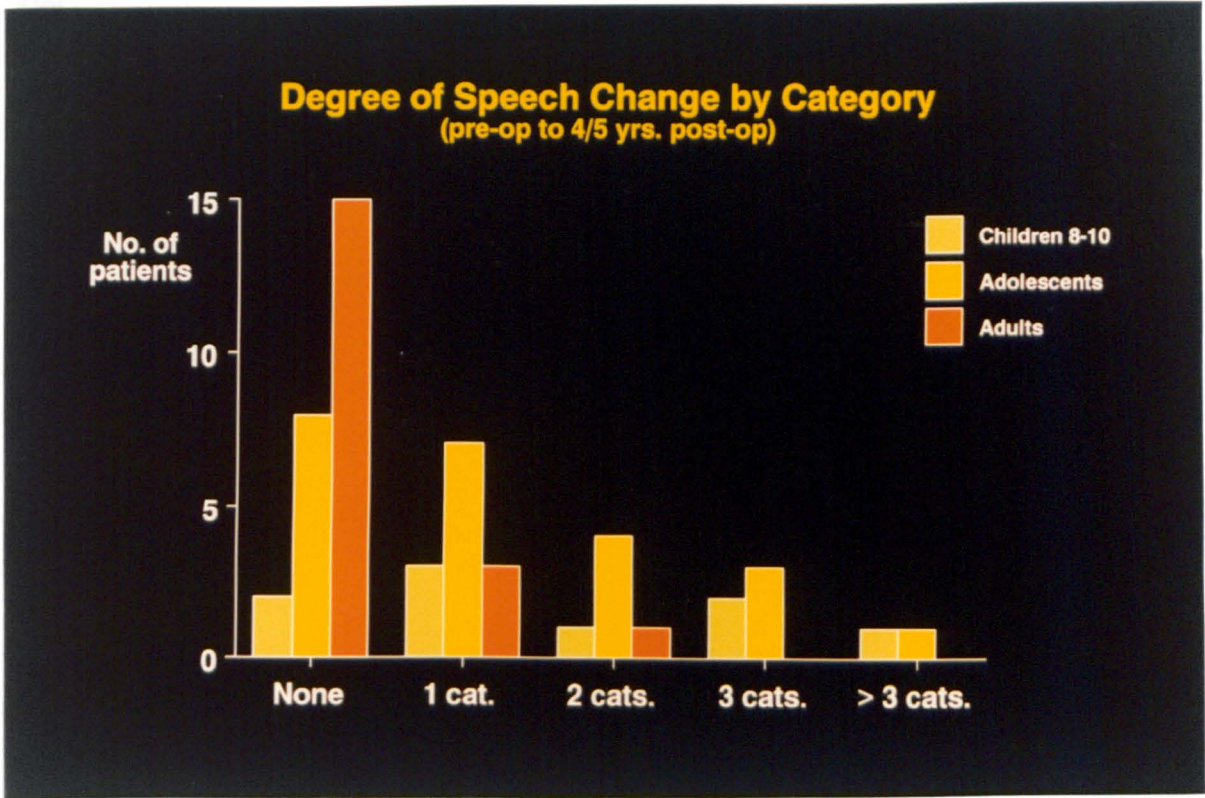


Figure 11



**Figure 12**



The implication is that a marked proportion of the adults do not maintain the small gains they make in therapy once active intervention has ceased. This is probably explained by the minimal nature of those gains as described above. In contrast, the ten adolescents maintained the improvements found at the post-therapy stage.

There is no statistically significant difference in the adolescents' speech at subsequent 4/5 year post-operative follow-up compared with post-therapy, suggesting that there was no marked change in speech performance, either positively or negatively, between these two data points. Figure 8 shows that there were some small shifts at either end of the spectrum of the speech categories. There was a slight increase in the number of patients in Speech Category F and Speech Category C representing some continuing positive change.

With regard to the children aged 8–10 years at surgery, there was some continuing positive change, a finding approaching statistical significance. Figure 9 shows that 16% of this group were found in Speech Category F immediately following therapy, but this rose to 33% at the subsequent 4/5 years post-operative follow-up stage. However, the sample size is small at this stage (N=9).

## V. Cleft Type

### **Aim**

The aim of this section is to determine the effect of cleft type on speech performance at the different stages.

### **Hypotheses**

- (1). Patients with lesser clefts have better articulation and less severe nasality pre-operatively than patients with major clefts (BCLP, UCLP, H&S).
- (2). Patients with lesser clefts demonstrate a higher incidence of normal speech or near normal speech than the major clefts post-operatively, following surgery and therapy.

### **Results**

An examination was undertaken to determine if there were significant differences between the speech categories according to cleft type at each data point.

Each data point was separately examined for the whole cohort. Using the Kruskal-Wallis one way analysis of variance, the following results were gained:

Pre-operative stage:	N=68	H=10.488	p = 0.015*
Post-operative stage:	N=88	H=10.212	p = 0.017*
Post-therapy stage:	N=87	H= 9.152	p = 0.027*
4/5 years post operative follow-up	N=66	H=13.124	p = 0.004*

A significant difference was found between the four cleft types in the speech categories at each data point. This indicates that there was a significant difference in the types of speech categories according to the cleft groups at the pre-operative, post-operative, post-therapy and 4/5 years post-operative follow-up stages.

Figures 13, 14, 15 and 16 show the distribution of patients according to speech categories and cleft type at each stage, and provides information as to where the differences lie.

Pre-operatively, (Figure 13), a similar distribution of patients for cleft groups BCLP, UCLP, and H&S occurred across the lowest Speech Categories A, B, and C. In contrast, the lesser cleft group is not represented in Speech Category A, but there are some patients with this cleft group occurring in Speech Category B. Indeed, it is interesting to note that the lesser cleft group is represented in Speech Categories B and C. However, a large proportion of the patients with lesser clefts is in pre-operative Speech Category E.

When the totalled place, manner, and voice results were used as the measure of articulation performance, the mean result for the lesser cleft group on these combined measures was 3.7, compared with the mean

Figure 13

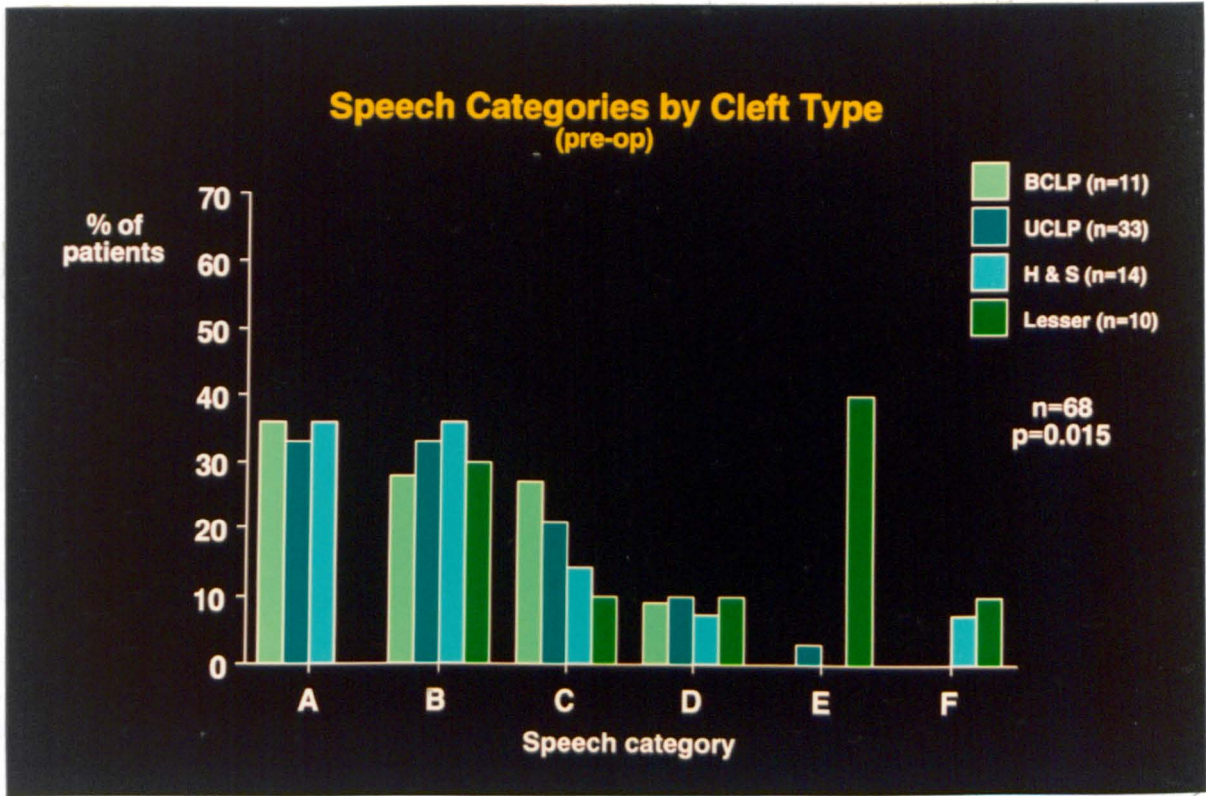
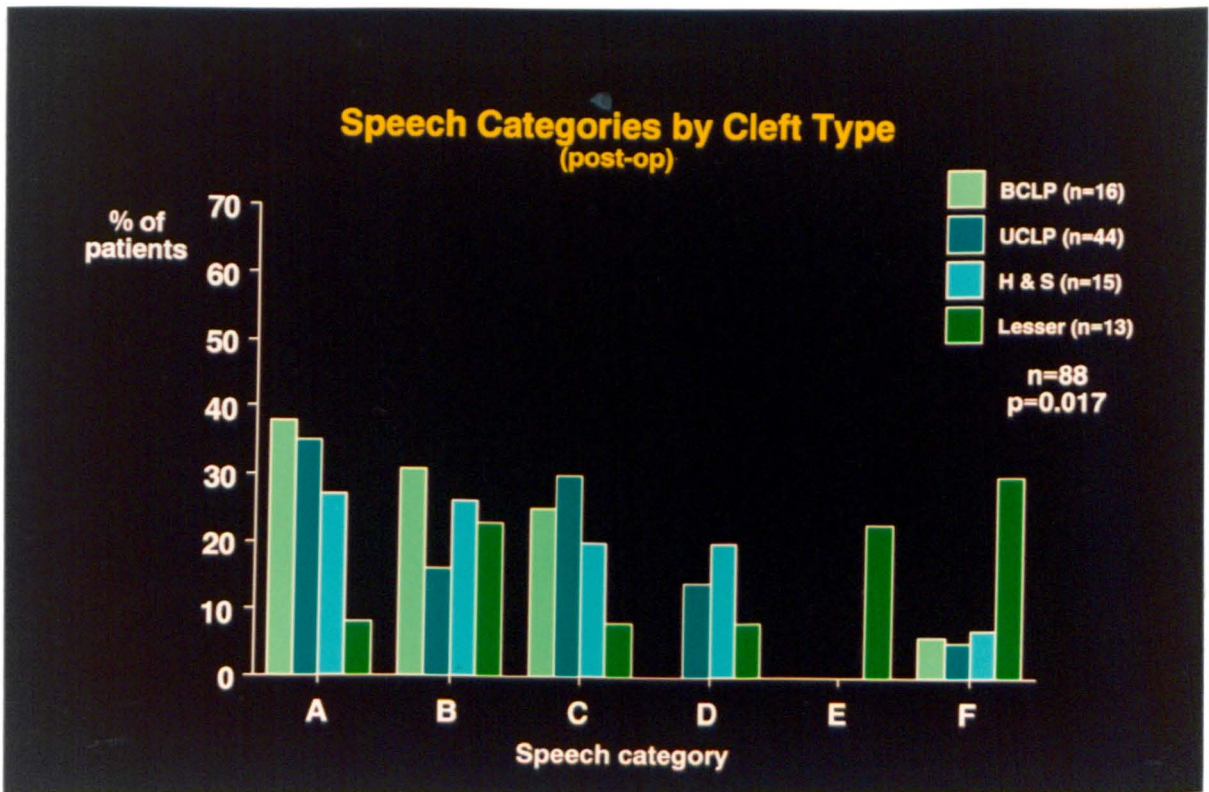
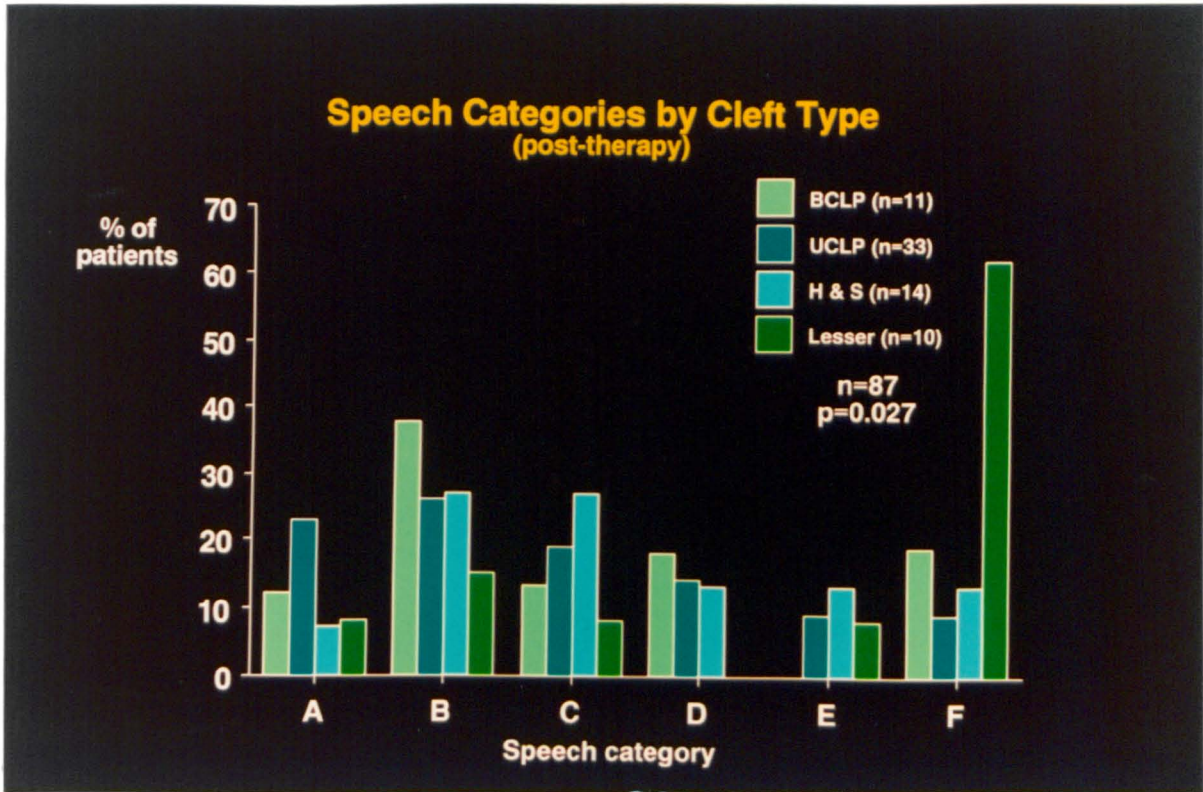


Figure 14

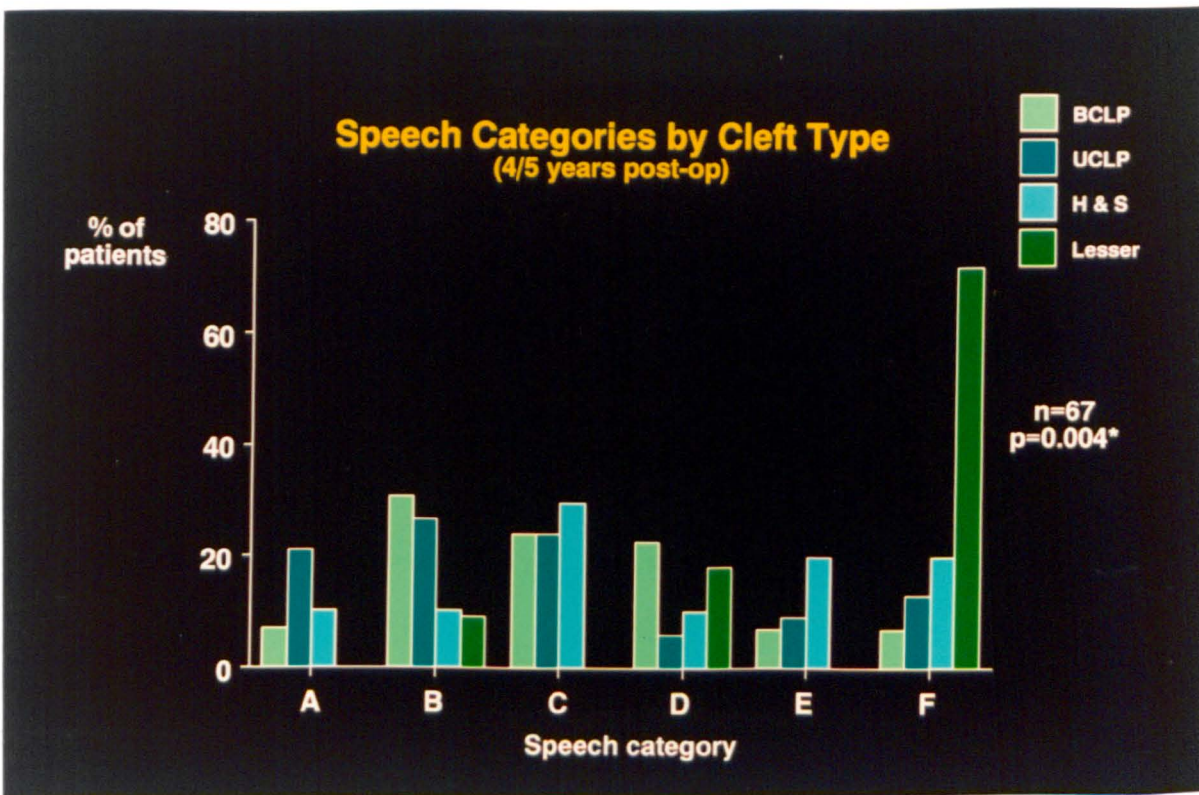


of 2.2 for the intergroup comparisons. Using the Kruskal-Wallis test of analysis of variance, a significant difference was found in articulation skills between the total cleft group and the BCLP cleft group ( $P=0.027$ ,  $n=87$ ) at the post-operative stage.

**Figure 15**



**Figure 16**





result of 2.2 for the other three major cleft groups. Using the Kruskal-Wallis one-way analysis of variance, a statistically significant difference was found in articulation skills between the lesser cleft group and the other three major cleft groups ( $H=8.750$ ,  $p = 0.033^*$ ) at the pre-operative stage.

The distribution of cleft groups according to the speech categories is similar post-operatively (Figure 14). The difference in the distribution of the lesser cleft group compared with the other groups is even more marked. This reflects spontaneous change from Speech Category E into Speech Category F.

Post-therapy (Figure 15), and at 4/5 years post-operative follow-up (Figure 16), the differences lie with the high proportion of the lesser cleft group occurring in Speech Category F.

The differences therefore appear to be related to the lesser cleft group. To determine if this was the case, the data was reanalysed with the lesser cleft group excluded. Based on the speech categories of the whole cohort at each data point, no significant difference was found between the cleft groups: BCLP, UCLP and H&S. Using the Kruskal-Wallis one-way analysis of variance, the following results were gained:

Pre-operative stage:	N=58	H= 0.027	p = 0.986
Post-operative stage:	N=75	H= 1.128	p = 0.569
Post-therapy stage:	N=74	H= 1.561	p = 0.458
4/5 years post-operative follow-up	N=55	H= 1.345	p = 0.510

This indicates that there were no significant differences in the speech categories for the three major cleft groups at any stage. The lesser cleft group therefore behaved differently to the major clefts.

The next approach to analysis was to determine if, for each separate cleft group, there were significant differences in the distribution of speech categories across the data points.

Based on the speech categories of the main cohort only, a Wilcoxon Signed Ranks Test was undertaken for each cleft group. Table 38 shows the results of this analysis.

*Table 38. Results of Speech Categories for each Cleft Group over Time*

*\* significant p values.*

	<b>BCLP</b>	<b>UCLP</b>	<b>H&amp;S</b>	<b>Lesser</b>
Pre-operative/Post-operative	0.705	0.285	0.129	0.102
Post-operative/Post-therapy	0.006*	0.001*	0.005*	0.023*
4/5 years post-operative follow-up	0.039*	0.054*	0.028*	0.017*

Figures 17, 18, 19 and 20 show the distribution of speech categories for each cleft group at the pre-operative, post-operative and post-therapy data points, providing information as to where the differences were found.

Information on the 4/5 years post-operative follow-up is not represented visually.

There are no significant differences in the distribution of speech categories between the pre-operative and post-operative data points for each cleft group. The speech categories of cleft group BCLP were virtually identical pre-operatively and post-operatively. There was almost no representation above Speech Category D. There was a slightly higher incidence of post-operative Speech Category C in the UCLP cleft group. The hard and soft cleft group showed a slight increase in Speech Categories C and D post-operatively. Although not statistically significant, some spontaneous change occurred in Speech Categories E and F in the lesser cleft group.

In contrast, there were significant differences in the distribution of speech categories following therapy, and at the subsequent 4/5 years post-operative follow-up for each cleft group. This suggests that therapeutic changes occurred and were maintained in all cleft groups. The post-therapy difference appears to be related to the changes that occurred in Speech Categories E and F compared with the post-operative data point. In both the BCLP and UCLP groups, greater representation was found in Speech Categories D and above following therapy. In the H&S cleft group, there was a considerable reduction in the number of patients who were found in Speech Category A following therapy. The majority of the lesser cleft group was found in Speech Category F post therapy.

Figure 17

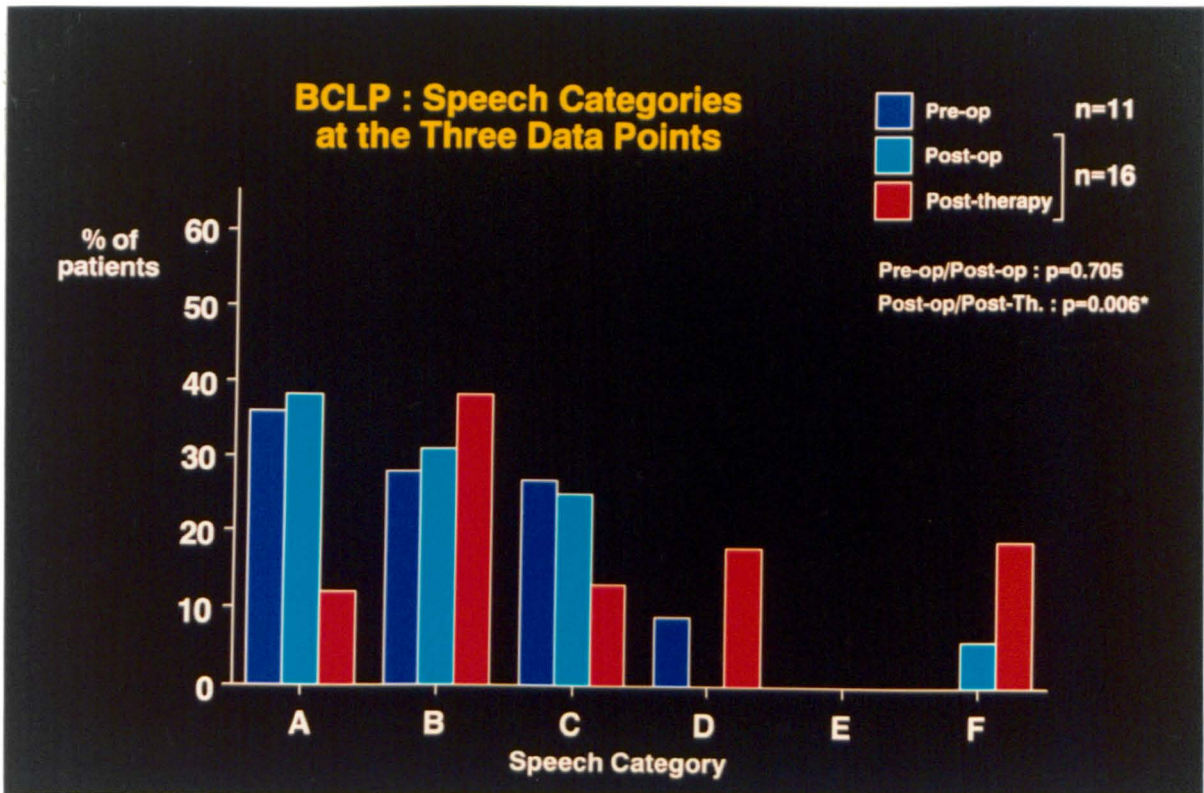


Figure 18

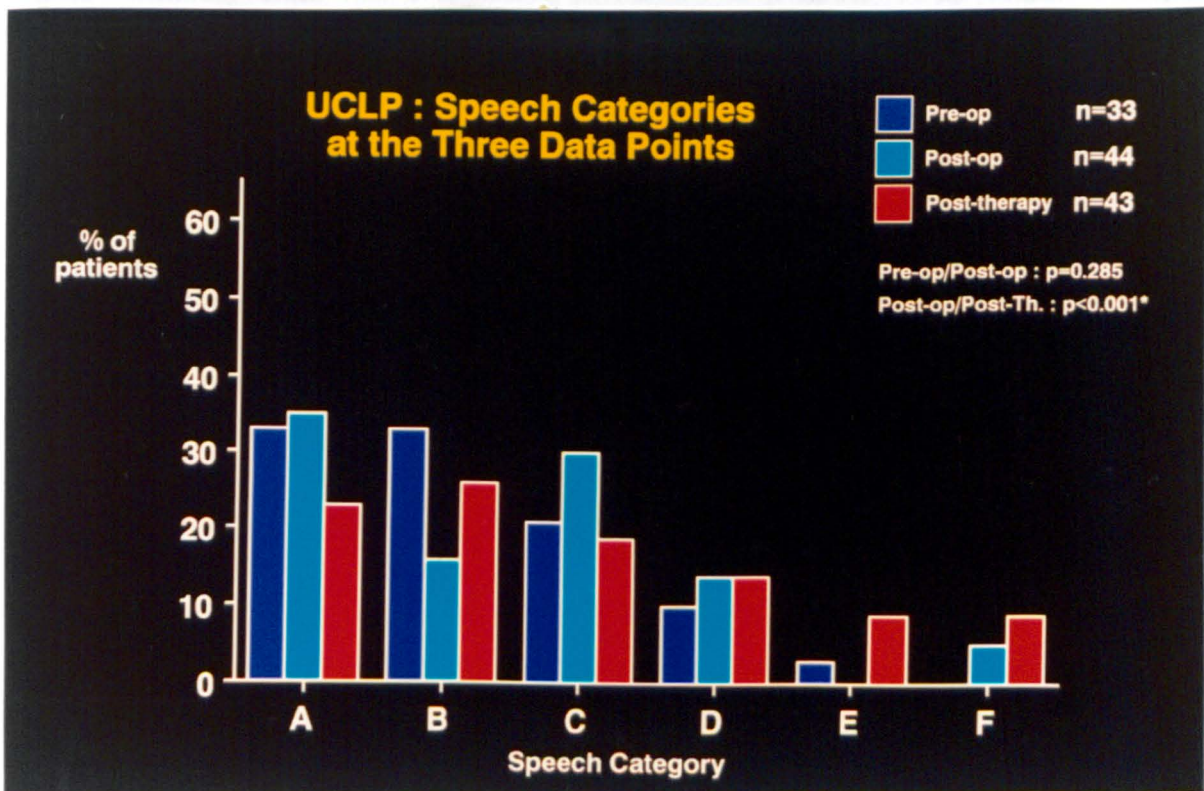


Figure 19

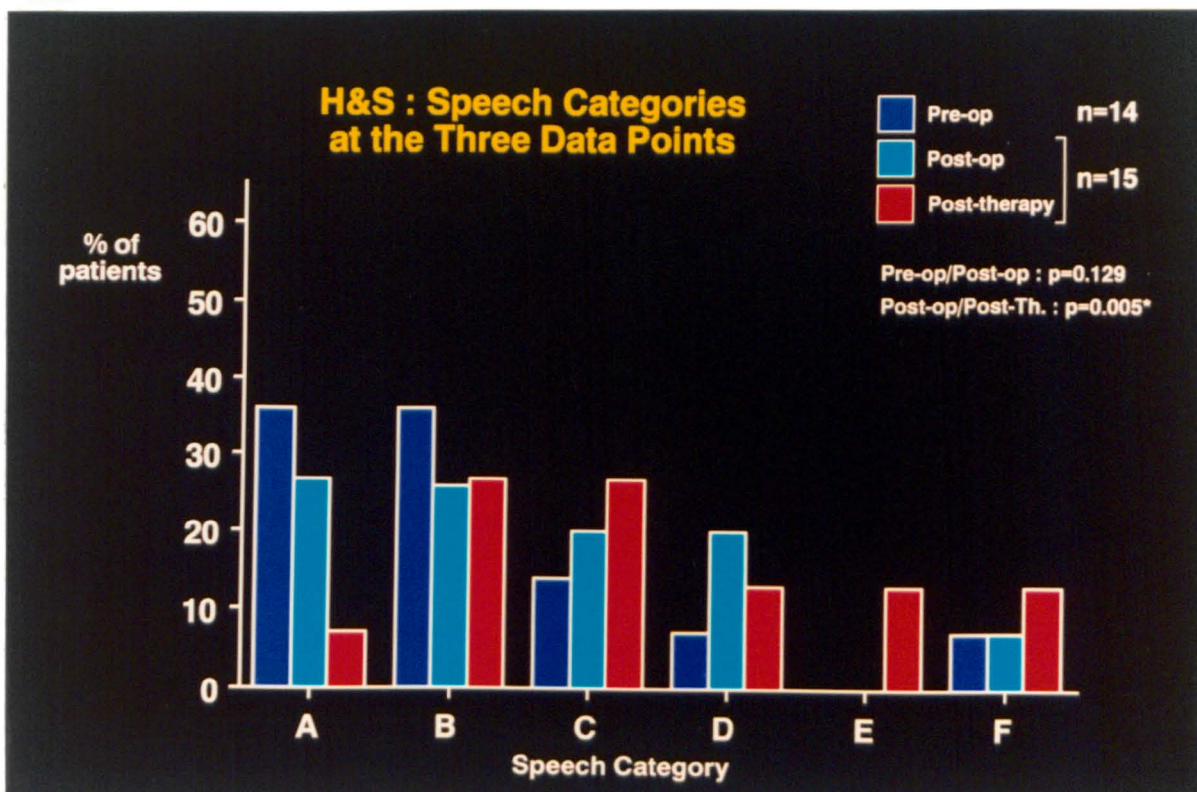
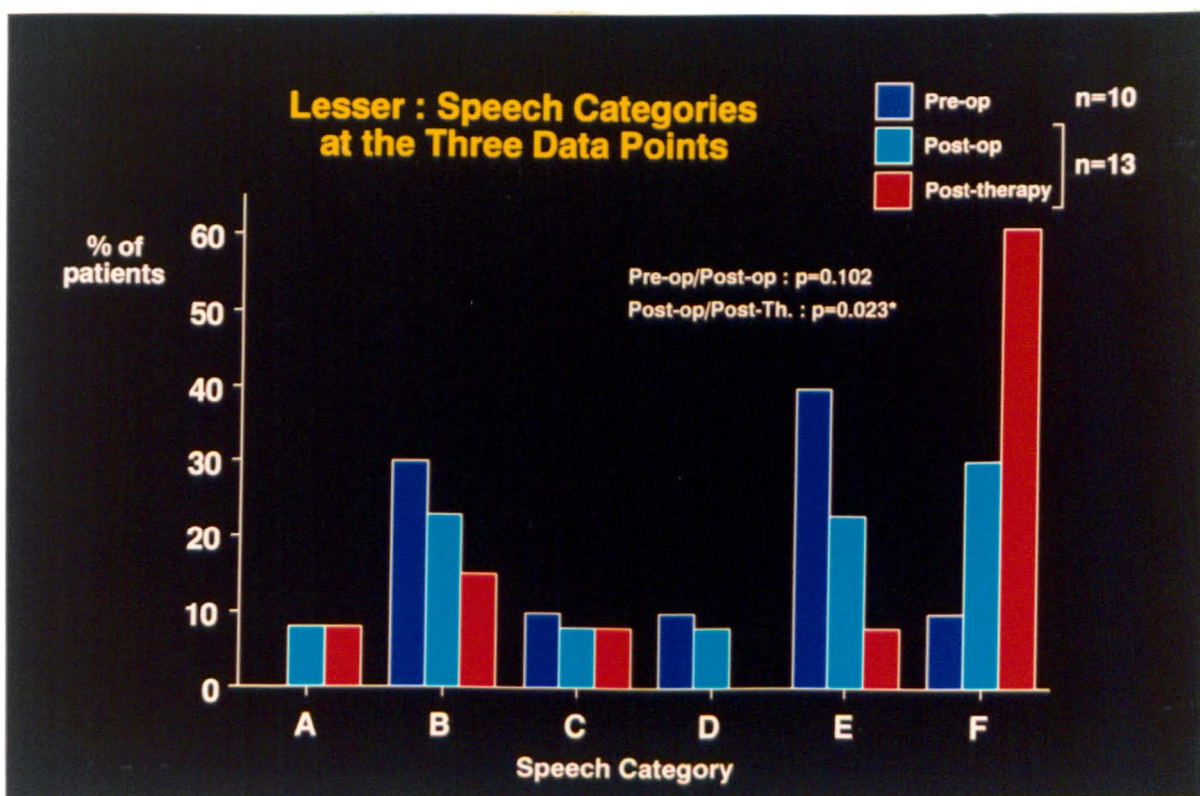


Figure 20



## **VI. Structural Issues**

### **a. Velopharyngeal Function**

#### **Aims**

The aim of this section is:

- (i) to describe the incidence of post-operative velopharyngeal insufficiency (VPI) according to the three methods of measurement.
- (ii) to provide descriptive information from the nasopharyngoscopy findings with regard to characteristics of the velopharyngeal sphincter, i.e. gap size, movement characteristics of the pharyngeal walls and soft palate, and the distribution of the different valving patterns.
- (iii) to examine the relationship of age to each measure of velopharyngeal function.
- (iv) to examine the relationship of cleft type to each measure of velopharyngeal function.
- (v) to examine the relationship between the speech categories to each of the three measures of velopharyngeal function.
- (vi) to examine the relationship between the speech categories characterized by compensatory articulations and nasopharyngoscopy.

#### **Hypotheses**

1. Adult patients exhibit a higher degree of velopharyngeal insufficiency following palatal closure than adolescents and children, and as a consequence their ability to improve speech production is severely impaired.
2. Patients with lesser clefts demonstrate a higher incidence of velopharyngeal sufficiency following palatal closure.
3. Notwithstanding the different ages of patients, speech outcome is related to the formation of a competent or marginal velopharyngeal mechanism.

#### **Results**

##### **(1). The incidence of post-operative velopharyngeal insufficiency according to the three methods of measurement.**

Figure 21 shows the distribution of patients according to a summary of the nasopharyngoscopy information, nasality rating, and lateral skull X-rays of patients phonating /i/. According to the nasopharyngoscopy results, 67% had inadequate velopharyngeal function, 23% had velopharyngeal closure, and 10% fell into the borderline category. The nasality results show that 66% had severe hypernasality, 18% fell into the oral/

hyponasal category, and 16% had mild hypernasality. According to the X-ray results, 65% had no closure, 22% had adequate closure, and 12% had marginal closure. Therefore the three measures apparently show very similar results. Table 39 shows the correlations between the three measures.

Table 39. Correlations between the Three Measures of Velopharyngeal Function.

	Nasopharyngoscopy	X-rays	Nasality
X-rays	0.723		
Nasality		-0.804	
Nasopharyngoscopy			-0.751

Spearman's rho correlation coefficient.

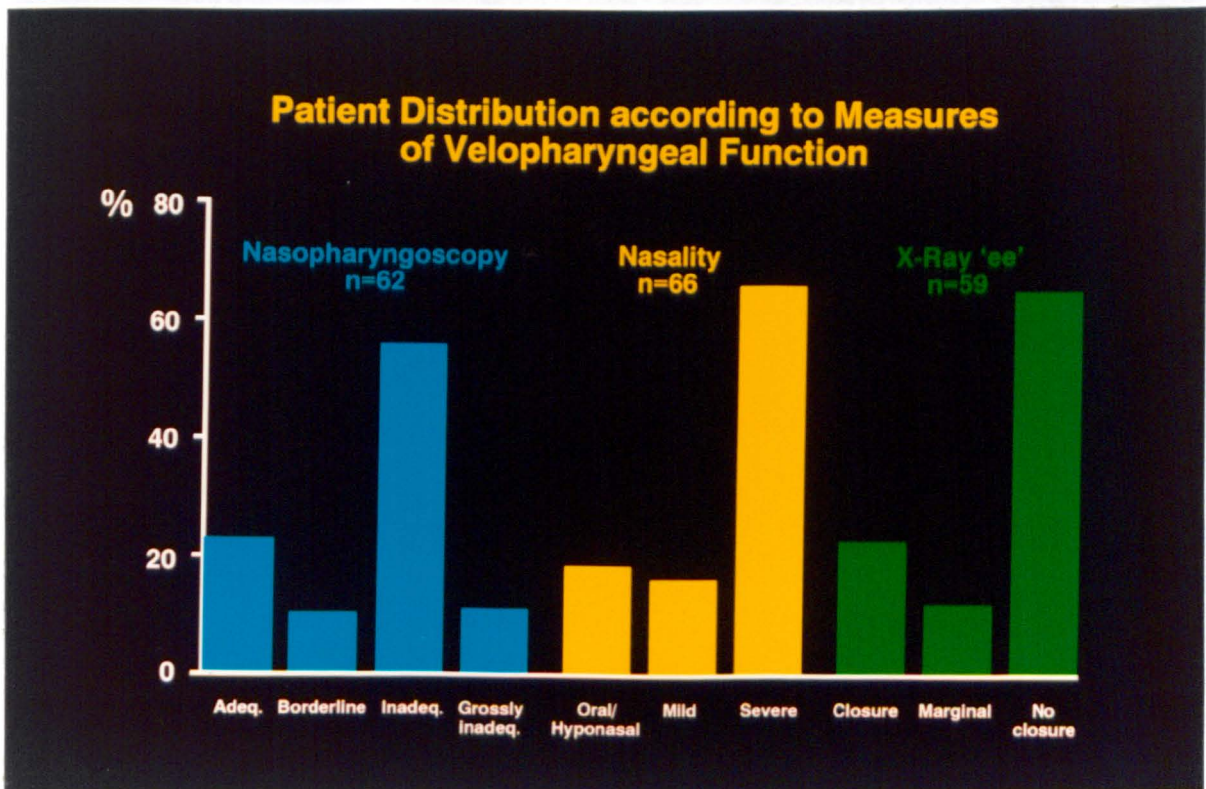
Legend: X-rays – Lateral skull X-rays of patients phonating /i/.

The relationship between these three measures is surprisingly high, especially in those correlations involving the X-rays of patients phonating /i/, given the well-recognised disadvantages of this procedure. The implication is that the X-ray procedure and the perceptual assessment do provide reasonably similar findings to nasopharyngoscopy about the degree of post-operative velopharyngeal closure in this population. Although nasality is not a direct measure of velopharyngeal function, it infers information about it.

The fact that the three different methods of measuring velopharyngeal function give similar results is interesting, and probably reflects the gross problem of velopharyngeal insufficiency in these patients.

In summary, all three measures indicate that approximately 65% of patients had velopharyngeal insufficiency. The level of velopharyngeal closure was about 22%, with 13% demonstrating borderline closure.

Figure 21



***(ii). Nasopharyngoscopy findings with regard to characteristics of the velopharyngeal sphincter, i.e. gap size, movement characteristics of the pharyngeal walls and soft palate, and the distribution of patients according to the valving patterns.***

Figure 22 shows the distribution of patients according to gap size. This shows that more than 50% of patients had a moderately sized or large gap. 36% were judged as small, and 11% as pinhole.

Figure 23 shows the movement characteristics of the pharyngeal walls and soft palate. The movement pattern of the left and right pharyngeal walls is very similar. Approximately 30% showed no movement, or slight movement, and 30% showed marked movement. 43% of patients were classified as having moderate movement. Approximately 50% of patients had no posterior pharyngeal wall movement.

The movement characteristics of the soft palate were similarly distributed to that of the lateral pharyngeal walls. Approximately 25% showed no or slight movement, and 25% showed marked movement. 50% demonstrated moderate movement.

Figure 24 shows the distribution of patients according to the valving pattern. 49% of patients had a coronal pattern, 34% had a circular pattern, 13% had a sagittal pattern, and only 4% had a circular pattern with Passavant's Ridge.

**Figure 22**

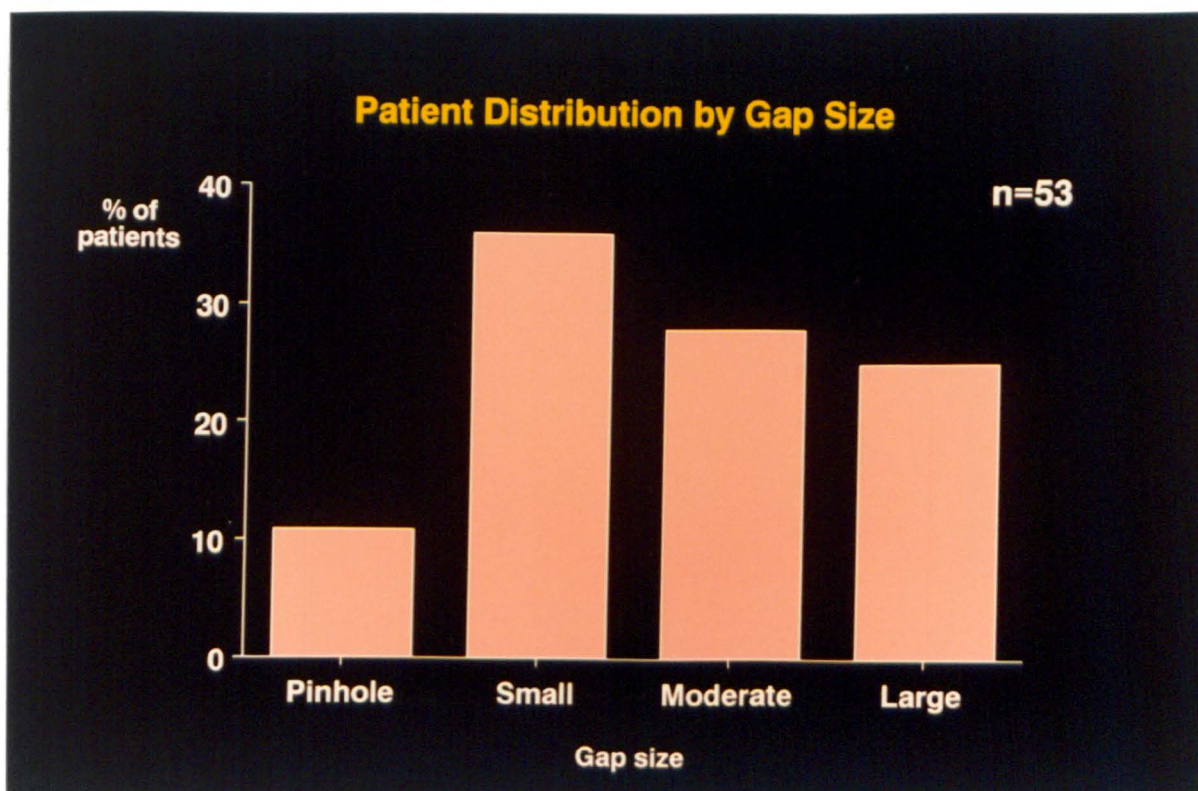


Figure 23

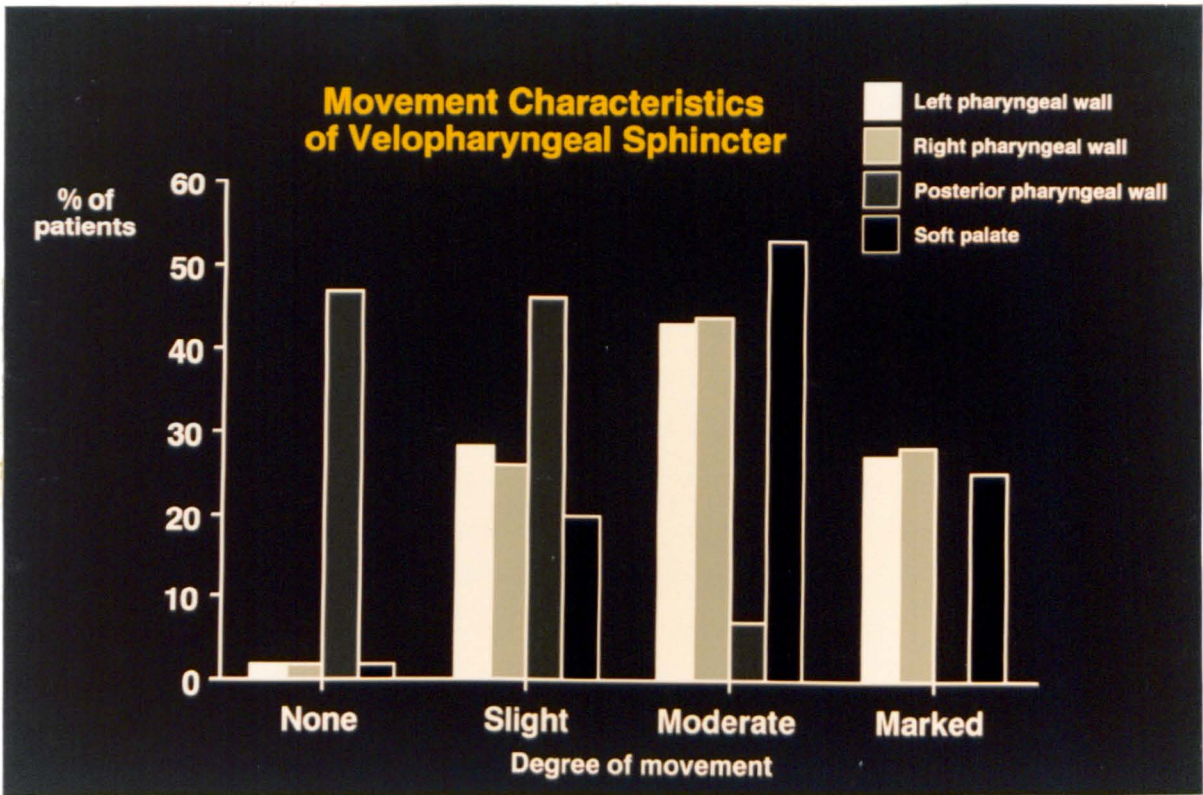
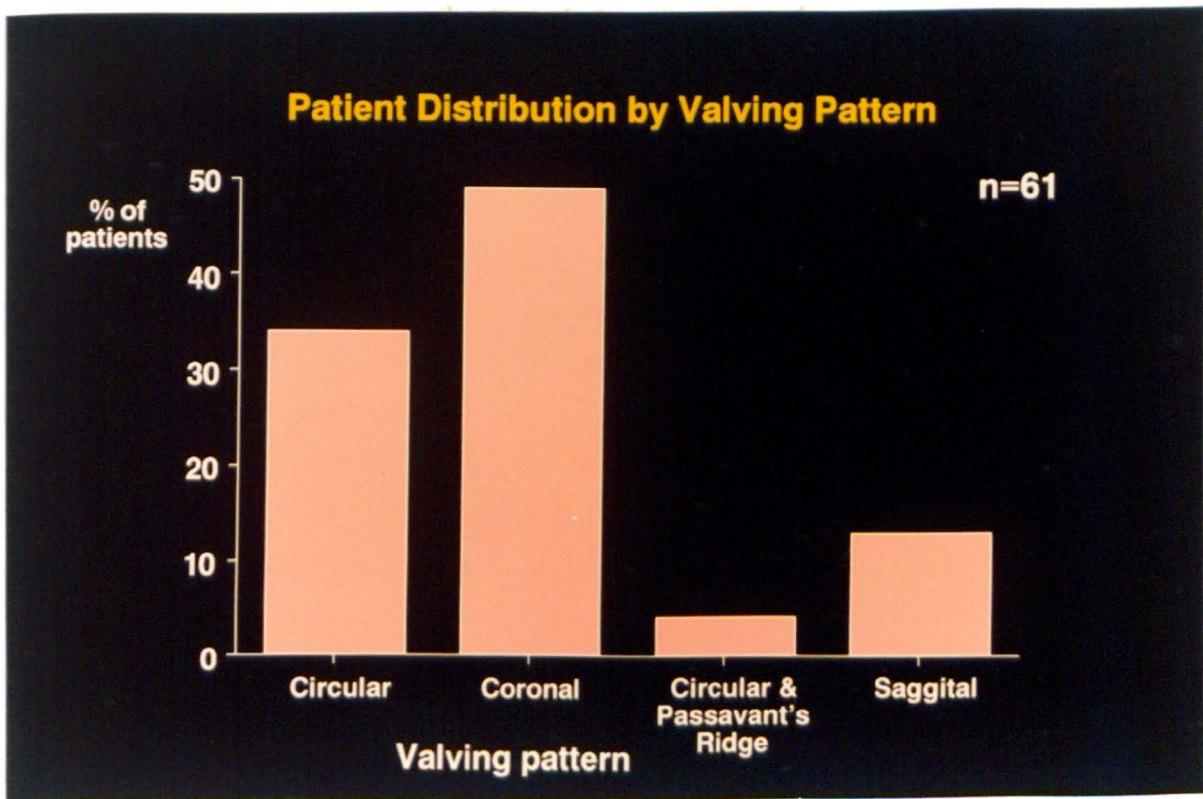


Figure 24





***(iii). The relationship of age to each measure of velopharyngeal function.***

An investigation was undertaken to examine the relationship of age to each measure of velopharyngeal function.

Using the Kruskal-Wallis one-way analysis of variance, a significant difference ( $N=62$ ,  $H=12.456$ ,  $p = 0.006^*$ ) in nasopharyngoscopy results was found between the age categories. Figure 25 shows that the adult group had the highest level of velopharyngeal insufficiency: 81% of this group were insufficient of which 31% were grossly insufficient. The adults, therefore, had not only the highest level of VPI, but also the severest form. The adolescents displayed the next highest degree of VPI, with 60% insufficient velopharyngeal function. However this includes the lesser cleft group which we have shown to have had the highest incidence of closure. When this cleft group is excluded, the adolescents had 86% insufficiency, but only 7% were grossly insufficient. This would seem to suggest that with advancing age the degree of insufficiency increases, but there was no distinction in the incidence of velopharyngeal insufficiency between the adults and the adolescents with major clefts. The children aged 8–10 years at surgery had 44% insufficiency compared with 55% in the children below the age of eight years at surgery.

The second measure of nasality was analysed. A significant difference in nasality was found between the age groups (Kruskal-Wallis one-way analysis of variance,  $N=66$ ,  $H=10.771$ ,  $p = 0.013$ ). Figure 26 shows the distribution of patients according to age and nasality. This reveals that the adult group was rated almost exclusively (94%) as severely hypernasal, implying velopharyngeal insufficiency. In contrast, 60% of the adolescents and 45% of the children aged 8–10 years at surgery were severely hypernasal. When the adolescents with lesser clefts were eliminated, 82 % of the adolescents were severely hypernasal.

The distribution of nasality results is therefore almost identical to the distribution for the nasopharyngoscopy results.

The third measure using lateral skull X-rays of patients phonating /i/ was analysed. Figure 27 shows the distribution of patients according to age and lateral skull X-rays of patients phonating /i/. Using the Kruskal-Wallis one-way analysis of variance no significant difference in X-ray results was found between the age groups ( $N=60$ ,  $H=2.192$ ,  $p = 0.534$ ). An examination of Figure 27 reveals that the three youngest age groups had very similar findings. Approximately 30% of each age group had closure. Approximately 60% of these three age groups had no closure, in contrast to the adult group, 80% of whom had no closure. These findings do not, however, reach statistical significance.

Therefore, the findings of nasopharyngoscopy and nasality support the hypothesis that adult patients exhibit a higher degree of velopharyngeal insufficiency following palatal closure than adolescents and children. When adults and adolescents with major clefts are compared, the incidence of VPI is similar for both age groups. However, the adults show a higher degree of velopharyngeal insufficiency.

Figure 25

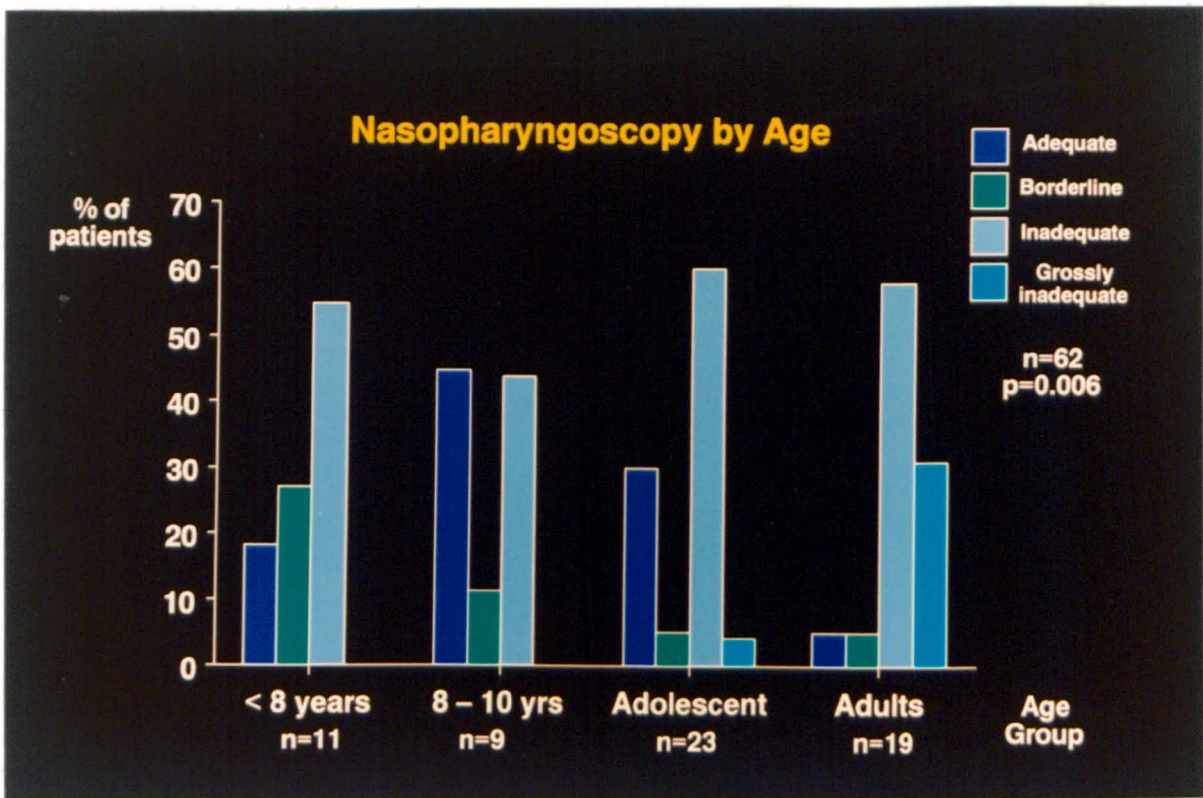
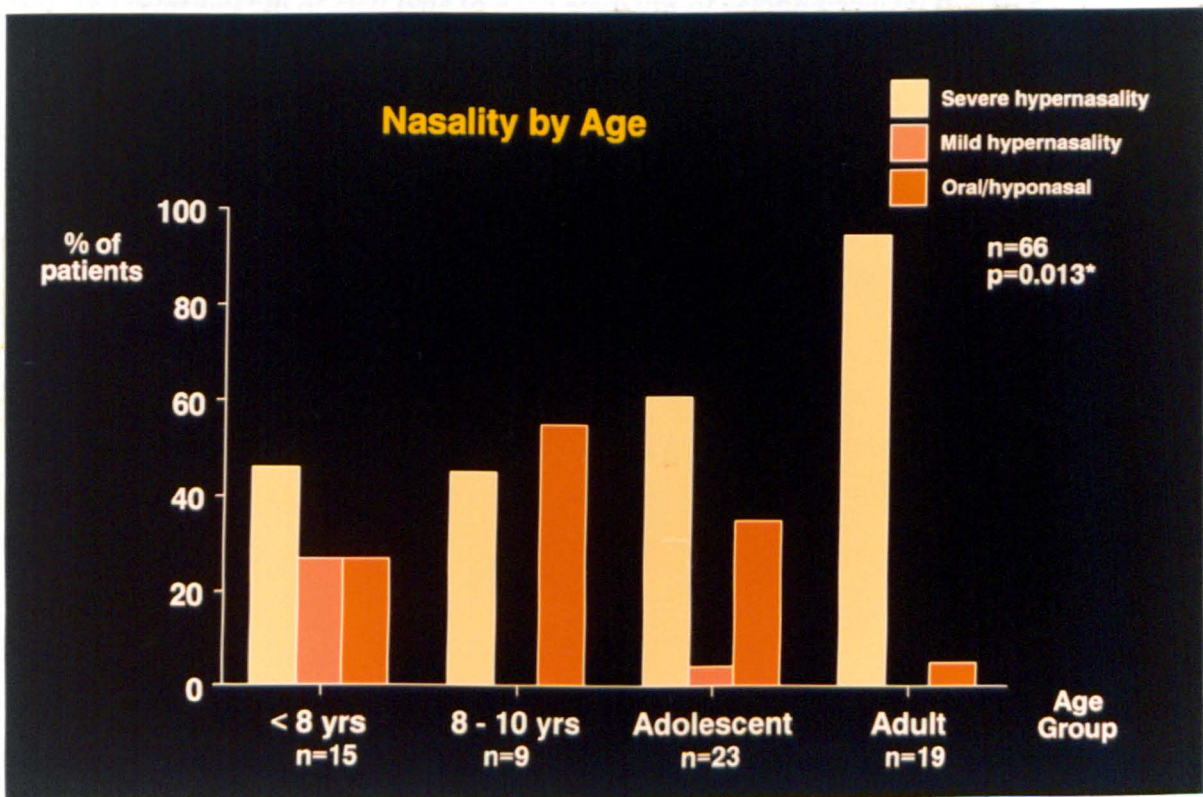


Figure 26



**Figure 27**



**(iv). The relationship of cleft type to each measure of velopharyngeal function.**

An investigation was undertaken to examine the relationship of cleft type to each measure of velopharyngeal function.

Using the Kruskal-Wallis one-way analysis of variance a significant difference ( $N=62$ ,  $H=10.463$ ,  $p = 0.015^*$ ) in nasopharyngoscopy results was found between the cleft groups. Figure 28 shows that the nasopharyngoscopy results were significantly different according to whether there was a major or lesser cleft. The lesser cleft group was almost completely characterized by the borderline or closure category.

The second measure of nasality was analysed. Figure 29 shows the distribution of patients according to cleft type and nasality rating. Using the Kruskal-Wallis one-way analysis of variance no significant difference ( $N=66$ ,  $H=5.010$ ,  $p = 0.171$ ) in nasality results was found between the different cleft types. Although not statistically significant, more than 60% of the lesser cleft group were classified as oral/hyponasal with the implication of adequate velopharyngeal function. Less than 20% of the lesser cleft group had severe hypernasality, in contrast to more than 70% in each of the major cleft groups.

The third measure using lateral skull X-rays of patients phonating /i/ was analysed. Figure 30 shows the distribution of patients according to cleft type and lateral skull X-rays of patients phonating /i/. Using the Kruskal-Wallis one way analysis of variance a significant difference ( $N=60$ ,  $H=8.894$ ,  $p = 0.031^*$ ) in X-ray

results was found between the different cleft types. Closure was found in approximately 60% of the lesser cleft group. This measure revealed a lower incidence of closure for the lesser cleft group than either nasopharyngoscopy or nasality.

Although qualitatively the results were similar for the three measures, the perceptual method of assessment gave statistically different results. Given this discrepancy, the following hypothesis was tested: patients with lesser clefts demonstrate a higher incidence of velopharyngeal sufficiency following palatal closure.

Patients in the lesser cleft group were compared with patients with major clefts on each of the measures of velopharyngeal function. A Mann-Whitney U test was performed on each measure for the two groups. The two groups were significantly different on each of the three measures as shown in Table 40.

*Table 40. Results of Post-operative Velopharyngeal Function: A Comparison between the Lesser Cleft Group and Major Clefts.*

	<b>X-ray</b>	<b>Nasality</b>	<b>Nasopharyngoscopy</b>
Lesser clefts	N=8	N=11	N=10
Other clefts	N=31	N=55	N=52
Total	N=39	N=66	N=62
	U=77.5	U=468.5	U=91.00
	p = 0.044*	p < 0.001*	p<0.001*.

These findings support the hypothesis that patients with lesser clefts demonstrate a higher incidence of velopharyngeal sufficiency following palatal closure than other cleft types.

Given these results, it was interesting to determine if the lesser cleft group functioned differently to the other cleft groups at the pre-operative stage. Only the nasality rating, as a measure of velopharyngeal function, was available at this data point. The quantitative information from the nasality rating scale was used as a measure of pre-operative nasality performance. The mean result for the lesser cleft group was 0.5, standard deviation of 0.5, compared with the mean result of 0.0 for the other three cleft groups. When tested for statistical significance, the lesser cleft group was significantly different from the other cleft groups (Kruskal-Wallis one-way analysis of variance,  $H=25.308$ ,  $p < 0.001^*$ ). Thus, these results show that patients with lesser clefts had less severe nasality pre-operatively than patients with major clefts.

These results indicate that the lesser cleft group behaved differently both pre-operatively and post-operatively from the major cleft groups. Based on the nasality measures at the pre-operative and 4/5 years post-operative follow-up stages, the lesser cleft group had less severe pre-operative and post-operative nasality following palatal closure than the major clefts.. The implication of this post-operative result is that there is a high incidence of velopharyngeal closure in this cleft group.

Figure 28

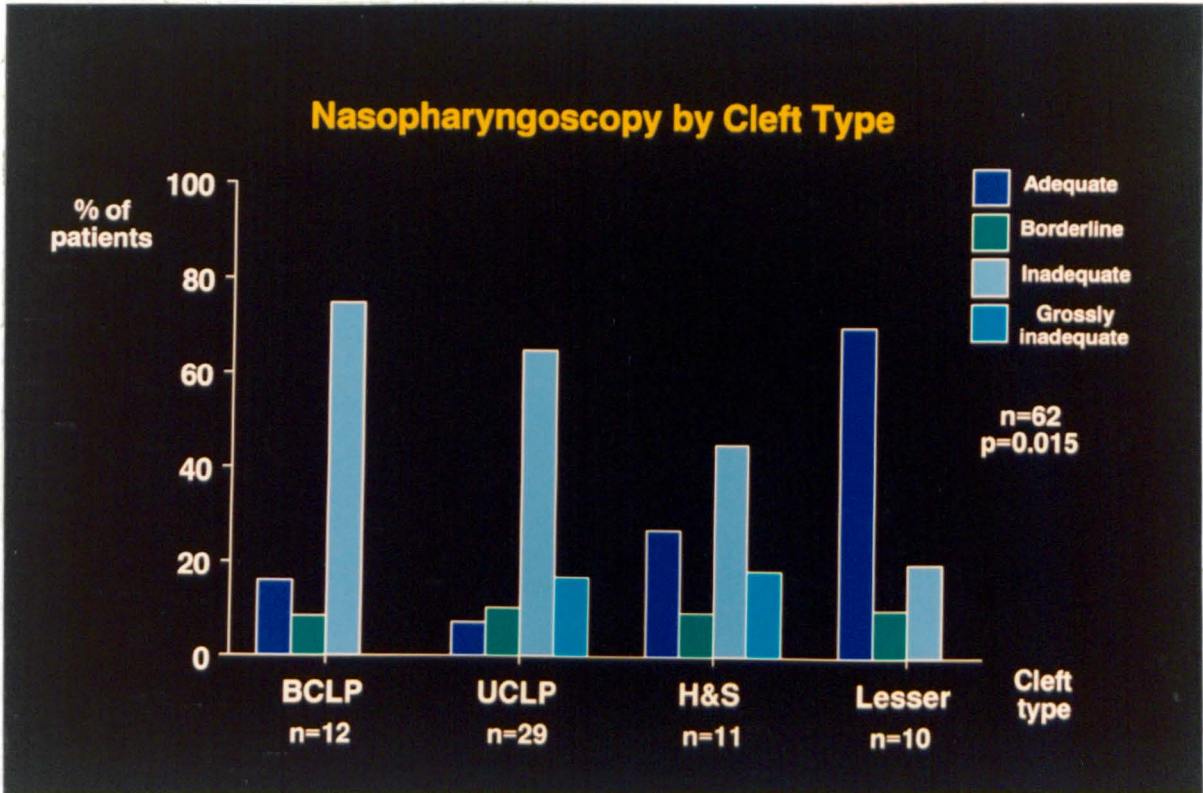
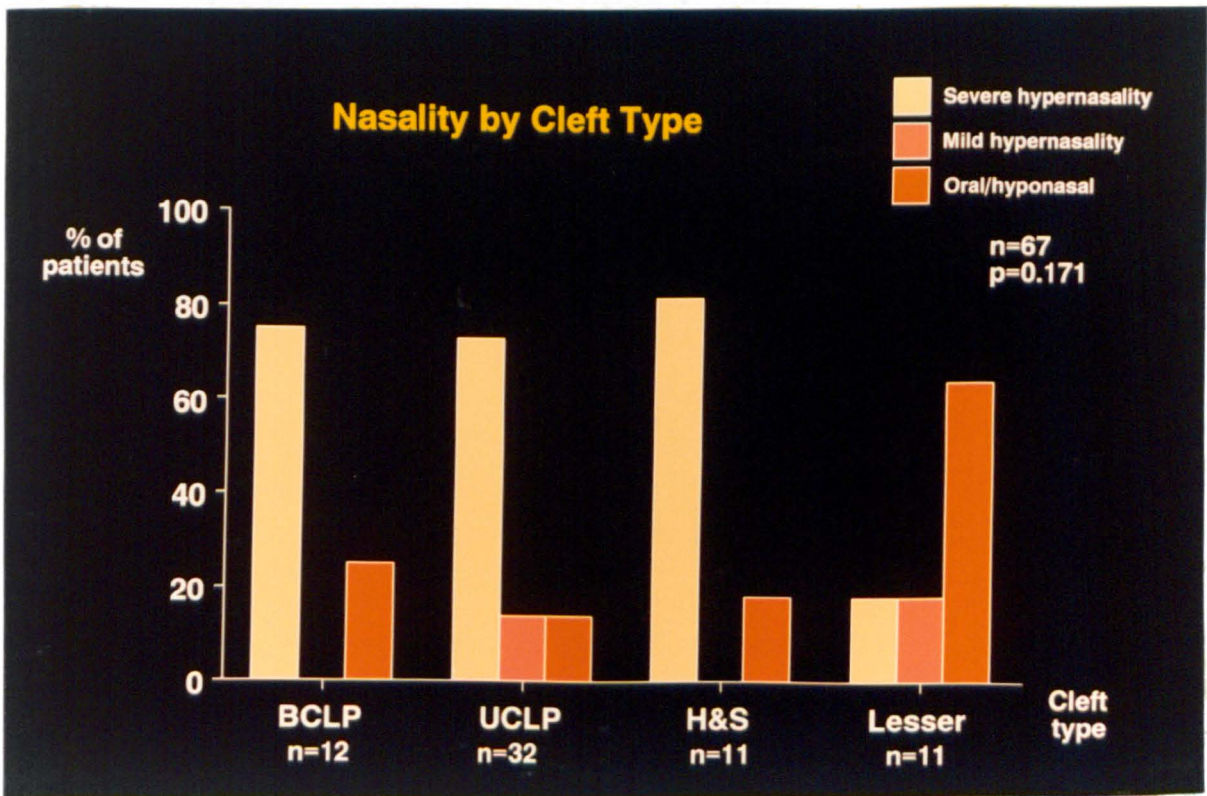
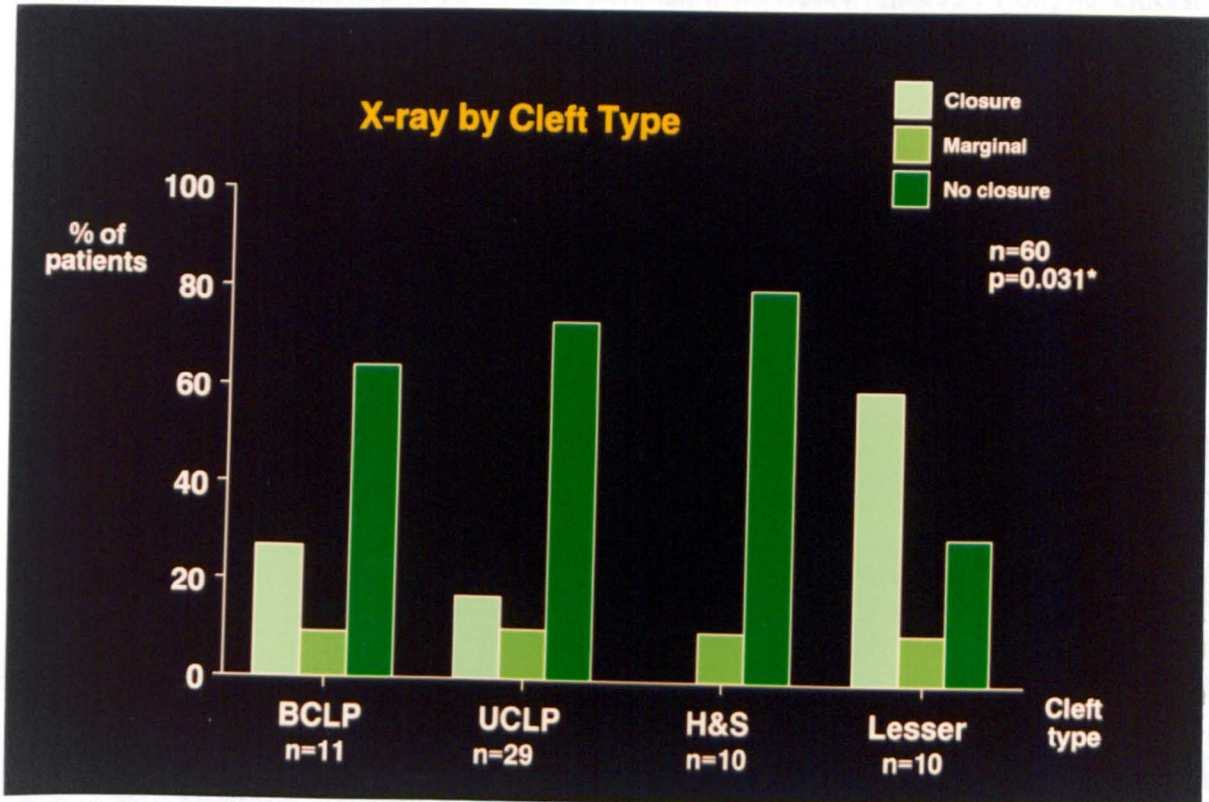


Figure 29



**Figure 30**



**(v). Speech categories according to velopharyngeal function**

The next stage in the investigation was to examine the distribution of patients in speech categories according to the three measures of velopharyngeal function at the 4/5 years post-operative follow-up.

Figure 31 shows the distribution of nasopharyngoscopy results according to the speech categories. A significant difference in nasopharyngoscopy results was found between the speech categories (Kruskal-Wallis one-way analysis of variance  $N=61$ ,  $H=30.116$ ,  $p < 0.001^*$ ). Speech Categories A and B were characterized by inadequate, or grossly inadequate closure. Speech Category C was almost identical with a limited incidence of borderline closure. Speech Category D was slightly better, with approximately 30% classified as borderline closure or closure. Speech Category F is distinctive in that virtually all the patients with closure were found in this category. Interestingly, there was one patient in this category with grossly insufficient closure. The small number of patients with borderline closure were distributed across all speech categories, except Speech Categories A and B.

Figure 32 shows the distribution of nasality results according to the speech categories. Again there was a significant difference in nasality results between the speech categories (Kruskal-Wallis one-way analysis of variance  $N=66$ ,  $H=40.874$ ,  $p < 0.001^*$ ). These results are almost identical to the nasopharyngoscopy results. Speech Category F is distinctive in the high percentage of patients with oral tone or hyponasality. Almost

all the patients in Speech Categories A, B, and C were severely hypernasal.

Figure 33 shows the distribution of X-ray results according to the speech categories. Using the Kruskal-Wallis one-way analysis of variance, a significant difference ( $N=59$ ,  $H=30.736$ ,  $p < 0.001^*$ ) in X-ray results was found between the speech categories. These results differ slightly from the previous two measures in that there was some representation of closure in Speech Categories A and B. There was minimal occurrence of marginal closure throughout the speech categories.

**Figure 31**

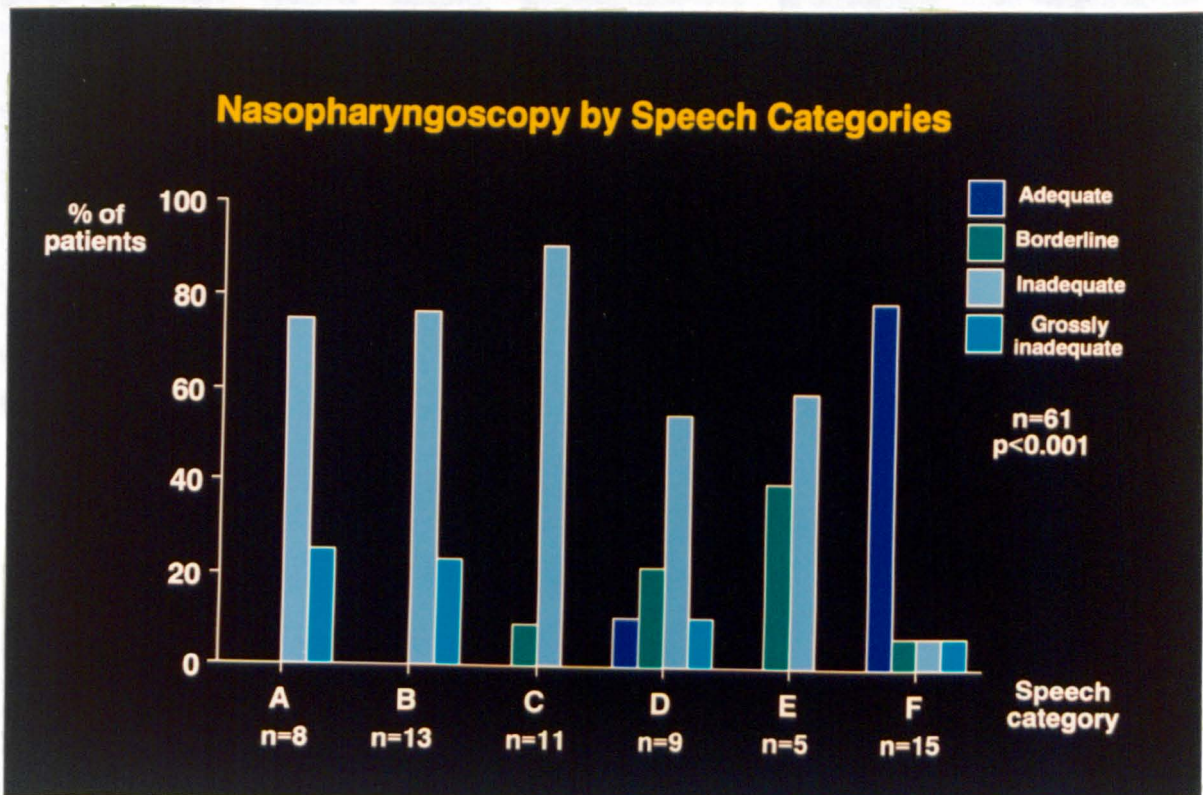


Figure 32

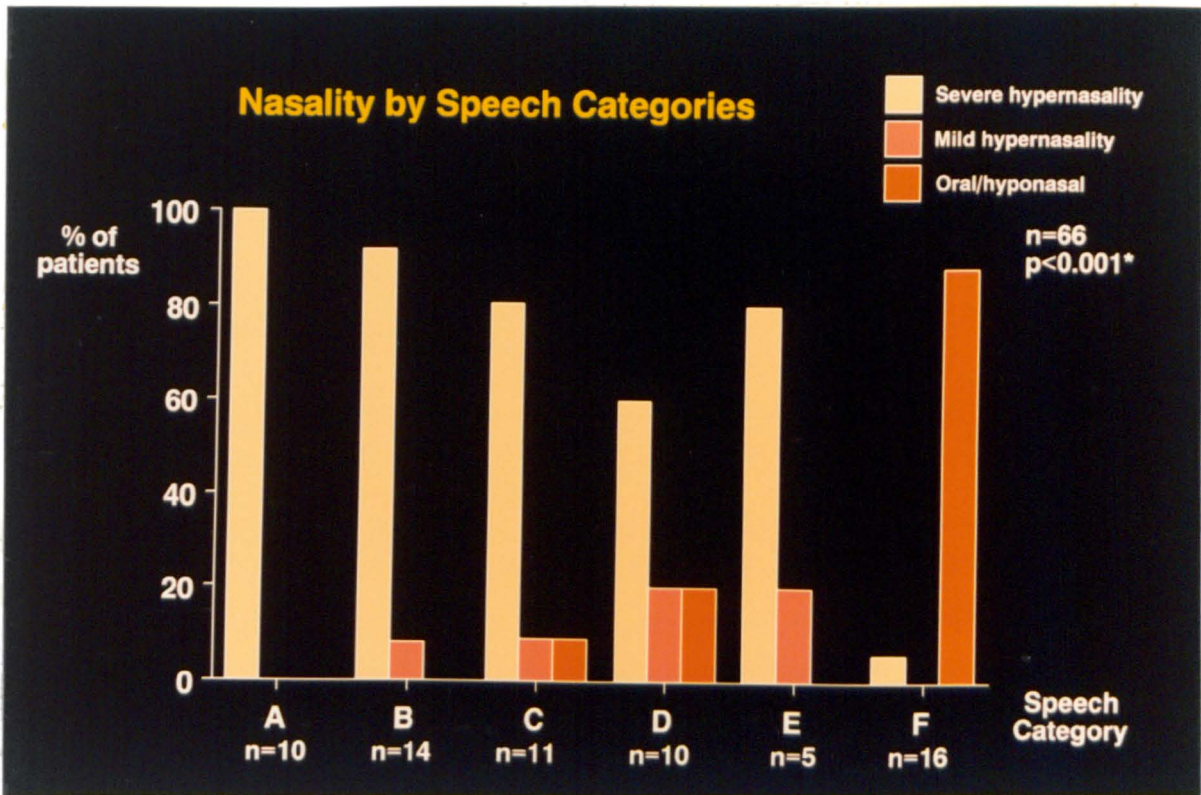
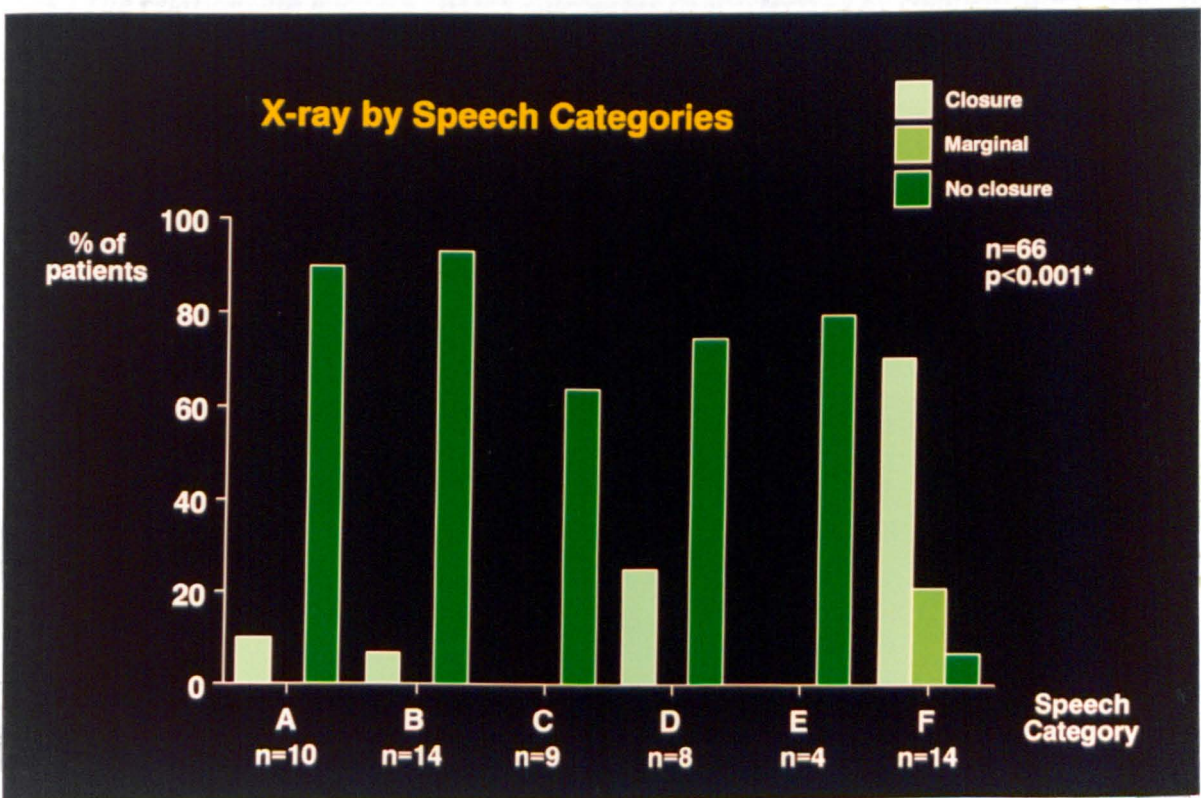


Figure 33





A Spearman's correlation coefficient was performed to determine if there was a relationship between speech at the 4/5 years post-operative follow-up, with the measures of velopharyngeal function (Table 41).

*Table 41. Correlations between the Speech Categories and Measures of Velopharyngeal Function.*

<b>Speech Categories 1990</b>	
Nasopharyngoscopy	-0.532
Nasality	0.599
X-rays	-0.329

*Spearman's rho correlation coefficient.*

Although these data do not reach statistical significance there is a trend towards this in the nasality and nasopharyngoscopy results. It is justifiable to interpret this information for its clinical significance.

On examining the speech categories at the 4/5 years post-operative follow-up, it may be suggested that there is a moderate relationship between nasality ratings and the speech categories. As nasality improves, speech improves (Figure 32). A negative correlation was found between nasopharyngoscopy and speech categories at the subsequent 4/5 years post-operative follow-up. The higher the speech category the more likely that there would be adequate velopharyngeal function. Figure 31 clearly demonstrates this.

The hypothesis has therefore been proven: notwithstanding the different ages of patients, speech outcome is related to the formation of an adequate or marginally adequate velopharyngeal mechanism.

***(vi ).The relationship between speech categories characterized by compensatory articulations, and velopharyngeal function at the 4/5 years post-operative follow-up.***

A Spearman's rho correlation coefficient was performed to determine if there was a relationship between speech categories characterized by compensatory articulations at the 4/5 years post-operative follow-up, with measures of velopharyngeal function (Table 42).

*Table 42. Correlations between the Speech Categories Characterized by Compensatory Articulations and Measures of Velopharyngeal Function.*

<b>Speech Categories A, B, C, D 1990</b>	
Nasopharyngoscopy	-0.620
Nasality	0.686
X-rays	-0.006

*Spearman's rho correlation coefficient.*

These data indicate that the relationship is stronger between the speech categories characterized by compensatory articulations, and nasality and nasopharyngoscopy, than the relationship between the combined speech categories and these two measures of velopharyngeal function.

This finding supports previous workers in that compensatory articulation is consistently associated with impaired velopharyngeal movement.

## **b. Fistulae**

### **Aim**

The aim of this section is:

- (i) to determine the nature, frequency of occurrence and degree of fistulae, according to age and cleft type.
- (ii) to determine the distribution of location of fistulae.
- (iii) to determine whether there is a relationship between fistulae and speech outcome.
- (iv) to determine whether there is a relationship between fistulae and lateral pharyngeal wall movements.

### **Hypotheses**

1. Adult patients exhibit a higher degree of palatal fistulae following palate closure than adolescents or children and, as a consequence, their ability to improve their articulatory patterns is severely impaired.
2. Notwithstanding the different ages of patients, the degree of articulatory change in controlled speech is related to the degree of palatal post-surgical breakdown.
3. Patients with lesser clefts demonstrate a lower incidence of palatal breakdown following palatal closure than other cleft types.

### **Results**

#### **(1), The nature, frequency of occurrence and degree of fistulae, according to age and cleft type.**

For the whole cohort, (N=80), the occurrence of fistulae was 52% (N=42). If buccal fistulae are excluded, the occurrence of fistulae was 30%. The following results include fistulae that occurred at the buccal sulcus. In 30% (N=24) of the total sample, a deliberate fistula was left at surgery. Therefore 70% (N=56) had complete closure of the palate. In this group the occurrence of fistulae was 32% (N=18).

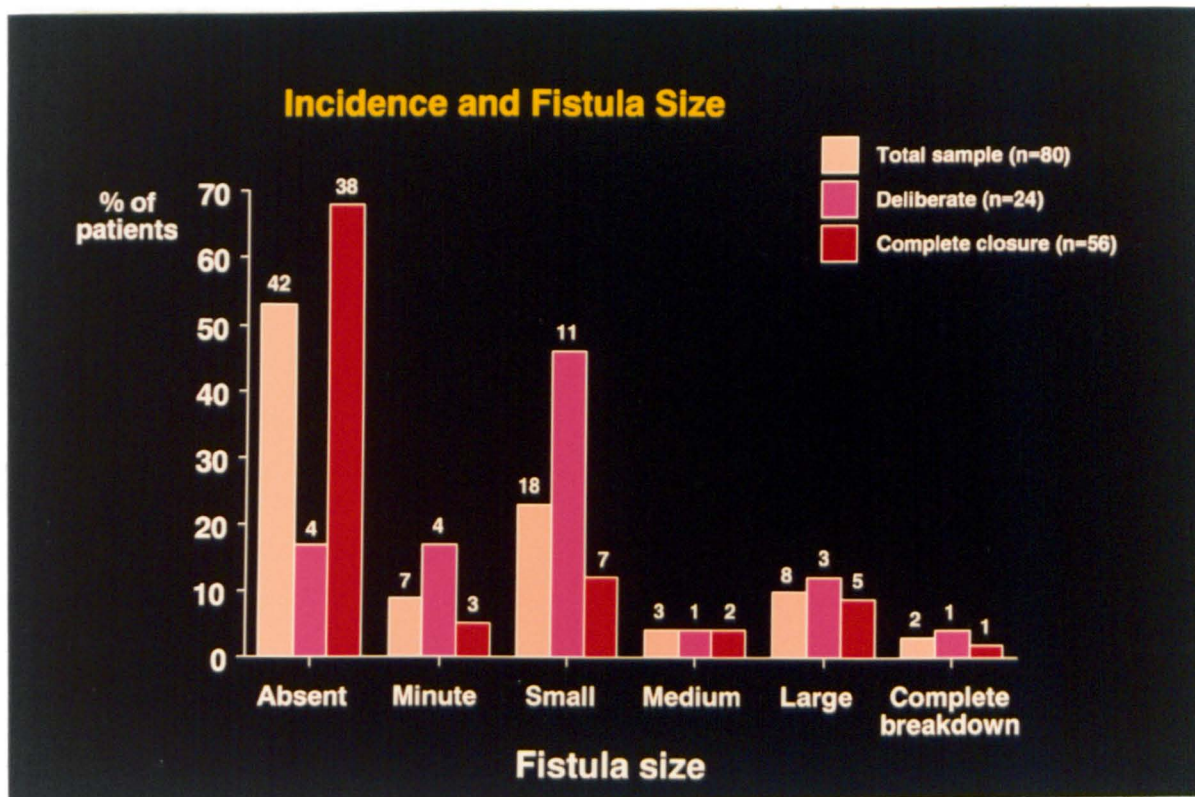
The occurrence and degree of fistulae were examined for three separate groups:

- a. The total sample (N=80)
- b. The group which was characterized by a deliberate fistula left at surgery (N=24)
- c. The remaining group who had total palatal closure (N=56)

#### **1a. The total sample**

A study of the total sample in Figure 34 shows the incidence and degree of fistulae. The majority of fistulae are small or minute.

**Figure 34**

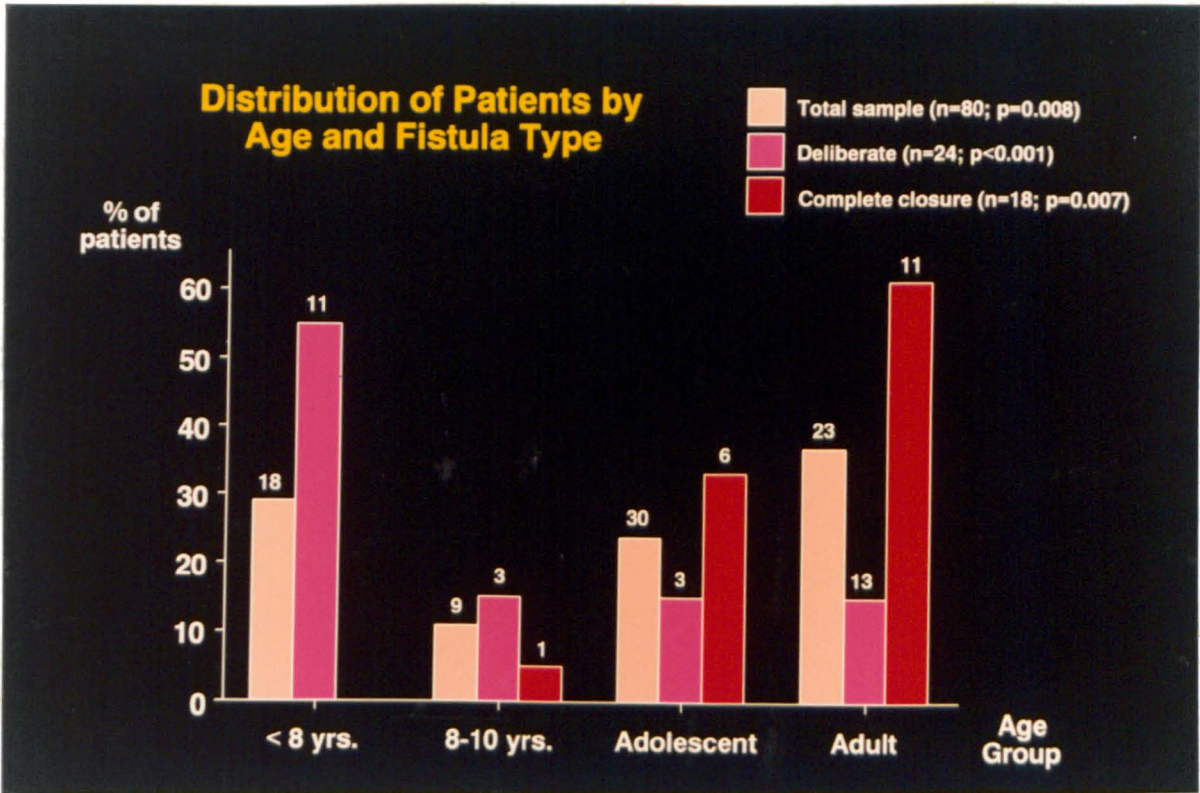


In the total group, a Kruskal-Wallis one-way analysis of variance revealed that there was a significant difference in the occurrence of fistulae according to age ( $N=80$ ,  $H=11.934$ ,  $p = 0.008^*$ ). Figure 35 shows that the highest occurrence of fistulae occurred in the adults (37%) and children below the age of eight years at surgery (28%). 24% of adolescents and 11% of the children aged between 8–10 years at surgery had fistulae.

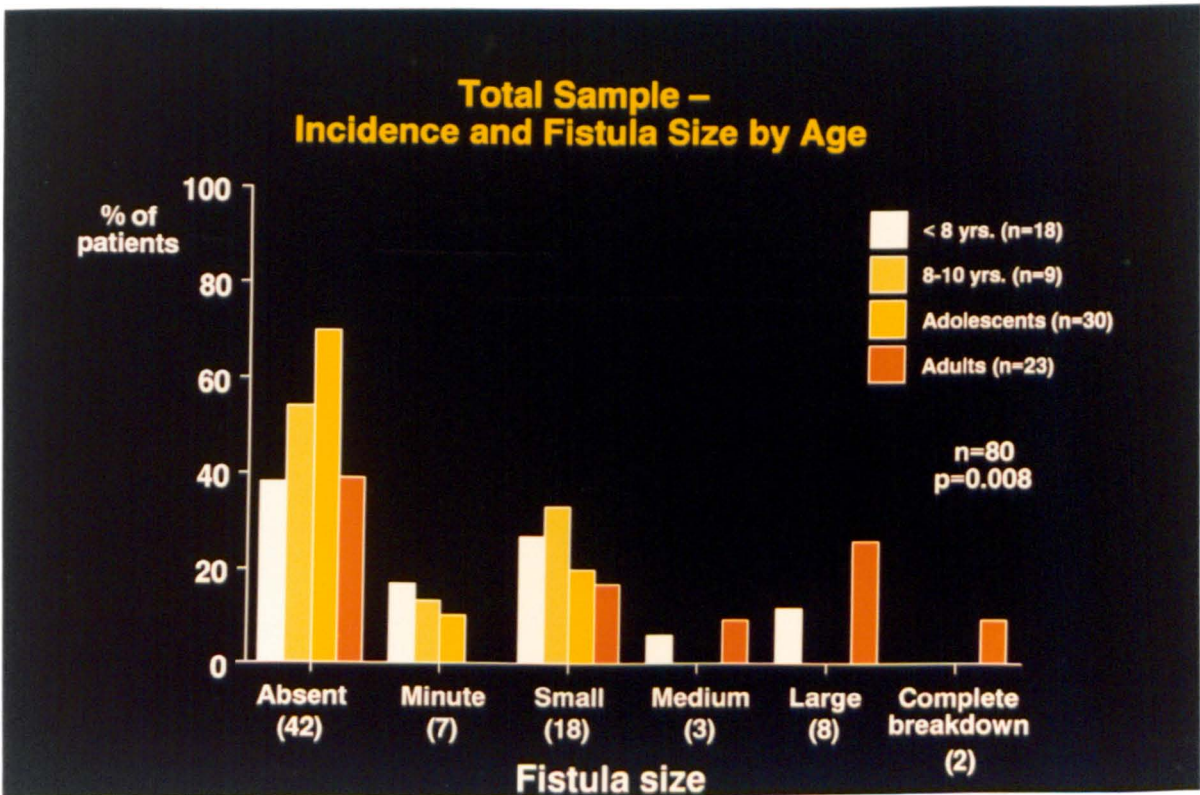
An examination of the relationship between age and the incidence and size of fistulae revealed that there was a significant difference according to age (Kruskal-Wallis one-way analysis of variance,  $N=80$ ,  $H=11.934$ ,  $p = 0.008^*$ ). Figure 36 shows that the incidence and size of fistulae was less for the adolescents and children between 8–10 years at surgery than for the other two groups. The highest incidence of the largest fistulae occurred in the adult group. However, somewhat surprisingly, there was a tendency for fistulae to occur across almost all the fistulae size categories in the children below eight years of age at surgery.

On comparing the distribution of the size of fistulae for each age group separately, the adolescents and the children aged 8–10 years at surgery had very similar results. The fistulae that were present in these two age groups were at most graded as small. The majority of the fistulae present in the adult group were large or medium sized. The youngest group had mainly minute or small fistulae, but as with the adults, there were some occurrences of medium/large fistulae. There was a tendency, therefore, for size of fistulae to be linked with age at the worst end of the spectrum. Minor fistulae did not appear to be linked to age.

**Figure 35**



**Figure 36**



With regard to cleft type, a Kruskal-Wallis one-way analysis of variance revealed that there was a significant difference in the occurrence of fistulae according to cleft type ( $N=80$ ,  $H=17.659$ ,  $p < 0.001^*$ ). In the total sample, Figure 37 shows that 30% fistulae occurred in the BCLP group and 65% occurred in the UCLP group. Fistulae were found in only 8% of the H&S group, and no fistulae occurred in the lesser cleft group. Therefore, the differences lay with the finding of an almost exclusive occurrence of fistulae in the BCLP and UCLP groups. A primary difference also lay in the lesser cleft group, which was characterized by no fistulae.

Figure 38 shows the incidence and degree of fistulae according to cleft type. A Kruskal-Wallis one way analysis of variance revealed that there was no significant difference in the size of fistulae according to cleft type ( $N=80$ ,  $H=1.440$ ,  $p = 0.487$ ). This finding therefore suggests that there is no difference in the size of fistula according to whether the cleft type is BCLP or UCLP.

***1b. Group characterized by a deliberate fistula left at surgery.***

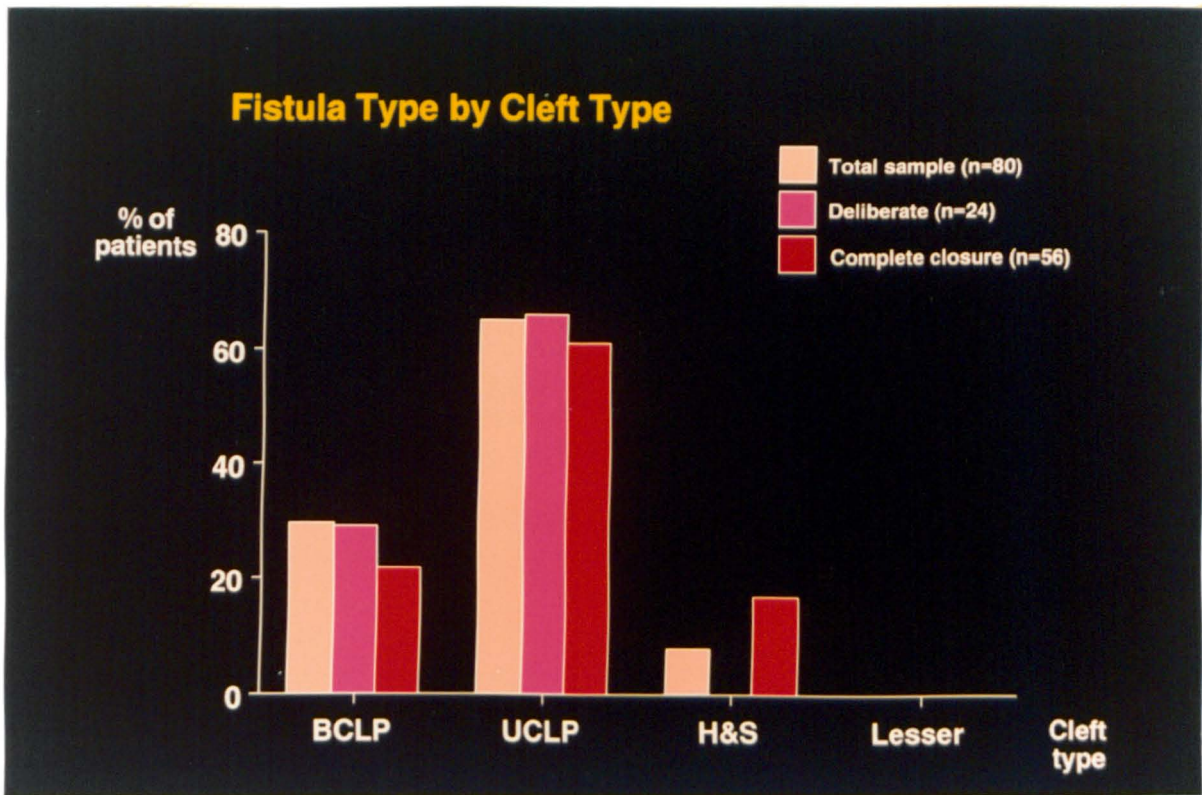
The second group examined was the group of patients who had had a deliberate fistula left at the time of palatal closure ( $N=24$ ). The reason for this appears to be related to surgical technique, as this feature was almost exclusively observed in patients operated on by one of the surgical teams. Ward and James (1990, p.14) write that,

*"The fistulae were on occasion an unavoidable compromise. Also in the course of dissecting and extensively mobilizing scarred and fibrotic nasal and oral layers of the palate linked under tension, ischaemia resulted with partial dehisence."*

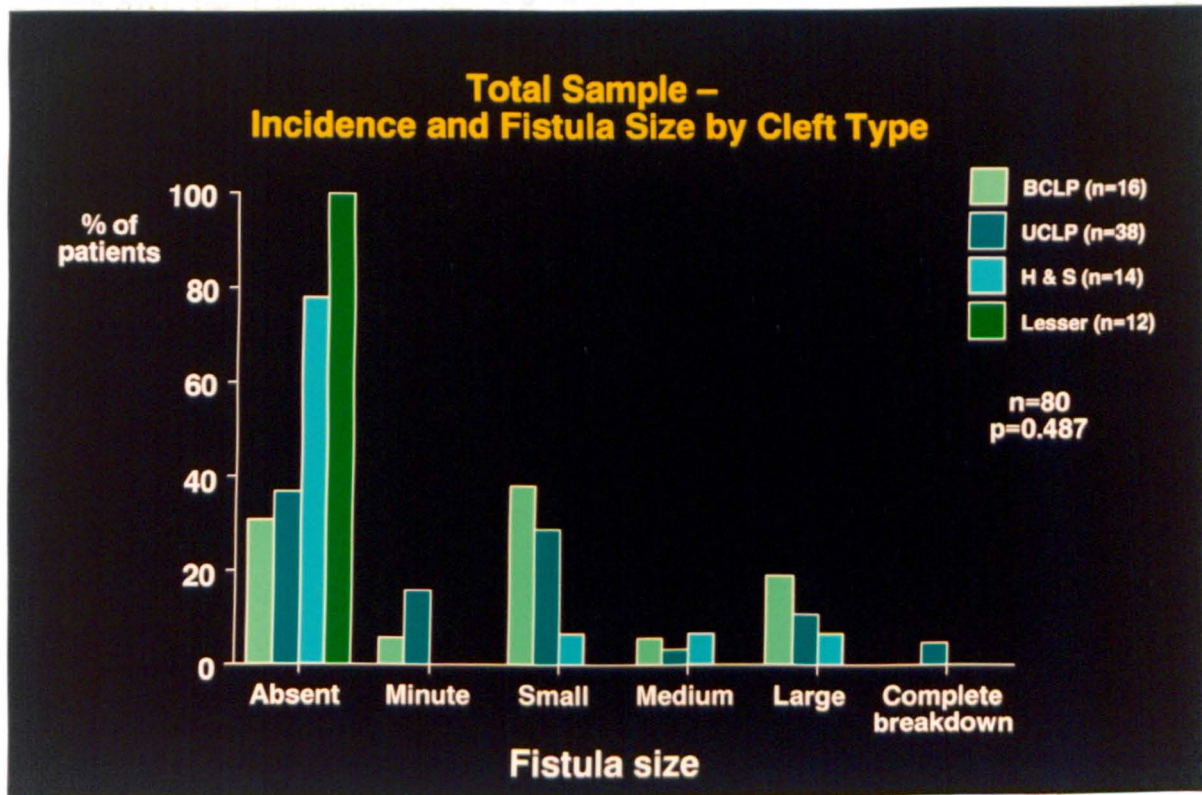
These data also suggest that the leaving of a deliberate fistula is also a function of age. Using the Chi-Square test, a significant difference in the occurrence of deliberate fistulae was found between the four different age groups ( $p < 0.001^*$ ). Figure 35 shows that 55% of all deliberate fistulae occurred in the children below the age of eight years at surgery, with an occurrence of 15% in each of the three other age groups. The small number of patients in the oldest two age groups is particularly noteworthy and this distribution is surprising. It was hypothesized that the adult group would have been the most challenging surgically, due to the characteristic fibrosed tissue, with the result that a deliberate fistula would be unavoidable. These results suggest that this was not the case.

Figure 34 shows that fistulae size was similar to the distribution of the total sample, except for a higher incidence of small fistulae. In four patients, although the surgical records indicated a deliberate fistula at surgery, it was not possible to detect these post-operatively, suggesting that spontaneous closure may have occurred. It is more probable, however, that they had not disappeared altogether, and that minute fistulae still remained. As can be seen in Figure 40, these four patients fell into the two youngest age groups. The youngest age group, which had the greatest number of deliberate fistulae, was found in all the size categories, except for complete breakdown. Figure 40 shows how deliberate fistulae in the children aged 8–10 years at surgery, and in the adolescents, were minute or small, as in the total sample. The fistulae that were left in the six adults were all small or large, and in the case of one adult, this developed into complete palatal

**Figure 37**



**Figure 38**



breakdown. However, there was no significant difference in the incidence and size of fistulae according to age (Kruskal-Wallis one-way analysis of variance,  $N=24$ ,  $H=6.321$ ,  $p = 0.097$ ).

With regard to cleft type, Figure 41 shows that all the deliberate fistulae occurred in cleft types BCLP and UCLP. No significant difference in the size of fistulae according to cleft type was found (Kruskal-Wallis one-way analysis of variance,  $N=24$ ,  $H=3.23$ ,  $p = 0.199$ ). Figure 41 shows that the size of fistulae was similar for both the BCLP and UCLP groups. This Figure also shows that a deliberate fistula left in the H&S group had disappeared by the post-operative follow-up, although again the more probable explanation is that it had not disappeared altogether, but that a minute fistula still remained.

#### ***ic. Group who had acquired fistulae.***

The third group examined was the group of patients who had total palatal closure (as determined by the surgical notes at palatoplasty:  $N=56$ ) but who presented with fistulae post-operatively. These fistulae were therefore described as acquired. The occurrence of fistulae in this group reflected the degree of true palatal breakdown post-operatively. Eighteen subjects had acquired a fistula, which represented 32% of the group who had complete palatal closure.

Figure 34 shows the incidence and degree of fistulae for this group. The distribution is similar to that of the total cohort.

A t-test revealed that there was a significant difference in the incidence of acquired fistulae according to age ( $t = -2.946$ ,  $p = 0.007^*$ ). Figure 35 shows the percentage of patients with acquired fistulae in each age group. The highest percentage occurred in the adults (61%), followed by an incidence of 33% in the adolescent group and only 6% in the children aged between 8–10 years at surgery. No breakdown occurred in the children below the age of eight years at surgery.

The distribution of patients according to fistulae size was similar to the total group. Figure 42 reveals that the number of patients in each age group is noteworthy. The two youngest age groups were surprisingly small and again this indicates that complete palatal closure was not as frequent as in the two oldest age groups.

A Kruskal-Wallis one-way analysis of variance revealed that there was a significant difference in the incidence and size of fistulae according to age ( $N=56$ ,  $H=11.686$ ,  $p = 0.009^*$ ). The adolescents and the children aged 8–10 years at surgery behaved very similarly. Approximately 25% of each group had fistulae, compared with 55% in the adult group. As age increased, the degree of fistulae increased. Minute and small fistulae characterized the adolescents and children aged between 8–10 years at surgery. The two largest categories of fistulae, and complete palatal breakdown, only occurred in the adult group.

With regard to cleft type, Figure 37 shows a similar distribution of fistulae in the BCLP and UCLP cleft groups. Fistulae found in the H&S group occurred after complete palatal closure. No fistulae occurred in the lesser cleft group.

A Kruskal-Wallis one-way analysis of variance revealed that there was a significant difference in the incidence

Figure 39

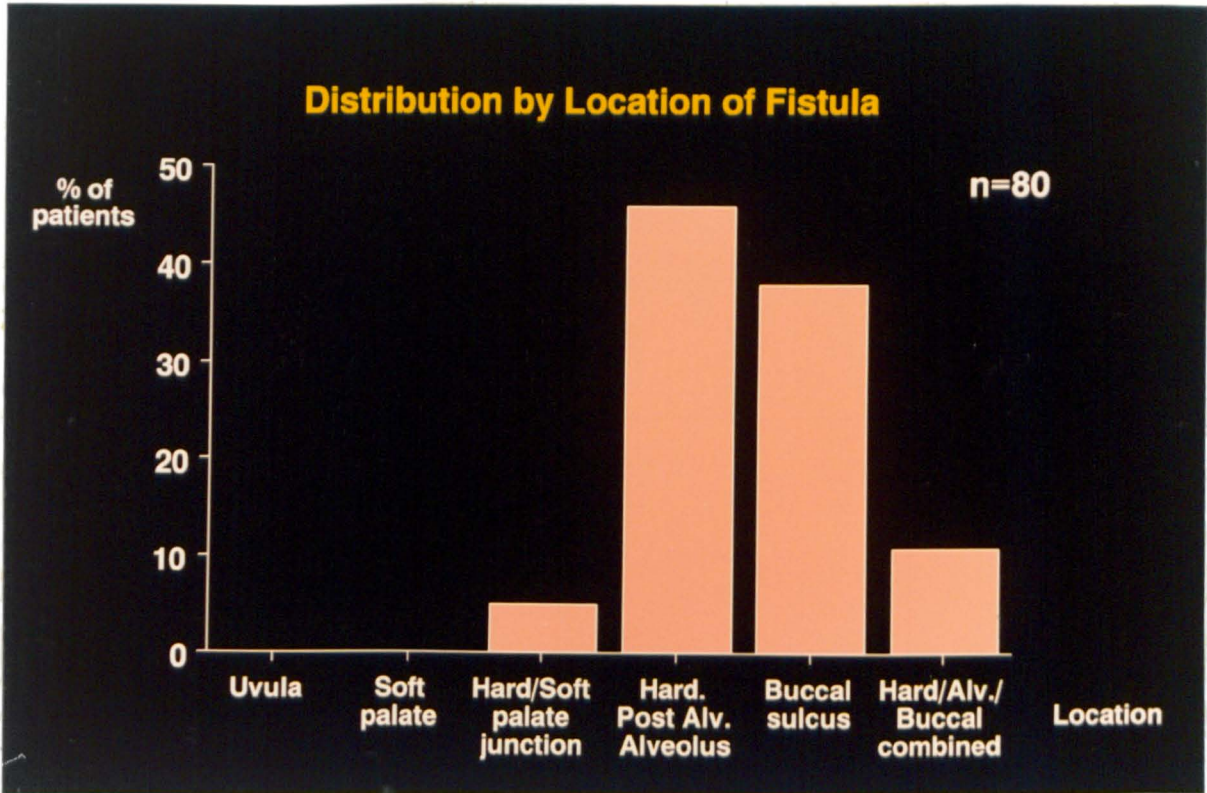


Figure 40

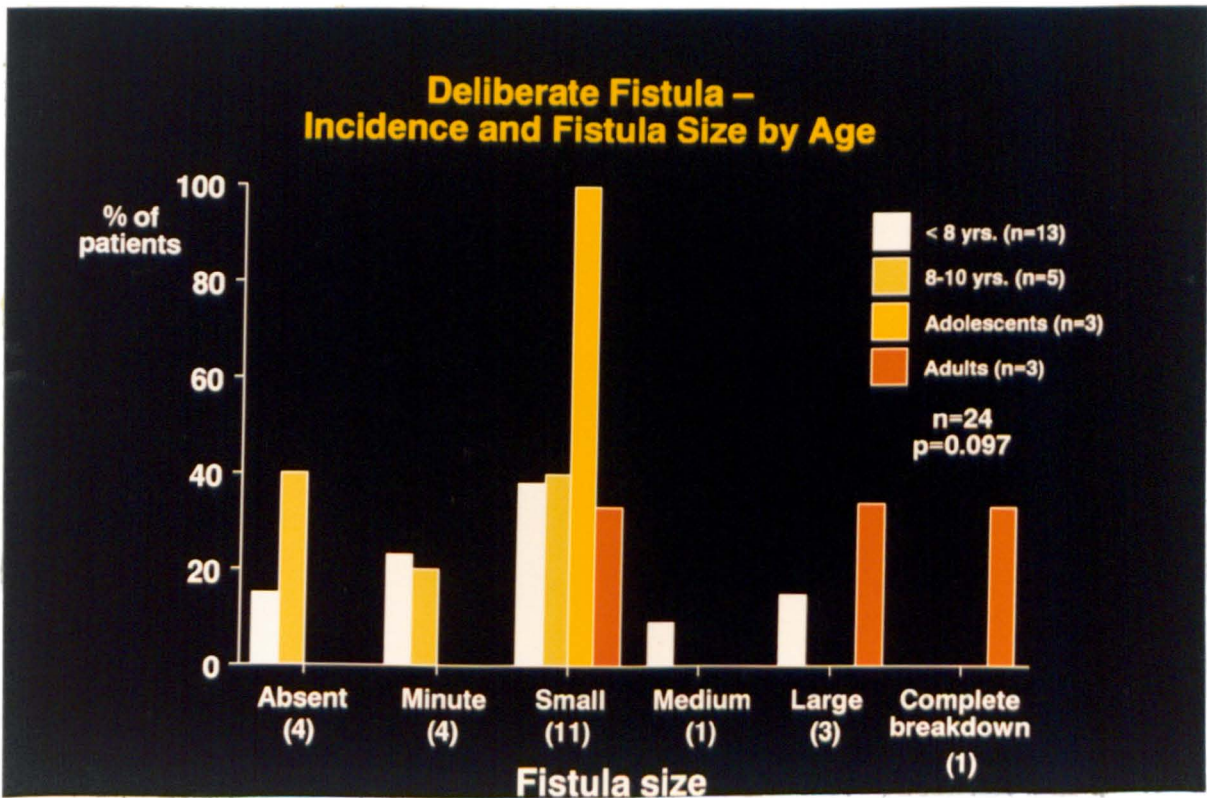




Figure 41

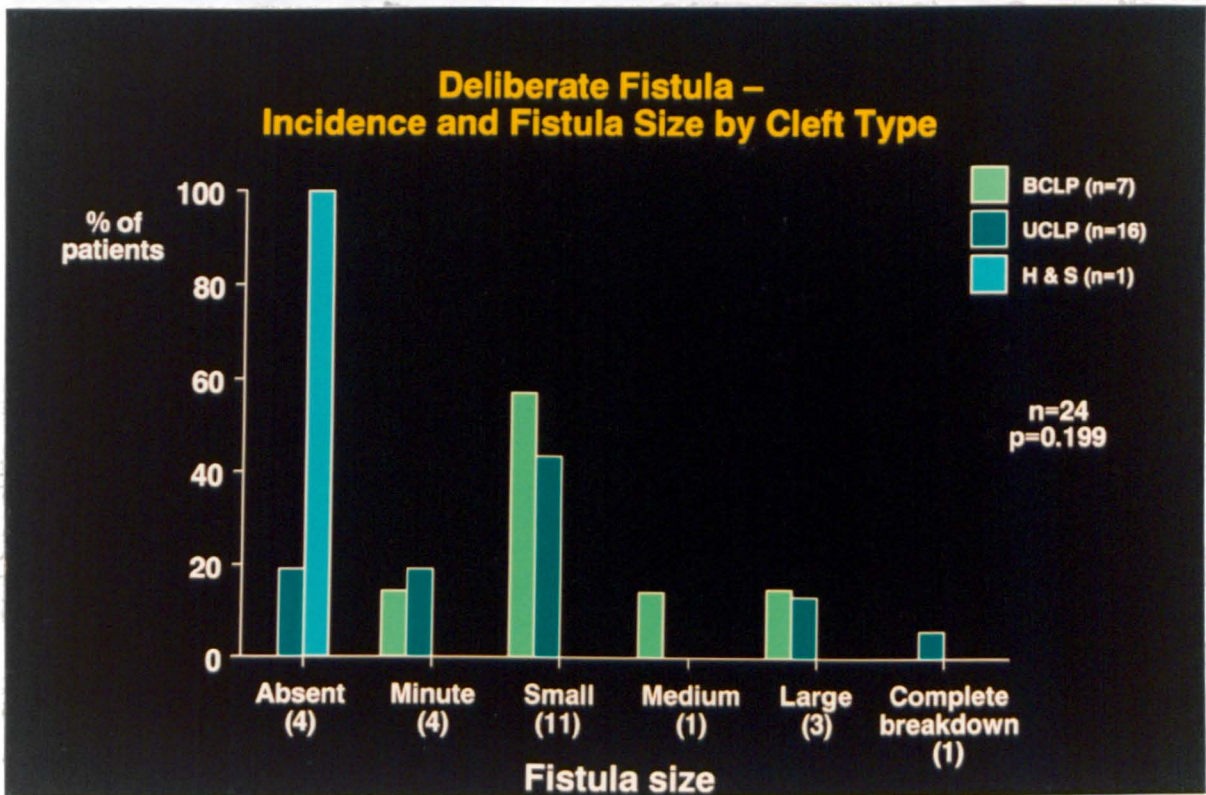
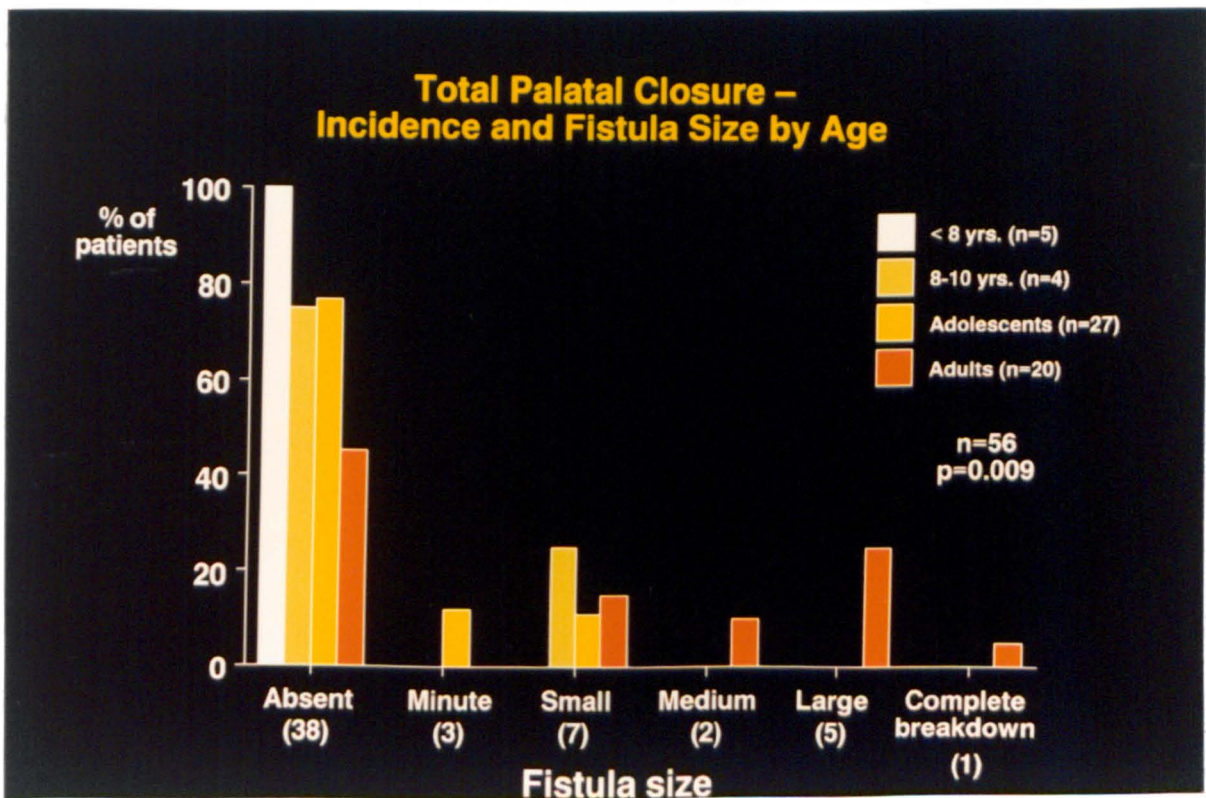
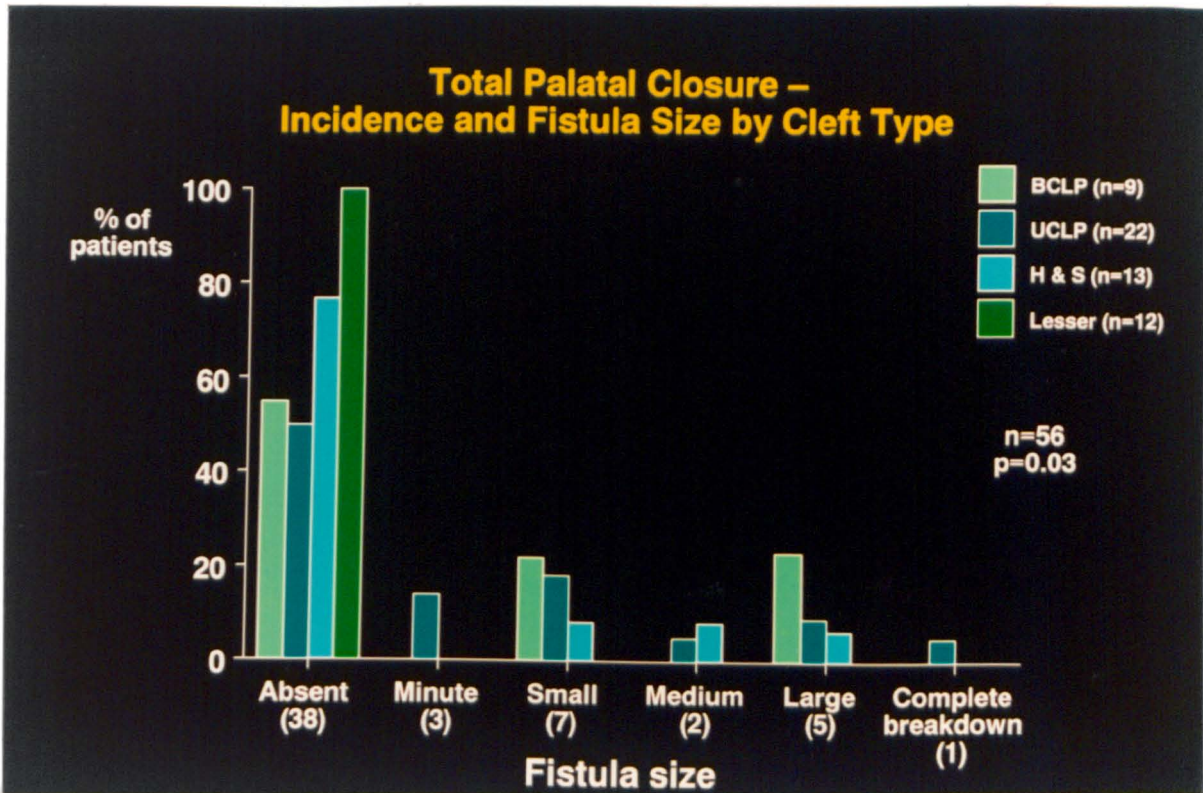


Figure 42



**Figure 43**



and size of fistulae (N=56, H=11.934,  $p = 0.03^*$ ) according to cleft type. Figure 43 shows how the BCLP and UCLP groups again behave very similarly. Approximately 50% of each of these cleft groups had fistulae. In contrast, approximately 25% of the H&S group acquired fistulae, and no fistulae occurred in the lesser cleft group. This pattern is very similar to the distribution found in the total group.

**(ii). Location of fistulae**

Figure 39 shows the percentage of patients according to where the fistulae occurred. Almost 50% occurred at the hard palate, postalveolus, or at the alveolus, two-thirds of which were deliberate fistulae. The remainder largely occurred at the buccal sulcus.

Patients were asked if they were aware of the fistula. Data was available for 76% of the patients, of whom 59% answered positively. When asked if the fistulae caused any problems, 50% considered the fistula did cause problems. Approximately half complained of food becoming impacted in the fistula, whereas the other half attributed nasal regurgitation to the fistula.

**(iii). Speech outcome and fistulae**

An investigation was undertaken to determine whether there was a relationship between the presence of fistulae and speech outcome (Table 43). Speech outcome was measured post-therapy, and at the 4/5 years post-operative follow-up.

*Table 43. Correlations between Fistulae and Speech Outcome Measures for the Total Group.*

	<b>Speech Categories</b>	<b>Speech Categories</b>
	<b>Post-therapy</b>	<b>at 4/5 years post-operative follow-up</b>
	<b>1988</b>	<b>1990</b>
Fistulae	-0.262	-0.319
	N=26	N=17

*Spearman's rho correlation coefficient.*

With reference to hypothesis 1, the same examination was undertaken on the adult group (Table 44).

*Table 44. Correlations between Fistulae and Speech Outcome Measures for the Adult Group.*

	<b>Speech Categories</b>	<b>Speech Categories</b>
	<b>Post-therapy</b>	<b>at 4/5 years post-operative follow-up</b>
	<b>1988</b>	<b>1990</b>
Fistulae	-0.234	-0.364
	N=26	N=17

*Spearman's rho correlation coefficient.*

The results for the total group and the adult group are very similar. There is a slight relationship between fistulae and speech results following therapy, and at the 4/5 years post-operative follow-up. A small negative correlation is found, with the implication that there was a slight trend for speech to be worse as the size of fistula increased.

At first glance, it is somewhat surprising that the relationship between speech outcome and presence and absence of fistulae was not stronger. Nevertheless, it can be explained. Henningsson and Isberg (1987) maintained that some types of deviant speech behaviour do not permit a valid evaluation of the effect of the fistula on speech. The compensatory articulations of glottal stops and pharyngeal substitutions are produced in the pharynx and glottis. The oral cavity, where the fistula is located, is never involved in the speech act for these sounds, and therefore it is impossible to determine the effect of the fistula on speech. Henningsson and Isberg (1987) further point out that if sounds are produced posterior to the fistula, the need for obturation will not even be noticed.

They maintain,

*"...it is not until speech therapy has corrected articulation substitution patterns that actual fistula contributions can be evaluated." (op. cit. p.189)*

However, in our sample, 58% of the three older age groups still exhibited compensatory articulations post-therapy and 42% at the 4/5 years post-operative follow-up. This implies that it is not possible or valid to

investigate the relationship of the fistula with speech in this population.

A second reason lies with the speech characteristics associated with fistulae. These are hypernasality, audible nasal air escape, an extra whistling component associated with a speech sound, and weak pressure consonants. (Henningsson and Isberg, 1990)

Since it was known that there would probably be a high incidence of hypernasality and nasal air escape post-operatively (Ortiz-Monasterio, 1966, 1974) the rating scale was designed to detect improvements in the manner categories of plosion, friction and affrication with coexisting hypernasality and nasal air escape. Therefore the speech characteristics described above were not being specifically measured in the framework of analysis used in this study. Furthermore no attempt was made to measure speech according to whether it was produced anterior or posterior to the fistula, as recommended by Henningsson and Isberg (1987).

Although a separate scale for the assessment of hypernasality was used, it was not possible to detect the aetiology of this speech symptom. Hypernasality may be associated, not only with fistulae, but also velopharyngeal insufficiency, the incidence of which was high in this sample. In order to determine the differential effects of fistulae and velopharyngeal insufficiency on nasality, it would have been necessary to have undertaken speech recordings and nasopharyngoscopy under two conditions, firstly with the anterior fistula blocked and then unblocked (Henningsson and Isberg, 1987). Even then, the high incidence of compensatory articulations would have interacted with the results. In any event, within the logistics of the Sri Lankan project, this time-consuming task was not possible. Therefore the measure of hypernasality cannot be used to examine the relationship of fistulae with speech outcome.

#### ***Iv. Lateral pharyngeal wall movements and fistulae***

An examination of the data was undertaken to determine if there was a significant difference in lateral pharyngeal wall movements and the presence or absence of fistulae. Using a Mann-Whitney U test, a significant difference was found in the movement of the right lateral pharyngeal wall ( $U=278.5$ ,  $p = 0.022^*$ ) and movement of the left lateral pharyngeal wall ( $U=264.00$ ,  $p = 0.012^*$ ), depending on whether a fistula was present or not. Table 45 shows the mean scores and standard deviations related to pharyngeal wall movement in the presence and absence of fistulae.

These data indicate that where a fistula was present, there was less lateral pharyngeal wall movement than when there was no fistula.

*Table 45. Descriptive Statistics related to Lateral Pharyngeal Wall Movements in the Presence and Absence of Fistulae.*

	<b>FISTULAE PRESENT</b>		<b>FISTULAE ABSENT</b>	
	<b>LPW</b>	<b>RPW</b>	<b>LPW</b>	<b>RPW</b>
N	25	25	34	34
Minimum score	0.0	0.0	1.0	1.0
Maximum score	5.0	5.0	6.0	6.0
Mean	2.76	2.96	3.85	3.94
Standard deviation	1.48	1.42	1.5	1.48

These data support the findings of previous researchers (Isberg and Henningsson, 1987) who reported decreased lateral pharyngeal wall movement during speech in the presence of anterior fistulae.

### **Conclusion**

With reference to the aims and hypotheses outlined above, the occurrence of palatal fistulae in this sample was 30% for the total group (i.e. the whole population) and 32% for those subjects who had surgery to effect complete palatal closure.

Fistulae in the youngest age group were the result of having been deliberately left at surgery in the BCLP and UCLP cleft groups. All the fistulae size categories except for complete breakdown were represented in this age category.

In contrast, the fistulae found in the adult group were primarily a result of palatal breakdown. The adult group was characterized by the highest incidence and degree of palatal breakdown, not only where fistulae were left at surgery, but also where fistulae were acquired.

Where fistulae occurred in the adolescents and children aged 8–10 years at surgery, these were no larger than the small fistulae size category.

When there had been complete palatal closure, as age increased, the incidence of fistulae increased.

Fistulae in this series occurred almost only in complete cleft lip and palate cases, and not at all in cases involving clefts of the posterior third of the hard palate and/or soft palate only. There was no difference in size of fistula between these two cleft groups.

The majority of palatal fistulae occurred in the hard palate, postalveolus, or at the alveolus.

A relationship between fistulae and lateral pharyngeal wall movements was found. With regard to the relationship between speech outcome and fistulae, only a slight relationship was found for the total group. The question of the validity of such a relationship in this study has been discussed.

The hypothesis with regard to adult patients exhibiting a higher degree of palatal fistulae has in part been upheld: adults were characterized by the highest degree of palatal fistulae, not only when fistulae were left at surgery, but also when fistulae were acquired. Where there had been complete palatal closure, the incidence of fistulae increased with age. Only a slight relationship was found between fistulae and speech outcome for the adult group.

### ***c. Surgical Observations at Palate Repair***

#### ***Aim***

The aim of this part of the study is to determine if the surgeons' observations at the time of palatal repair were predictive of speech outcome and post-operative velopharyngeal function.

There have been surprisingly few studies in this area. Van Demark (1974a) evaluated cleft width before surgery, and correlated this with articulation but the correlation was low ( $r = 0.28$ ), indeed similar to the correlations found in this study. In an unpublished study, Tobe and Salyer (1989) examined retrospectively one surgeon's rating of the levator muscle complex and tissue deficiency at the time of palatoplasty of thirty-five patients with nonsyndromic clefts of the palate or lip and palate. Unlike in the present study, the surgeon made a prediction about ultimate velopharyngeal function. All the patients were below the age of 12 months when they underwent palatoplasty. Tobe and Salyer found that the surgeon was able to predict with 100% accuracy where either the levator muscle complex or tissue was rated as very good. However, when these two parameters were rated as moderate or very poor, his ability to predict decreased, implying that some of this group developed velopharyngeal insufficiency and some did not. They concluded that the characteristics of the levator muscle complex and tissue deficiency in themselves are insufficient to predict ultimate velopharyngeal adequacy.

#### ***Hypotheses***

1. The degree of post-operative and post-therapy speech change is related to the characteristics of the repair observed by the surgeon at the time of palatoplasty.
2. Post-operative velopharyngeal function is related to the characteristics of the repair observed by the surgeon at the time of palatoplasty.

#### ***Subjects***

These surgical findings were only available for the 1986 surgical cohort, which consisted of 21 patients: 7 children below the age of 8 years, 3 children aged 8–10 years at surgery, 4 adolescents, and 7 adults. Each section was totalled, and an overall score for surgical observations was calculated. The mean overall score was 19.2, with a range of 14–27. Table 46 shows the raw data relating to speech, velopharyngeal function and surgical observations.

Table 46. Raw Data relating to Speech, Velopharyngeal Function and Surgical Observations.

Pt	Sp.Patterns			X-rays	Nasopharyn.	Nasality	Fib.	Mus.Qua.	Ove.
	pre.	pst.	psth.						
1		1	1	1		0	3	7	16
2		4	4	3		1	3	6	14
3		6	6	3		1	3	6	16
4		1	1	3	3	0	5	8	20
5		14		1	1	3	3	7	18
6		1	1				4	7	20
7		4	4	3	3	0	5	8	20
8	1	1	2	3		0	5	6	17
9	2	5	7	1	2	3	6	9	23
10		3	5	3	3	0	6	9	23
11		17	17	1	1	3	3	6	16
12	1	9	10				3	6	16
13	7	7	7	3	3	0	3	7	16
14	3	3	3	3	3	0	5	8	20
15	1	1	5	3	3	0	8	9	26
16	1	1	1	3	3	0	9	10	27
17	11	11	12	2	3	0	6	8	19
18	1	1	1	3	4	0	5	6	16
19	1	1	1	3	4	0	9	11	26
20	3	1	5	3	3	0	5	6	18
21	9	14	14	3	3	0	5	6	18

LEGEND: Pt. patient Pre. pre-operative  
 Nasopharyn. nasopharyngoscopy Pst. post-operative  
 Fib. fibrosis Psth. post-therapy  
 Mus.Qua. muscle quality Ove. overall score

The X-ray data showed that there were two patients with missing data. Fourteen patients had VPI, one patient had marginal closure and four patients had closure. The nasopharyngoscopy data showed that there were five patients with missing data. Thirteen patients had VPI, one patient had borderline closure, and two patients demonstrated closure. The nasality data showed that there were two patients with missing data. Fourteen patients were hypernasal, two patients had mild hypernasality, and three patients had oral/hyponasal resonance.

A Spearman's rho correlation coefficient was performed to see if there was a relationship between the speech results pre-operatively, post-operatively, and following therapy, and the different sections of surgical observations at the time of surgery (Table 47).

*Table 47. Correlations between the Speech Results Pre-operatively, Post-operatively, and Following Therapy, and the Three Different Sections of Surgical Observations.*

	<b>Pre-operative speech</b>	<b>Post-operative speech</b>	<b>Post-therapy speech</b>
Section on degree of fibrosis	-0.399	-0.010	-0.01
Section on degree of muscle quality	-0.328	-0.303	-0.245
Section on miscellaneous observations	-0.102	-0.022	-0.155
Section on overall surgical observations	-0.235	-0.263	-0.11
N	13	21	19

*Spearman's rho Correlation Coefficient.*

A slight negative correlation was found between pre-operative speech and degree of fibrosis section (-0.399) and degree of muscle quality of the velum section (-0.328). In other words, as the speech rating increased, the degree of fibrosis decreased, and muscle quality of the velum improved. There was no relationship, however, between the overall surgical observations and the pre-operative speech ratings (-0.235).

A slight negative correlation was found between post-operative speech and degree of muscle quality of the velum section (-0.303). Therefore the same relationship existed: as the speech rating increased, muscle quality of the velum increased. There was no relationship, however, between the overall surgical observations and the post-operative speech ratings (-0.263).

No correlation existed between post-therapy speech and overall surgical observations section (-0.110), degree of fibrosis section (-0.010), and muscle quality of the velum section (-0.245).

A Spearman's rho correlation coefficient was performed to see if there was a relationship between the three post-operative measures of velopharyngeal function, and the surgical observations at the time of surgery (Table 48).



*Table 48. Correlations between Surgical Observations and the Three Post-operative Measures of Velopharyngeal Function.*

	<b>Nasality</b>	<b>Nasopharyngoscopy</b>	<b>X-ray</b>
Section on degree of fibrosis	-0.355	0.385	0.220
Section on degree of muscle quality	-0.362	0.155	0.003
Section on overall surgical observations	-0.324	0.131	0.144
N	19	16	19

*Spearman's rho Correlation Coefficient.*

A slight negative correlation between the nasality rating and the sections on degree of fibrosis, muscle quality of the velum, and overall surgical observations was found. There was a trend, therefore, that as nasality improved, the degree of fibrosis decreased and muscle quality of the velum improved.

There was a slight positive correlation between the nasopharyngoscopy results and degree of fibrosis section, but no relationship with the sections degree of muscle quality and overall surgical observations.

No relationship existed between the X-ray results and any of the categories of surgical observations.

From this sample, the section on overall surgical observations had no significant relationship to speech at the different data points. Sections on degree of fibrosis and muscle quality of the velum had a slight relationship with speech over time.

The post-operative measure of nasality did show a consistent, albeit slight, relationship with the overall surgical observations. Nasopharyngoscopy showed a similar relationship with the degree of fibrosis section.

The possibility that specific features of the palatal repair might demonstrate higher correlations with the post-operative measures of velopharyngeal function was investigated further. A Spearman's rho correlation coefficient was performed to see if there was a relationship between the three post-operative measures of velopharyngeal function and four individual items: mobilization of levator palatini muscle, quality of levator muscle, tensor palatini, and the estimate of tension in the velar repair (Table 49).

*Table 49. Correlations between Selected Features of Palatal Repair and the Three Post-operative Measures of Velopharyngeal Function.*

	<b>Nasality</b>	<b>Nasopharyngoscopy</b>	<b>X-rays</b>
Mobilization of levator palatini muscle	-0.260	0.218	0.107
Quality of levator muscle	-0.351	0.374	0.152
Tensor palatini	-0.203	0.034	0.203
Estimate of tension velar repair	-0.112	0.122	0.046
N	19	16	19

*Spearman's rho Correlation Coefficient.*

These data show that the X-rays had no relationship with the individual items. The strongest correlations were found between both nasality and nasopharyngoscopy with the item on quality of the levator muscle. A slight negative correlation (-0.351) between nasality, and quality of levator muscle suggests that as nasality improved, the muscle quality of the velum improved. This finding is similar to that found using the section on degree of muscle quality.

There was a slight positive correlation (0.374) between nasopharyngoscopy and quality of levator muscle, indicating a trend that as nasopharyngoscopy improved, muscle quality improved too. Nasopharyngoscopy is therefore more highly related to the specific item on quality of levator muscle than the section on the degree of muscle quality of the velum.

### ***Discussion***

These data suggest that observations by the surgeons at the time of surgery do not distinguish patients according to their speech performance at that time, and more importantly, how they subsequently perform in terms of articulation post-operatively and post-therapy.

In addition the ten surgical observations were not highly related to velopharyngeal function, even when individual items on the scale were examined.

An examination of the data helps clarify the reasons for these results. Table 46 demonstrates that two patients with velopharyngeal closure on nasopharyngoscopy scored at the lower end of the range of the overall scores. Almost the whole range of overall scores was found in the group with velopharyngeal insufficiency. Similar results were found for the measures of nasality, and X-rays. Furthermore, an examination of the speech patterns in relation to the overall scores shows that there is no relationship. For example, patients 1, 4, 16, 18, and 19 all had the worst speech pattern, but almost the whole range of the overall surgical scores is found.

Despite the fact that these observations were made on a small sample of the total study group (N=21), the findings appear to be conclusive. Surgical observations at the time of palatoplasty are not predictive of speech outcome and post-operative velopharyngeal function in patients undergoing late palatoplasty.

However, a weakness in the methodology should be addressed. The framework for the recording of surgical observations was designed by one surgeon, but used by seven surgeons. No attempt was made for each surgeon to achieve inter- and intra-rater reliability on the measures. It is reasonable to conclude that there was probably considerable variability in the way in which the surgeons graded the items in the scale. Therefore, these conclusions need to be considered within the weaknesses of the study.

The present study is slightly different in design from Tobe and Salyer's (1989). In that study, the one surgeon involved made a prediction about ultimate velopharyngeal function, and all the patients were below the age of 12 months.

In this study, the surgeons' assessments of the levator muscle complex and tissue were correlated with measures of velopharyngeal insufficiency and speech. Six surgeons were involved and patients of all ages were included.

Despite this, the findings agree with those of Tobe and Salyer. In particular, the two studies are similar where there are poor ratings on the levator muscle complex. Tobe and Salyer also found variability in velopharyngeal outcome in this situation.

## **VII. Intervention: Therapy**

### ***Aim***

The aim of this part of the study was to determine the effects of two different therapeutic approaches on imitation skills and speech production used during the first ten day intervention course in July 1986.

### ***Hypothesis***

Patients who receive palatal closure supported by subsequent articulation therapy result in positive changes in articulatory skills in imitation and single words compared with patients who receive palatal closure supported by conversation therapy.

The initial approach to this hypothesis was to examine whether improvements occurred with each type of therapy. The following two hypotheses were formulated:

- (i) Patients will improve on articulation skills in imitation and single words as a result of palatal closure and subsequent articulation therapy.
- (ii) Patients will improve on articulation skills in imitation and single words as a result of palatal closure and subsequent conversation therapy.

It was predicted that hypothesis (i) would be accepted, and hypothesis (ii) would be rejected.

### ***Results***

#### ***Imitation of Singletons***

Based on the groups who had received articulation therapy, the imitation of singletons at the post-operative stage was compared with the scores at the end of the July therapy course. The number of correct imitations was converted into a percentage score. Using the Wilcoxon Signed Ranks Test, there was a significant difference between the post-operative and post-therapy course scores ( $p < 0.038^*$ : one-tailed test).

In contrast, based on the groups who had received conversation therapy, there was no significant difference between the post-operative and post-therapy course scores (Wilcoxon Signed Ranks Test,  $p > 0.339$ ).

#### ***Imitation of Trisyllables***

Based on the groups who had received articulation therapy, the imitation of trisyllables at the post-operative stage was compared with the scores at the end of the July therapy course. The number of correct imitations was converted into a percentage score. Using the Wilcoxon Signed Ranks Test, there was a significant difference between the post-operative and post-therapy course scores ( $p < 0.001^*$ ). Similarly, based on the groups who had received conversation therapy, there was a significant difference between the post-operative and post-therapy course scores (Wilcoxon Signed Ranks Test,  $p = 0.018^*$ ). However, it is noteworthy that the significance level is not as high for the conversation group.

### ***Single Word Utterances***

The raw scores for place, manner and voice were totalled for single word utterances at the post-operative stage. They were compared with the same measures at the post-therapy stage for the articulation groups. Using the Wilcoxon Signed Ranks Test, there was a significant difference between the post-operative and post-therapy course scores ( $p = 0.05^*$ ; one-tailed test).

The raw scores for place, manner and voice were totalled for single word utterances at the post-operative stage. They were compared with the same measures at the post-therapy stage for the conversation groups. Using the Wilcoxon Signed Ranks Test, there was a significant difference between the post-operative and post-therapy course scores ( $p = 0.009^*$ ). It is relevant to observe, however, that the average degree of 'improvement' in the articulation group (1.47) was marginally higher than in the conversation group (1.38).

Therefore, on the task of singletons imitation, hypotheses (i) was upheld and hypothesis (ii) was rejected, validating the predictions. The imitation of singletons improved with articulation therapy, but not with conversation therapy.

For the task of trisyllables imitation and single word utterances hypothesis (i) was similarly upheld, but hypothesis (ii) was not rejected as predicted. Significant changes were made by both the articulation and conversation groups on single word utterances and imitation of trisyllables.

These results suggest that while the two therapies are quite different, both result in improvement. It is noteworthy however that the articulation group gained higher scores on both the imitation tasks than the conversation group. Furthermore, an examination of the speech categories of both groups at the post-operative and post-therapy stages suggests some small differences between the groups, in favour of the articulation groups. 88% of the conversation groups stayed in the same speech category compared with 78% of the articulation groups. Only one patient (4%) in the articulation groups improved by more than one speech category: no patients in the conversation groups did so. Therefore these data do suggest that the articulation groups did marginally better. Fewer patients stayed within the same speech category and the one patient who made significant improvement had been in the articulation group.

Even so, by examining the data using the speech categories and recalling the criterion that in order for a change to be perceptually significant there had to be a change of more than one speech category, the overriding impression gained is that improvements were negligible. On reflection these results are not surprising given the length of the therapy course.

The next stage in the hypotheses testing was to examine if there were differences between the articulation groups and the conversation groups on the different speech tasks.

The following results were found:

#### ***Imitation of Singletons***

Using the Mann-Whitney test, there was no significant difference ( $U=206.5$   $p = 0.277$ ) between the articulation

groups and the conversational groups.

### ***Imitation of Trisyllables***

Using the Mann-Whitney test, there was no significant difference ( $U=178.5$   $p = 0.794$ ) between the articulation and the conversation groups.

### ***Imitation of Single Words***

Using the Mann-Whitney test, there was no significant difference ( $U=211.5$   $p > 0.354$ ) between the articulation and the conversation groups.

These results indicate that, although the articulation groups did marginally better, there were no differences between the groups on the separate tasks following therapy.

The hypothesis states that patients who receive palatal closure supported by subsequent articulation therapy should result in positive changes in articulatory skills in imitation and single word utterances compared with patients who receive palatal closure supported by conversation therapy. This, however, was not proven. Although this hypothesis was not proven, our initial view that both types of therapy are relevant to this group of individuals was confirmed, as positive responses were obtained from both groups. Indeed, given the difficulties of matching patients before the course, further investigation was undertaken to determine if the groups differed in other ways, which could account for the unexpected finding of the conversation group making small changes. An examination of two variables, those of years of education, and concern/worry about speech, was undertaken.

The number of years of education was determined for each patient and converted into a percentage score according to the number of years of possible attendance. This was from 5 years of age until 18 years, a total of 13 years.

There was no significant difference between the groups in the number of years of education (Mann-Whitney U test,  $N = 45$ ,  $U = 294.0$ ,  $p = 0.054$ ). This result, however, almost reached significance. An examination of the means and standard deviations for each group revealed a higher proportion of educated people in the conversation group, as shown in Table 50.

*Table 50. Means and Standard Deviations for Conversation and Articulation Groups.*

	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Standard Deviation</b>
Conversation	23%	100%	87.286	21.845
Articulation	0%	100%	68.714	32.506

There was a wider range of scores in the articulation group, accounting for the differences in standard deviations. The mean of the articulation group was lower than that of the conversation group. It is possible therefore that the conversation group consisted of brighter individuals used to participating in an educational type environment.

A further question was to determine whether the patients' degree of concern or worry about their speech affected their response to therapy (see Appendix Vd). Although recognizing that attendance is affected by many factors, it could be argued that level of attendance at all the speech therapy courses may have reflected a patient's concern about his/her speech. This surgical cohort could have attended a maximum of three courses.

The Mann-Whitney U test was used to determine if there was a significant difference between the groups on the number of courses attended. No significant difference was found ( $N=45$ ,  $U = 273.5$ ,  $p = 0.613$ ).

Another less direct measure which may reflect the patients' attitudes towards their speech and therapy may be found from the attitudes ratings (see Appendix Vd). Patients were asked to judge their speech post-operatively (either July or November 1986) on the continuum: speech worse – speech better. The patient was asked to imagine a photo of himself glued onto a lollipop stick, and to place the stick at the point on the continuum where he/she rated his/her speech at the time, a second rating as to where he/she rated his/her speech change to in reality, and a third rating as to where he/she would ideally like his/her speech to be.

The Mann-Whitney U Test was used to see if there was a significant difference between the conversation and articulation groups for each of the points in time. No significant differences were found:

rating at the present time  $U = 129.0$   $p = 0.690$

rating as to change in reality  $U = 104.000$   $p = 0.738$

rating as to ideal change  $U = 137.5$   $p = 0.459$

Therefore these measurements appear to suggest that the groups were the same in terms of their worry or concern about their current speech status, their predictions about how their speech could improve in reality, and their ideas of what would constitute ideal speech.

In conclusion, these groups did not differ in their degree of concern or worry about speech, but the results indicate that the conversation group consisted of people who had received more years of education, and therefore were arguably more used to receiving instruction.

It may also be possible to account for the small changes in the two groups as a result of sudden attention to their speech. The majority of these patients were frequently reluctant communicators with little experience of functioning in a group. They had an expectation of improving their speech not only because of the recent surgery but also as a result of the therapy that they were experiencing. All the patients gained in confidence and undertook the post-course video recording in a much more positive manner. It is possible that the small averaged increase in scores in both groups on the controlled speech sample is a reflection of this.

In addition, it is quite possible that there was some contamination of the therapeutic approaches. All the patients had formed friendships with each other, and all of them stayed in hospital accommodation for the duration of the ten-day course. The articulation groups were given handouts as part of the treatment, unlike

the conversation groups, and were instructed to practise specific tasks together. It was not possible to determine whether the conversation groups were involved in this practice. Indeed one of the patients specifically asked how speech would improve using the conversation technique, so there was some awareness of the differing therapeutic approaches.

This study represents only a crude attempt at assessing two different types of therapies, by using the conversation approach as the experimental control. In so doing, it was hoped to ensure that if there were any benefits in speech production, the actual form of therapy would not be contaminated by a sudden intensive attention to communication. The results serve to emphasize the complexity of the factors involved when examining the effectiveness of therapy. One of the weaknesses of this study, for example, is the limitations in the matching of patients in the two groups, in particular with regard to variables such as velopharyngeal status, speech characteristics, and imitation.

The possibility of not providing any speech therapy, as a form of control for the articulation intervention was discussed, but ethical concerns prevented this approach from being adopted. Given that there is only one speech therapist in Sri Lanka (Wirt et al., 1990a, 1990b) this was the one opportunity that these patients had of receiving speech therapy, which could not be withheld. The conversation approach, in fact, is not usually used in therapy with cleft palate children. Huber (1957) criticized the emphasis placed by some upon socialization and psychotherapy as a means of improving the patient's speech. McWilliams et al. (1984, p.316) agreed with this in part, in their comment,

*"...the encouragement of language use in social contexts and psychotherapy is not a means of training articulation."*

Even so, they did recognize that it is often an important component in a total rehabilitation programme, and therefore, on an ethical basis, was judged to be an appropriate control therapy.

Furthermore, the comments by Huber (1957) and McWilliams et al. (1984) appertained to patients treated at more conventional ages in the West, where knowledge and understanding of the condition is completely different from the patients in this study. In an environment where there is little understanding about the nature of the deformity, associated speech problems and difficulties in communication, an approach which also embraces wider issues in communication is advocated. Within the context of this project, both intervention approaches, one aimed directly at the speech problem, and the other at the impaired communication process, were justifiable and viable philosophies of rehabilitation. Subsequent therapy courses included both approaches.



## **VIII. Imitation of Singletons and Imitation of Trisyllables**

### ***Aim***

The aim of this section is:

- (i). to determine if surgery, and surgery supported by articulation therapy, affected the ability to imitate single sounds (singletons), and trisyllables.
- (ii). to investigate the relationship of imitation of singletons at the significant data points with changes in speech post-therapy.

### ***Hypotheses***

The following hypotheses were tested

1. Palatal closure alone does not change the ability to copy trisyllables and singletons.
2. Palatal closure supported by speech therapy does change the ability to copy trisyllables and singletons.
3. Patients with low imitation scores on singletons at the pre-operative, post-operative, and post-therapy stages do not make significant changes in speech post-therapy.

### ***Results***

1. Palatal closure alone does not change imitation scores. Surgery supported by therapy may result in positive changes in imitation scores.

#### ***Imitation of Singletons***

Based on the whole sample (including children below the age of eight years where data was available), the imitation of single consonant sounds at the pre-operative stage was compared with those scores at either 8 or 20 months post-operatively. The number of correct imitations was calculated as a percentage of the total number (10 singletons). Using the Wilcoxon Signed Ranks Test, there was no significant difference between the pre-operative and post-operative data points ( $p = 0.52$ ).

The imitation of single consonant sounds at the post-operative stage was compared with those scores post-therapy. Using the Wilcoxon Signed Ranks Test, there was a significant difference in imitation scores between the post-operative and post-therapy data points ( $p < 0.001^*$ )

#### ***Imitation of Trisyllables***

Based on the whole sample (including children below the age of eight years where data was available), the imitation of trisyllables at the pre-operative stage was compared with those scores at either 8 or 20 months post-operatively. The number of correct imitations was calculated as a percentage of the total number (12 trisyllables). Using the Wilcoxon Signed Ranks Test, there was a significant difference between the two data

points ( $p = 0.039^*$ ).

The imitation of trisyllables at the post-operative stage was compared with those scores post-therapy. Using the Wilcoxon Signed Ranks Test, there was a highly significant difference in imitation scores between the post-operative and post-therapy data points ( $p < 0.001^*$ ).

It was predicted that surgery alone would not specifically affect a patient's ability to imitate speech sounds in isolation, and speech sounds in combination with vowels. It was predicted that therapy would facilitate this imitation skill. The results indicate that this hypothesis was upheld for singletons. However, only part of the hypothesis was upheld for trisyllables. Unexpectedly, surgery alone improved trisyllable imitation. Undoubtedly, however, therapy made a highly significant difference to the imitation of trisyllables. The differences in the degree of change at the post-operative and post-therapy stages are seen when the mean scores are examined. An examination of the mean scores for the imitation scores at each of the data points (Table 51) shows that the amount of improvement for the imitation of trisyllables post-operatively (35.11) was considerably less than that post-therapy (51.8). This clearly shows that therapy made a considerable difference to the imitation of trisyllables.

*Table 51. Means of Imitation of Singletons and Trisyllables at the Pre-operative, Post-operative and Post-therapy Stages.*

	<b>N</b>	<b>Mean Score</b>
Imitation of singletons pre-operatively	60	27.233
Imitation of singletons post-operatively	84	27.6
Imitation of singletons post-therapy	82	57.37
Imitation of trisyllables pre-operatively	48	30.67
Imitation of trisyllables post-operatively	82	35.11
Imitation of trisyllables post-therapy	81	51.83

2. Patients with low imitation scores at the pre-operative, post-operative, and post-therapy stages do not make significant changes in speech post-therapy.

Experience of the patient's imitation skills suggested that those patients who do not imitate well at all the data points are the patients who make no or minimal changes in speech. When patients scored below 26% on the task of singletons imitation at all the data points, a Wilcoxon's Signed Ranks test showed that there was no significant difference in the pre-operative and post-therapy speech categories ( $p = 0.577$ ).

Therefore this hypothesis was upheld: patients with low imitation scores of less than 26% correct on the singletons imitation at the pre-operative, post-operative, and post-therapy stages did not make significant changes in speech post-therapy.

A further investigation was undertaken to find out if there was any predictive value in low pre-operative imitation scores in terms of speech outcome. It was predicted that patients who had low pre-operative imitation scores would not make significant changes in speech post-therapy.

An examination was therefore undertaken to determine if there was a significant difference between the pre-operative and post-therapy speech categories of patients who had scored less than 26% correct on the imitation of singletons pre-operatively. Using a Wilcoxon Signed Ranks test, a significant difference was found ( $p < 0.001^*$ ).

This hypothesis was therefore not upheld. These data suggest that the group who scored less than 26% correct on the pre-operative imitation of singletons made significant changes in their post-therapy speech categories. Clinical experience suggests that this is not the finding for all patients who score at a low level pre-operatively on the task of imitation of singletons. It is thought, therefore, that this group of patients probably consisted of subgroups of patients in terms of outcome. An examination of the pre-operative and post-therapy speech categories supports this. Figure 44 reveals how 18 (N=25) of patients (72%) who scored less than 26% correct on the pre-operative imitation of singletons, fell into Speech Categories A and B pre-operatively. 7 (28%) met the criterion of moving more than one category resulting in a perceptual change. Therefore, although the majority of patients did not make appreciable changes, approximately 20% did. Therefore a low pre-operative imitation score does not necessarily mean poor speech outcome.

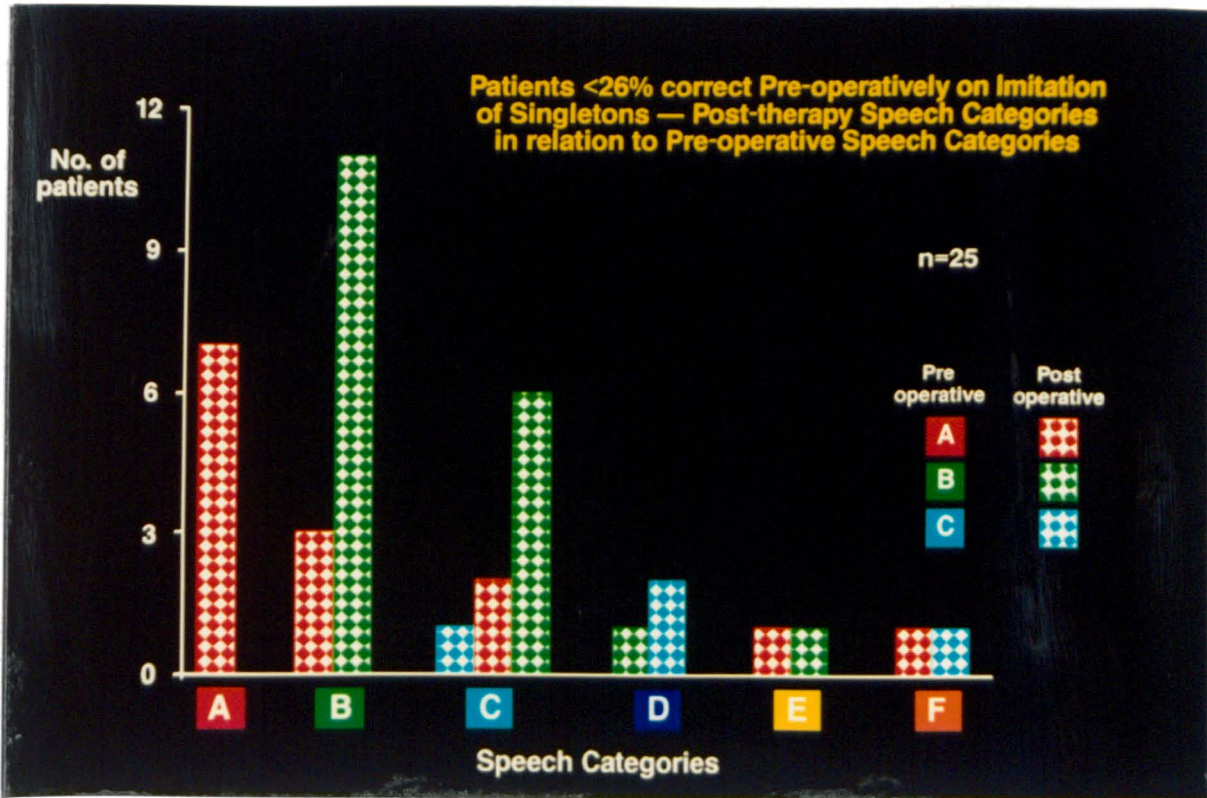
One subgroup that was of particular interest to study were the adults who scored less than 26% pre-operatively on the imitation of singletons task, and who also fell into the pre-operative Speech Categories A and B. Using a Wilcoxon Signed Ranks test, an analysis was undertaken to determine if there were significant differences between the speech categories at the pre-operative and post-therapy data points for this group of patients. No significant difference was found ( $p = 0.059$ ). This suggests that this group do not make significant changes in speech following therapy. Such findings start to define those factors that may be the important criteria in the prediction of outcome for patients who have late palatal surgery.

As a total group, patients who scored less than 26% pre-operatively on singletons imitation did therefore significantly change their speech. However, for patients who scored less than 26% on the singletons imitation post-therapy, no significant difference was found (Wilcoxon Signed Ranks test:  $p = 0.317$ ) between the pre-operative and post-therapy speech categories.

These data suggest that the speech categories at the pre-operative and post-therapy stages are similar for patients who scored less than 26% on the imitation of singletons at the post-therapy stage. This indicates that patients with poor imitation at the post-therapy stage do not significantly change their speech.

The literature has primarily been written on stimulability, which is very closely associated with imitation. Stimulability testing refers to the assessment of the patient's ability or potential to improve with instruction and awareness. This information informs the clinician of the sounds which may respond most readily to speech therapy, and therefore can be viewed as a predictor of a patient's response to therapy (see below).

**Figure 44**



Stimulability also contributes to a descriptive understanding of the child's articulatory status and capability. The failure to use sounds that are stimutable in spontaneous speech may be influenced by such other factors as phonological variables.

However, imitation testing used in this study is somewhat different from that of stimulability, in that these patients were not given maximum visual and auditory stimulation. They were instructed only to copy the therapist, and therefore the two tasks are not entirely comparable.

Morris (1990b) and Witzel and Stringer (1990) believe that there is a relationship between stimulability and speech outcome. Poor performance on stimulability measures tends to be associated with poor speech improvement (McWilliams et al., 1990). Equally the converse is true: patients who are easily stimulated to improve their speech patterns are excellent candidates for speech therapy (Witzel and Stringer, 1990). Despite this, McWilliams et al. (1990) state that stimulability testing does not provide a basis for predicting articulation change

Our findings suggest that the ability to imitate may play a limited part in predicting outcomes of therapy. For example, patients who were consistently poor on imitation tasks did not significantly change their speech. In contrast, the discrepant speech results of the patients who did poorly on imitation tasks at the pre-operative stage suggests that other variables influence speech outcome.

This latter finding, however, may in part be explained by the circumstances in which the patients were examined. The patients had unrepaired clefts of some long-standing, unused to any type of speech assessment. At the pre-operative stage, in particular, patients were in an unusual situation, undergoing a whole series of examinations by the British Team. The fact that they were asked to copy speech sounds in isolation, (indeed the assessment began with this task), must have been a very strange request for them. The possibility should therefore be recognized that they may not have performed to their potential, which may have distorted their true pre-operative imitation skills.

An alternative explanation lies with the fact that just as the failure to use sounds that are stimulative in spontaneous speech may be influenced by such other factors as phonological variables, it is quite possible that the same applies to imitation testing.

## IX. Years of Education

### Aim

The aim of this section is to determine if there was a relationship between the amount of schooling and pre-operative speech, and speech attainment following therapy.

### Hypotheses

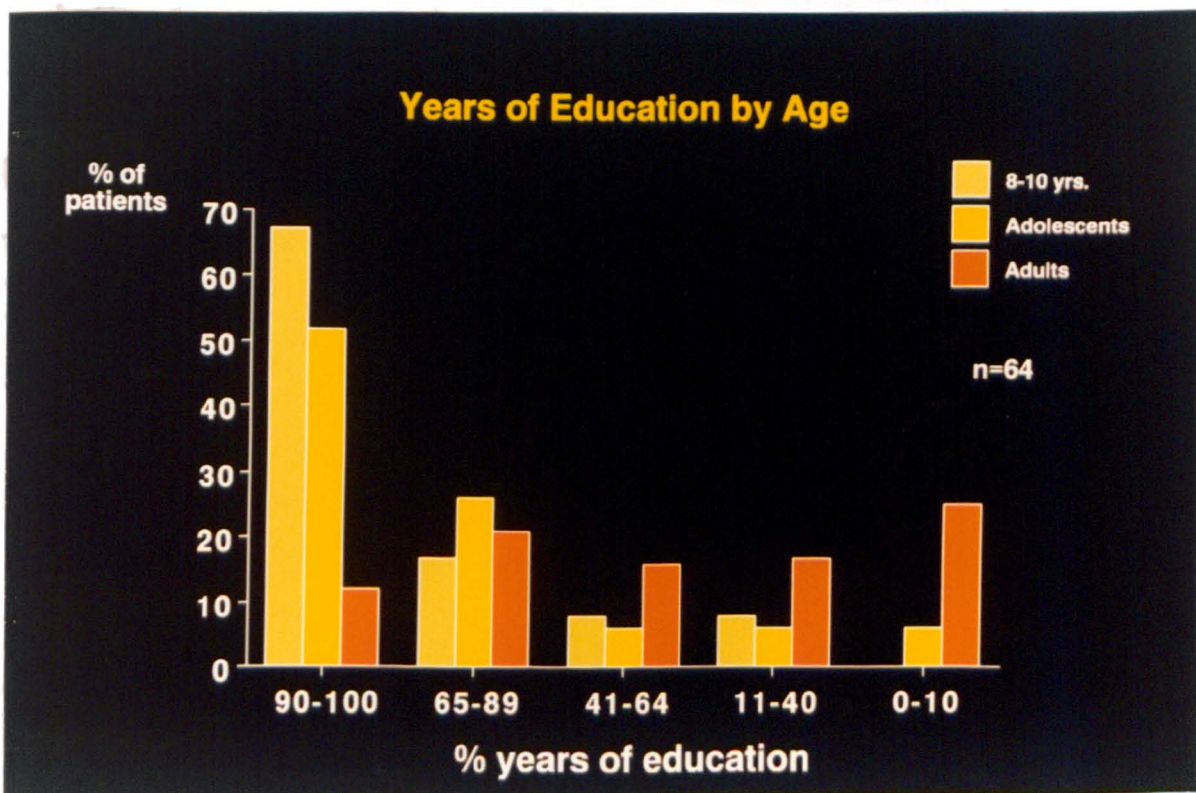
1. Patients who received minimal education have the more severe speech disorders pre-operatively.
2. Patients who received minimal education are less likely to benefit from subsequent therapy.

### Results

An impression was gained from the pre-operative psychosocial histories that there was a tendency for patients to leave school early, and in some cases not to attend at all. This was frequently attributed to the severe speech disorder.

Figure 45 substantiates the lack of school attendance, especially in the adult group. All patients in the children aged 8–10 years at surgery group had been to or were attending school. Two (6%) adolescents and five (20%) adults had never been to school.

**Figure 45**



An even more interesting issue to consider was the number of years of education the patient had actually received compared with the total number of years of education he/she could have received, according to his/her age. The number of years of education was determined for each patient and converted into a percentage score according to the number of years of possible attendance. Possible attendance was from 5 years of age until 18 years, a total of 13 years.

In the main cohort, fifteen (22%) patients had attended for less than 40% of the possible amount of time he/she could have. The distribution of these patients according to ages was as follows: one (8%) child in the 8–10 years at surgery age group, four (12%) adolescents and ten (42%) adults.

A pattern was observed in that the tendency to drop out of education occurred with advancing age.

Given that the reason for leaving school was frequently the speech disorder, it was hypothesized that the least educated patients had the more severe speech disorders pre-operatively.

### ***Hypotheses***

1. Patients who have received minimal education have the more severe speech disorders pre-operatively.

Based on 62 patients in the main cohort, a Spearman's rho correlation coefficient was performed to see if there was a relationship between the pre-operative speech results and the number of years of education. Only a slight correlation was found (0.355).

Therefore, the hypothesis was not proven. These data indicate that there is only a slight relationship between the number of years of education and the level of pre-operative speech performance.

2. Patients who have received minimal education are less likely to benefit from subsequent speech therapy.

Based on the main cohort (N=62), a Spearman's rho correlation coefficient was performed to see if there was a relationship between the post-therapy speech results and the number of years of education. Only a very slight correlation was found (0.253).

This suggests that the number of years of education do not determine speech results after therapy; hypothesis 2 was not proven.

It was important to determine if a lack of education, or only a minimal education, was important in determining the amount of change that could be effected. Therefore, the relationship was examined between the number of years of education and the amount of spontaneous change that occurred in speech, and the number of years of education and the amount of change that occurred when surgery was supported by speech therapy.

Based on the main cohort (N= 61), a Spearman's rho correlation coefficient was performed to see if there was a relationship between the amount of spontaneous change in speech and the number of years of education. No correlation was found (0.158).

This result is not unexpected given that only the children's group aged 8–10 years at surgery significantly

changed their speech post-operatively. Therefore, the population as a whole was characterized by a minimal amount of spontaneous change. In addition, only 17% of the children's group aged 8–10 years at surgery could be considered as having received minimal education i.e. below 40%.

An examination of the relationship between the number of years of education and the amount of change in speech that occurred with therapy in the three older age groups revealed a higher correlation (0.438; N=59), indicating a weak association between years of education and response to therapy. Therefore the number of years of education appears to have had some small effect on how patients respond to therapy. An examination of the data shows that 72% of the patients who had received a minimal education (below 40%) or no education had exactly the same pre-operative and post-therapy speech categories. 22% improved by one category, and 5% by two categories. Given the criterion laid down for an appreciable improvement, these data do suggest that patients who received minimal education did not apparently benefit from subsequent therapy. Thus, years of education may be a contributing factor to post-therapy speech results.



# Chapter 7

## Discussion

### **I. The Research Problem**

The first aim of this project was initially to study speech production in individuals under three conditions: with unoperated palates, following palatal closure, and immediately following therapeutic intervention. The second aim was to examine the relationship between speech production at the different data points: pre-operatively, post-operatively, and post-therapy. The third aim was to assess the influencing variables that accounted for speech attainment at each stage: age, cleft type, surgical intervention, therapeutic intervention, the nature of the therapeutic intervention, surgical observations at the time of palatoplasty, post-operative structural characteristics, nature of pre-operative speech, imitation skills, and years of education were investigated to determine if and how they accounted for speech performance and changes in speech production.

With regards to post-operative structural characteristics, one of the methods used to judge the success of palatal surgery is the incidence of velopharyngeal closure in a surgical series (Van Demark and Morris, 1990). However, it only became possible to collect objective data on post-operative velopharyngeal function in the latter stages of this study. This was then identified as an additional objective of this investigation. Indeed, at the outset, the future of the Sri Lankan Project was unknown. Following the initial visit in 1985, the timing of further surgical and post-operative visits and the breadth of work have necessarily been determined by factors extraneous to this study, not least the continuing civil war in Sri Lanka. The final aim of this investigation, which arose in the course of the study, was to take the opportunity to study speech production following a period of no therapeutic intervention, four or five years post-operatively. The overall purpose of this study, then, is to evaluate the success of surgery, not only through a perceptual assessment, but also by determining the success of surgery, in terms of creating an effective velopharyngeal mechanism and providing an intact palate.

The importance of studying the effects of palatoplasty on both facial growth and speech in a surgical series is recognized by authorities (Morris and Bardach, 1990, p.850),

*"For the best assessment of surgical method for palatal surgery, data about both speech-velopharyngeal function and dento-occlusion status should be reported for the same group of patients."*

Similarly, the results of the present study are required to complement the results of the studies of facial growth in this population (Mars and Houston, 1990; Mars: work in progress, 1991a), in order that information on the two primary outcome measures of palatal surgery is available.

This chapter begins with a discussion of the methodological issues, including a critical review of the methods

used in measuring speech, velopharyngeal function and fistulae in this study. The results of the major hypotheses are examined, followed by a discussion of the minor hypotheses. Other factors, that possibly influence these results, are discussed. Finally suggestions for further research are presented.

## **II. Methodological Issues**

One major advantage of this study is its prospective longitudinal nature especially in studies of late-operated individuals. At the outset, however, it was not known when it would be possible to collect post-operative data. Anecdotal reports suggest that velopharyngeal function following surgery can spontaneously improve for as long as eight months to a year post-operatively. Furthermore Kaplan (1981) stated that the repaired palate has limited mobility due to post-operative oedema and scarring up to three to six months post-operatively.

In this study, the timing of post-operative recall was determined by extraneous factors. The minimum period between surgery and post-operative recall was eight months. Moreover, at the outset nasopharyngoscopy was not considered possible in that environment; however, it was used in the last two visits (August and November 1990).

Although the main cohort have a complete set of recordings (pre-operatively, post-operatively, and post-therapy), a disadvantage of the longitudinal design is the reduction of the sample at the 4/5 years post-operative follow-up stage. Data have only been collected on 73% of the main cohort, due to the problems of recall. However, this recall rate is excellent, particularly given the political instability in Sri Lanka.

Initially it was intended to use only the complete set of data collected at the pre-operative, post-operative and post-therapy data points. However, data collected at 4/5 years post-operatively have also been included in these results, given their unique contribution (i.e. nasopharyngoscopy), and the additional information provided for better understanding and interpretation of the study. Table 52 shows the post-therapy speech categories of patients who did not return for follow-up in 1990. This shows that patients were fairly evenly distributed across the speech categories at this stage, suggesting that the non-returners probably represented the range of speech disorders.

*Table 52. Post-therapy Speech Categories of Patients who did not return for Follow-up in 1990.*

<b>Speech Category</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>
% Patients	11%	23%	23%	17%	9%	17%

The sample size of the main cohort appears initially to be satisfactory. However, when it is divided into the three age groups, the group of children aged 8–10 years at surgery is small. The results of this group must be interpreted carefully, in particular those results at 4/5 years post-operatively. Furthermore, an attempt to examine the different cleft groups in each age category led to further subdivision of the sample, such that

the results of the statistical analysis must be interpreted with caution (see Appendix VI). Even so, this study has the advantage over previous studies of not collapsing different age groups and cleft types into one large group to overcome the problem of sample size. Partly as a result of the reduced sample size of the main cohort at 4/5 years post-operatively, data on the children below the age of eight years at surgery were included in the evaluation of some results (viz. overall results of intervention and therapy, cleft type, structural observations, and imitation) in order that tests of statistical analysis could be undertaken. It may be, however, that inclusion of some results on the children below the age of eight years at surgery has somewhat 'blurred' the overall picture.

No attempt has been made to study the speech of this age group in any detail given the possibility that their speech would also be characterized by developmental disorders, unrelated to the success or failure of surgery, and also given the lack of pre-operative recordings in this age group. Clinical experience of this population suggested that children below the age of seven years could not reliably comply with the protocol for speech recordings. McWilliams et al. (1990) write that it is necessary to ensure that patients are old enough and sufficiently mature to participate in the testing required.

Another difficulty with the main cohort is its skewed nature in relation to cleft type. No adults or children aged 8–10 years at surgery presented with lesser clefts. The reason for this is unknown, but may indicate that there were no major speech problems (see below), or other difficulties associated with the cleft palate, from the family or adult's point of view. Financial and work commitments may also have discouraged attendance.

It must also be acknowledged that this is not an absolutely true consecutive surgical series. There were a few instances of older patients, who presented with such severe degrees of cleft palate that surgical closure was judged not to be possible. Morris (1973) highlights the need to acknowledge this limitation in his review.

It is now well recognized that a large majority of individuals with this condition have cleft palate as a single feature of a multiple anomaly disorder or syndrome (Rollnick and Pruzansky, 1981; Shprintzen et al., 1985; Jones, 1988). When clefting occurs as part of a syndrome, it is only one of many symptoms, each of which may have an effect on the performance of the individual. For example, a cognitive deficit is a very common syndromic feature, and has been reported to occur in over 20% of individuals with clefts. Shprintzen (1991) acknowledges that the elimination of all syndromic cases is difficult, but possible. Indeed, he has previously stated that syndromes of clefting are so common in most clinical populations that it is probably impossible to select any sizeable sample of patients for study without including some syndromic cases (Shprintzen et al., 1985). Shprintzen (1991, p.138) states that,

*"Unless a clinical population of individuals with clefts has been carefully examined for associated anomalies by a competent dysmorphologist they cannot possibly be regarded as a valid sample population for study."*

No dysmorphologist was included in the team. Every effort was made, however, to ensure that no patients

with syndromes were included in this sample, although this remains a possibility.

With regards to assessment, due to the cross-linguistic nature of this study, the speech results are based on controlled speech at single word level, where the targets are known to the listener. Indeed, the word sample is elicited as a modelled response. Therefore, these results are based on a rather artificial speech sample, but one which is most likely to show improvement. Although it was recognized that conversation should be assessed (Grunwell, 1987), the evaluation of spontaneous speech is not usually possible when the language is unknown to the investigator. It is acknowledged, however, that this is particularly important in that the difficulties of carryover into spontaneous speech are well-recognized in patients with this condition (McWilliams et al., 1984; Albery and Enderby, 1984; Van Demark and Hardin, 1990).

Indeed, they were demonstrated in an adolescent sub-sample of this study (Sell and Grunwell, 1990: see Appendix VII). Sell and Grunwell attributed the lack of carryover to both the limited amount of therapy, and also the probability that speech production could only be maintained when individuals concentrated on their speech. Furthermore, although velopharyngeal insufficiency, one of the characteristics of this population, does not prohibit progress with therapy, neither does it usually facilitate the rate of progress. Even when there is velopharyngeal closure, carryover of articulation improvements into spontaneous speech is often limited by persistent habit factors established in the presence of an open palate, especially in older patients (Bzoch, 1979; McWilliams et al., 1984, 1990; see Chapter 2, section VI).

Shprintzen (1991) suggests that investigator bias often confounds results. Bias may be present in this study, in particular in the evaluation of the effects of therapy. Therapy was provided by the speech therapists, who were also responsible for the analyses of the tapes. To attempt to eliminate observer bias, tapes were analysed by the therapists without knowledge of the timing of recordings, wherever possible. Therefore the possibility of observer bias is a recognized weakness of the study, and may have led to over-generous ratings of speech following therapy. However, the appreciable changes detected using the speech categories are probably too great to have been influenced by observer bias.

### ***III. Critique of the Method of Measuring Speech***

A broad-based framework of assessment in the form of a rating scale was devised. It has been shown that this scale can be used reliably by trained speech therapists. This practical, simple system can be used with large numbers of patients about whom surgical decisions need to be made very quickly. It has the advantage of being fast to administer and is easily understood by colleagues, particularly other team members. The system of speech patterns and speech categories facilitates the investigation of the relationship between pre-operative speech and speech outcome.

The current assessment clearly has face validity. It is difficult to demonstrate other types of validity in the absence of measures from other assessments. However, to improve the content validity, an early aim was to develop the rating scale further, by devising a more detailed approach using a narrow phonetic

transcription, as advocated by some authorities (Ball, 1989; Trost, 1981; McWilliams et al., 1990). However, it became evident that this aim could not be realised because of the characteristics of the population studied. All the patients spoke Sinhala, a language not spoken by the investigators. Morris (1978) stressed the importance of attending to issues of reliability and validity when the investigator does not know the language spoken by the patients. The difficulties of analysing the speech of cleft palate individuals cross-linguistically has recently been reported on by the Eurocleft speech group (1991), who demonstrated the difficulties of achieving reliability, when using a detailed phonetic analysis. This resulted in the collapsing of detailed phonetic categories into broad-based categories in order to meet the requirements described by Morris (Morris, 1978). The Eurocleft speech group also showed that it was not possible to reach adequate consensus about targets which did not occur in the native language of the rater. Furthermore, these findings were based on speech which could be viewed as considerably less disordered than the late-operated population of the present study. Indeed, the severely disordered speech of most of the population in this study was actually characterized by features which are known to complicate narrow phonetic transcription. These include severe hypernasality, compensatory articulations requiring videoradiographic analysis, and sounds apparently formed in the region of the unrepaired palate. McWilliams et al. (1990, p.290) write,

*"Distinctions among these sounds (compensatory articulations) would be difficult to make without radiographic analysis."*

This observation is also made by Kawano et al. (1985) and Brown et al. (1990).

Therefore, a narrow phonetic transcription would probably not be valid, and achieving satisfactory inter- and intra-rater reliability would have been extremely difficult and time-consuming. Furthermore, it is argued that such a detailed method of analysis was unnecessary, given the aims of this investigation. The aim was to provide reliable speech results which would indicate whether late palatal surgery was of value. Detailed analysis is not required to achieve this aim. As a result of these considerations, the rating scale has formed the basis for the speech results. Furthermore, the direction of the study changed, as the possibility of investigating velopharyngeal function became viable, and the importance of such information was appreciated.

Interestingly, the experience of interpreting the results of the rating scale led to the development of an even broader approach, rather than the detailed phonetic approach originally planned. Each of the place, manner and voice scales consisted of a hierarchy of levels, reflecting small, yet detectable differences in this severely disordered speech. Results were initially presented using the average place and manner scores (Sell and Grunwell, 1990: see Appendix VII). However, when the scores from each scale were used as a basis for statistical analysis, the detailed nature of the scale resulted in misleading findings of statistical significance. Furthermore, these were often clinically irrelevant, and difficult to interpret qualitatively. The development of Speech Patterns and Speech Categories arose from the need to be able to discuss the meaning of the results in terms of perceptual criteria and clinical relevance.

This kind of difficulty is illustrated by examining the results of the hypothesis with regard to the effects of

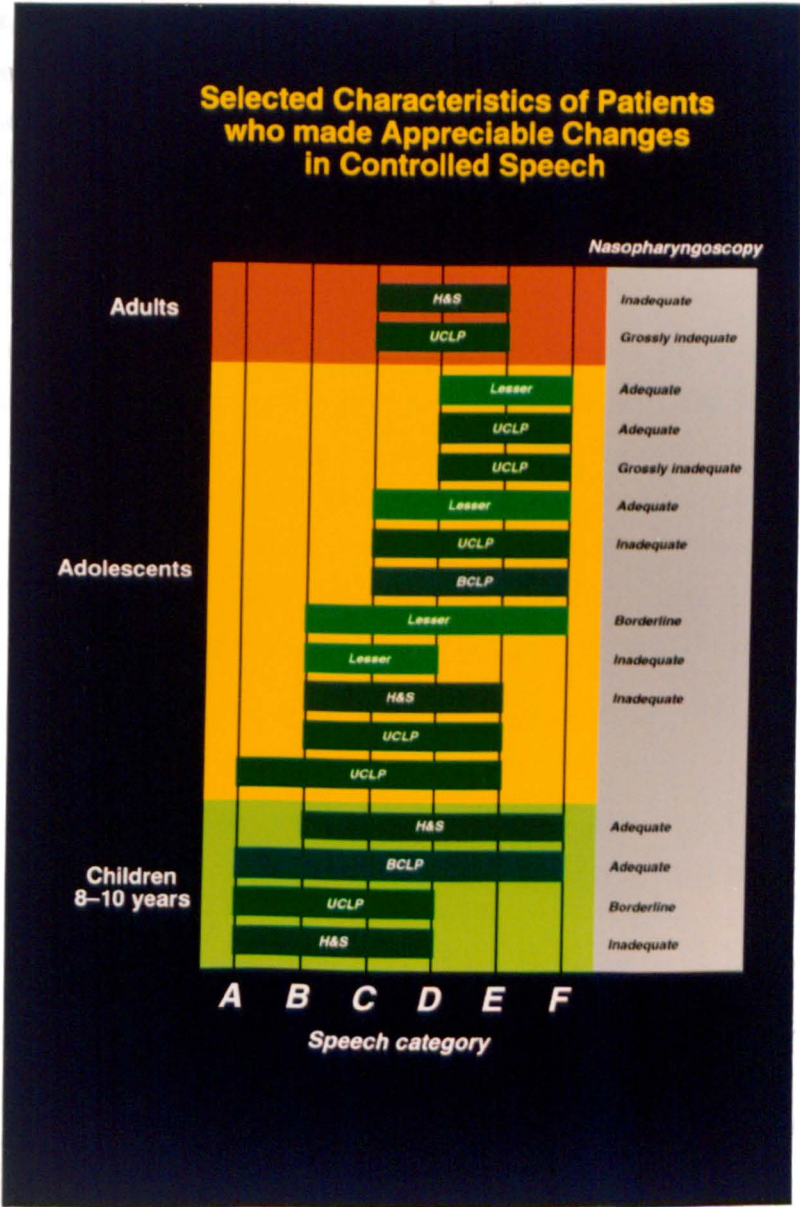
surgery and therapy in the different age groups. Analysis was undertaken using both approaches, which are now compared. Both analyses showed the same results in terms of statistical significance (see Appendix VI and Chapter 6: section IV). The first approach, using the place and manner scales, gave information about the means and standard deviations of each age group. For example, following therapy, the mean score for the adolescent group was 3.672 (standard deviation 3.042) compared with the mean score of 2.6 for the adult group (standard deviation 2.267). This indicated that the adolescent group on average made greater changes in speech following therapy than the adult group.

The system of speech categories, on the other hand, showed that only 9% of the adults moved more than one category, compared with 31% of the adolescents who moved across three categories. 50% of the adults remained within the same speech category as they had been in before therapy, compared to 38% of the adolescents.

The second approach, using the method of speech categories, facilitated the interpretation of the results of statistical significance, so that the nature and degree of improvement could be determined. Furthermore, this system has the advantage of showing the position of patients in the hierarchy of speech categories at the different data points. For example, Figure 46 shows some of the characteristics of those speakers who made appreciable improvements: their position at the pre-operative and post-therapy stages within the hierarchy of speech categories is easily seen.

The precedent for using this rather coarse type of system comes from the orthodontic literature. Mars et al. (1987) used a similarly coarse system for the categorization of dental arch relationships in patients with unilateral clefts of the lip and palate. This methodology has since been used in several studies (Mars et al., 1987, Lonnen et al., 1991, Mars et al., in press: 1992).

**Figure 46**



Although the speech categories are rather broad in definition, and are incapable of distinguishing the finer differences in the severity of speech disorder, the development of the type of approach involving speech patterns and speech categories follows a recent trend towards the need for qualitative descriptions of speech whilst retaining scientific method (Grunwell and Russell, 1987: Henningsson, 1988: Harding, Sell and Grunwell, 1990: Albery, 1991).

#### ***IV. Critique of the Method of Measuring Velopharyngeal Function***

Three methods were available for measuring velopharyngeal function: the direct methods of nasopharyngoscopy and lateral skull X-rays of patients phonating /i/, and the indirect method of perceptual assessment. The high correlations between these methods suggest that they give similar results.

The high correlation of the X-ray results with the other two methods probably reflects the high degree of velopharyngeal insufficiency in these patients. This supports the observation of Van Demark (1974b), who found that lateral radiographs clearly predict subjects with an obviously incompetent mechanism, and recommended their use with other measures. In a developing world environment the present study suggests that the simple lateral skull X-ray procedure is a useful tool to document post-operative velopharyngeal function following palatoplasty, despite the known disadvantages of this technique.

Indeed, the information provided by the lateral skull X-rays has been particularly useful in verifying the results of the other two measures of velopharyngeal function. The results of nasopharyngoscopy and nasality may not be the optimum.

Nasopharyngoscopy may be adversely affected by anterior fistulae and/or compensatory articulations, such that the potential movements of the lateral pharyngeal walls are not fully realised resulting in an underestimate of velopharyngeal function (see Chapter 2: section Va and below). In this study, 39% of patients had anterior fistulae co-occurring with velopharyngeal insufficiency. Similarly, the use of nasality, as a measure of velopharyngeal function, is complicated by the fact that hypernasality may be attributable to fistulae and/or velopharyngeal insufficiency (Chapter 2: section V). In this study, 52% of the cases did not have fistulae; in these patients the nasality rating was a valid indicator of velopharyngeal insufficiency.

By comparison with the other two measures, the lateral skull X-ray procedure does not interact with any structural characteristics (i.e. fistulae), or features of speech (i.e. compensatory articulation).

Given that the results for all three measures are very similar, the results of the lateral skull X-ray procedure suggest that any structural or phonetic interactive effects on the nasopharyngoscopy and/or nasality measures are probably contraindicated for the majority of patients.

Nasality results include hyponasal speakers in the oral category. Strictly, results of hyponasality should be presented separately (Dalston et al., 1988). However, this requirement is based on literature appertaining to early palatal repair and secondary pharyngeal surgery, where hyponasality may occur or co-exist with hypernasality. The incidence of hyponasality was extremely low in this study (post-operatively, only 6% were

rated as hyponasal). The number of patients presenting with hyponasality is likely to be small in this type of population, to the extent that the use of a separate category is probably unnecessary.

The collection of nasopharyngoscopy information is, without doubt, of immense value. The framework of analysis used is comprehensive, incorporating both quantitative and qualitative descriptions. Attention has been paid to issues of intra- and inter-rater reliability. Furthermore, the reliability study was undertaken by two different professionals, as advocated by D'Antonio et al. (1989).

The system of measurement recently devised by the International Working Party is still undergoing studies of reliability and validity (Golding-Kushner et al., 1990). If this system is eventually adopted, it is recommended that it be applied to this study's population. This type of analysis would provide actual measurements, which could then be compared with the characteristics of velopharyngeal function found in a Western population. This would provide detailed information about actual differences of velopharyngeal insufficiency between this population and populations repaired at more conventional times.

It is appreciated that the investigation of nasopharyngoscopy alone does not meet the current standards of practice advocated in the West for investigating velopharyngeal function (Golding-Kushner et al., 1990). A standard method of assessment, and one which is used to complement the information gained from nasopharyngoscopy, is that of multi-view videofluoroscopy. This radiological technique allows evaluation of the velopharyngeal valve in several planes during speech production. Shprintzen (1986) asserts that multi-view videofluoroscopy provides the best physiological assessment of velopharyngeal function, whereas nasopharyngoscopy provides the better anatomical assessment. This is primarily because as tissues move in front of an endoscope, movements occurring behind or below those tissues cannot be seen. In contrast to this, multi-view videofluoroscopy allows the observer to see through tissues, so that movements can be discerned at all vertical and horizontal positions within the pharynx. Unfortunately, the sophisticated equipment required for this assessment was not available in Sri Lanka, and nor is it portable. This lack of multi-view videofluoroscopy information is a recognized disadvantage.

However, the primary purpose of investigating velopharyngeal function in this study was to document the incidence and nature of velopharyngeal insufficiency. In contrast, in the West, the usual purpose of investigating velopharyngeal function is to determine the nature of a defect where there is a suspected velopharyngeal inadequacy, in order that appropriate treatment be instigated (Shprintzen, 1986). As Witzel and Stringer (1990) point out,

*"The information provided by the technique (multi-view videofluoroscopy) is often crucial..., particularly if surgery is required for speech problems related to velopharyngeal insufficiency."*

In the present study, no secondary surgery was planned, and therefore it is contended that the inclusion of multi-view videofluoroscopy in the evaluation of velopharyngeal dysfunction is not as crucial. Furthermore, the issue of moving tissue inhibiting the endoscopic view is arguably less applicable in a population which is characterized by not only a very high incidence of velopharyngeal insufficiency, but also a high incidence



of gross velopharyngeal insufficiency. Nasopharyngoscopy has apparently provided extremely useful and detailed information regarding the incidence and nature of velopharyngeal insufficiency in this population.

Indeed, it is argued that a greater disadvantage of the lack of multi-view videofluoroscopy is the information it would have provided about tongue movements, which would not only have facilitated a valid approach to a narrow phonetic transcription of speech (McWilliams et al., 1990), but also validated some of the perceptual observations. For example, Shprintzen (1989) describes how it is possible for the tongue to contribute to velopharyngeal closure by physically lifting the velum into the velopharyngeal orifice even when the velum itself has no intrinsic movement. In such cases, the tongue is beneath the velum, and is therefore out of the view of the nasopharyngoscope. Trost-Cardamone (1986) describes the tongue functioning as a "lingual assist" in these circumstances, causing inevitable backing of many consonants. Based on perceptual analysis this pattern as classified as Speech Pattern 4 in this study.

The difficulties of assessing velopharyngeal function when speech is characterized by a high percentage of compensatory articulations have already been alluded to. More than 50% of patients presented with compensatory articulations at the time of this assessment. Ideally, these judgements should have been based on speech which was free of compensatory articulations because of the relationship between velopharyngeal function and compensatory articulations (Kawano et al., 1985; Henningsson and Isberg, 1986; Hoch et al., 1986; Shprintzen 1990c). It is possible therefore that the nasopharyngoscopy results are an underestimate of velopharyngeal function. Although Henningsson and Isberg (1986) recommend that patients should be trained to produce some oral pressure consonants prior to the examination, time constraints and the logistics of the project prevented this.

It could be argued, however, that by judging only that part of the sample consisting of consonant-vowels with bilabial targets (pa pa pa, pi pi pi, ba ba ba, bi bi bi) this problem would have been overcome to some extent. However, such a limited sample would have had disadvantages. Glottal stops and glottal coarticulations would still have occurred in some patients. The sample would have been very short, and inconsistency or variability of closure patterns would probably not have been detected.

It is also the case that the known relationship between velopharyngeal function and compensatory articulations has been established from studies of patients where the palate repair has occurred at a conventional age. The patients in this study are fundamentally different in that they acquired a repaired palate relatively late in life, when their habituated speech patterns were already characterized by many compensatory articulations. In this population, there has been no possibility of long-term interaction between the actions of the soft palate and the movements of the posterior pharyngeal walls. It is questionable, therefore, whether comparison of the effects of a repaired palate upon the relationship of velopharyngeal function to compensatory articulations is appropriate between such disparate populations.

## **V. Critique of the Method of Measuring Fistulae**

For the majority of these patients, the classification of fistulae was made through a joint decision by two experienced clinicians of differing professional backgrounds (a speech therapist and an oral-maxillo-facial surgeon). Using this method the actual measurement of fistulae was undertaken quickly, because of the time constraints imposed by the Sri Lankan project.

There are, however, some acknowledged shortfalls in the system used for measuring fistulae. No attempt was made to measure fistulae directly. The judgement of fistula size was based on the largest linear dimension. Measurements should have included length, maximal width and area of fistula measured in millimetres based on dental study models (Isberg and Henningsson, 1987). Only in a small percentage of the population were these used. Neither were attempts made to evaluate the inter- and intra-rater reliability of the two raters, primarily as a result of the time constraints imposed by the working conditions.

These are recognized limitations: nevertheless, the data presented here represent the first attempts to systematically evaluate fistulae in a population undergoing late palatoplasty.

In future, it is recommended that the location category of buccal sulcus is eliminated. As stated previously, a prealveolar fistula is rarely associated with abnormal speech or resonance, as the upper lip usually covers any fistula satisfactorily. In addition, such fistulae are often left deliberately in the West, until closure at the same time as alveolar bone graft (9–11 years).

The difficulties of assessing the relationship between fistulae and speech production have already been discussed (see Chapter 6: section VIb). It is concluded that it is not possible or valid to examine this relationship within a population characterized by a high incidence of articulations posterior to the fistulae and hypernasality related to velopharyngeal insufficiency. It was impossible to undertake the time-consuming task of assessing patients, with and without fistulae obturated, within the logistics of this project. Even if fistulae obturation had been possible, the compensatory articulations and the method of measuring speech would still have prevented a valid assessment.

This methodology, despite its disadvantages, does meet to a large extent the recommendations advocated by McWilliams (1990),

*"Greater reliance on instrumentation, on objective methods of assessing speech, on establishing reliability when judgements are made about speech or the results of endoscopy or videofluoroscopy should provide replicable data ... for conducting research."*

### **Footnote:**

To determine the degree of accuracy of these findings, it is recommended that actual measurements of fistulae are undertaken using the dental study models, and compared with the findings of this study. If the instrument used in this study is satisfactory, a small reliability study should be undertaken in any future visits to Sri Lanka.

Furthermore, with reference to velopharyngeal dysfunction, she urged for studies to specify the nature of the velopharyngeal defect, rather than use the designation of velopharyngeal incompetence alone.

## ***VI. Major Hypotheses***

The major hypotheses in this study relate to surgical and speech therapy intervention, cleft type, age, and structural issues of velopharyngeal function and fistulae. The minor hypotheses of surgical observations at the time of palatoplasty, imitation skills, nature of speech therapy intervention, and years of education have also been examined in order to determine if and how these factors contribute to our understanding of patients who undergo late palatoplasty. The results of these variables have each been presented and discussed separately in the preceding chapter. The purpose of this section of the discussion is to draw together and interpret these results.

### ***Surgical and Speech Therapy Intervention***

It was hypothesized that surgery alone would result in positive spontaneous change in nasal resonance and nasal escape, but would not change articulatory skills, in view of the well-established articulation habits. In contrast, palatal closure supported by speech therapy would result in positive spontaneous change in articulatory skills, but would not change nasal resonance and nasal escape.

This study has shown that surgery alone did lead to a significant improvement in nasality. However, surgery did not change the articulation characteristics of the carefully controlled speech of patients who had their palates closed when they were over eleven years old of age at palatoplasty. Children aged 8–10 years at surgery apparently do improve spontaneously, although it should be recalled that the size of this group is small. Furthermore, even then, only two patients met the criterion of improving by more than two speech categories.

In contrast, when therapy was provided, a significant improvement in articulation in carefully controlled speech was found for all patients. Therapy did not effect any change in nasality.

Therefore, the group overall has behaved as predicted. These results suggest that surgery alone beyond the age of eleven years, with no supportive speech therapy, does not produce significant improvements in articulation.

The reason for this becomes apparent when the nature of the pre-operative speech is examined. Pre-operatively, 81% of patients presented with severely disordered speech. In the majority of patients, speech was characterized either by many glottal and pharyngeal articulations (88%), or by Speech Pattern 4 (back place of articulation with nasalized oral plosion: 8%), or Speech Pattern 8 (nasals and approximants: 4%).

These data support the first type of speech proposed in speakers with velopharyngeal dysfunction by Trost-

Cardamone (1990c) (see Chapter 2: section 111). She proposed that the majority of patients overcome their inability to produce high-pressure oral sounds by developing compensatory articulation or "adaptive" strategies in order to accomplish speech pressure-valving. Only 4% of speakers avoided producing high-pressure oral sounds, using a speech pattern characterized by a restricted phonetic inventory of nasals, glides and liquids. This evidence lends support to the theory proposed by Hutter and Bronsted (1987) that active and passive strategies are universal for coping with the organic condition, rather than being language dependent (see Chapter 2: section III)

The articulation patterns of speakers with any of these pre-operative speech characteristics did not appreciably change with surgical closure of the palate. In the context of patients treated in the West, Trost-Cardamone (1986) stated that compensatory articulations usually persist when secondary pharyngeal surgery is performed. Although primary closure of the palate as undertaken in this study, and secondary pharyngeal surgery as reported in the literature, are two very different surgical procedures, the results of the current study suggest that the effect of both surgical procedures on compensatory articulation are similar. Neither surgical procedure changes these types of errors. Furthermore, this study indicates that surgery does not change the speech pattern characterized by a restricted phonetic inventory of nasals and approximants. Even when surgery was supported by speech therapy, 58% of speakers retained this severely disordered speech.

However, it must be acknowledged that the provision of speech therapy in Sri Lanka was minimal, and in most cases the amount of therapy was insufficient. The courses, although intensive and residential, were necessarily of limited duration. The ratio of patients to the number of British therapists was high. This situation, although improved, still remained, even when speech therapy assistants were available (Wirt et al., 1990a, 1990b). In addition, there were considerable limitations imposed by the constraints of working through translators. Our experience suggests that speech therapy needs to be prolonged and intensive in order for patients to improve.

Pre-operatively, only 16% of the cohort presented with mainly oral placements and minimal compensatory articulation. Plosion, friction and affrication were established to varying degrees, and nasalized plosion and friction occurred to an appreciable extent. These results indicated that in these high level pre-operative speakers 36% (N=11) of patients made some spontaneous change (N=4), but that after therapy a further six patients showed improvement. The majority of the group who presented with pre-operative Speech Categories D and E made appreciable change only when surgery was supported by therapy. Therefore, even in those pre-operative speakers who demonstrated some occurrence of oral place and weak manner types of plosion, friction and affrication, speech therapy was required to maximize the benefits of surgery.

This study suggests that it is easier to change speech in therapy where there is some occurrence of oral place and weak manner types of plosion, friction and affrication. In addition, Speech Pattern 8 (characterized by a restricted phonetic inventory of nasals, glides and liquids) showed potential for change. One of the speakers showed appreciable improvement. The other speaker demonstrated change in the imitation of singletons, but the lack of change in the controlled speech sample was probably partly attributable to insufficient therapy.

Wu et al. (1990) have provided the most detailed account of the sounds that responded to therapy in a group of unrepaired adults who had combined palatoplasty and pharyngeal flap. They found that the posterior nasal fricative, and "omissions with hard glottal attack" were the easiest sounds to remediate. However, this phonetic description is rather confusing and contradictory, and supports the observations by Noordhoff et al. (1987) and Bernthal and Weiner (1976) that it is difficult to distinguish omissions from glottal stops.

The importance of studying the nature of pre-operative speech was suggested by Landis and Cuc (1972). They commented that specific types of pre-operative articulation errors may play a part in decisions regarding surgery, but provided no further detail. The present study is therefore unique in its attempt to relate the pre-operative speech pattern to speech outcome following therapy. It strongly suggests that speakers with pre-operative Speech Categories A and B do not make appreciable changes to their speech with surgery alone, and usually stay within the lowest three speech categories even with some speech therapy intervention. Speakers with pre-operative Speech Category C, on the other hand, behave similarly to Speech Categories A and B post-operatively, but with therapy, 38% made appreciable improvements. Speakers with pre-operative Speech Category D only made appreciable improvements with speech therapy. The majority of speakers who presented in pre-operative Speech Categories E and F were adolescents with lesser clefts (more than 50% of the lesser cleft group). This type of information can be used to define predictive criteria for surgery in the developing world (see below).

### ***Cleft Type***

It is unfortunate that in the main cohort, patients with lesser clefts were only found in the adolescent age group. There were, however, three children aged below 8 years at surgery with lesser clefts, and therefore this age group was included in the analyses of speech related to cleft type.

It was hypothesized that patients with clefts of the posterior third of the hard palate and/or soft palate (lesser cleft group) would have better articulation and less severe nasality pre-operatively than patients with either bilateral cleft lip and palate (BCLP), unilateral cleft lip and palate (UCLP), and patients with complete clefts of the hard and soft palate (H&S). As previously indicated, these latter three cleft types are referred to as the major cleft group(s) in this discussion.

In addition, it was hypothesized that the lesser cleft group would demonstrate a higher incidence of normal speech or near normal speech than the major cleft groups, both post-operatively and post-therapy.

The results of this study have supported these hypotheses. Patients who have established their speech with a lesser cleft have significantly better articulation pre-operatively, post-operatively and post-therapy than patients with either cleft type BCLP, UCLP, or H&S. Pre-operatively, approximately 50% of the lesser cleft group showed normal or near normal speech compared with an incidence of less than 7% for each of the three other major cleft groups. Post-operatively, 54% of the lesser cleft group showed normal or near normal speech compared with an incidence of less than 10% for each of the other major cleft groups. Post-therapy,

approximately 70% of the lesser cleft group showed normal or near normal speech compared with less than 25% for each of the other major cleft groups. These findings support the suggestion of Trost (1990c) that the extent of the cleft condition influences the nature of speech.

These results only agree to some extent with the findings of Landis and Cuc (1972). The two studies, however, are not entirely comparable, since the cleft type classification is different. Landis and Cuc did not distinguish between complete clefts of the hard and soft palate, and clefts of the posterior third of the hard palate and/or soft palate, as in this study. The present study, however, shows that this is an important distinction.

A major difference between the two studies relates to the pre-operative speech characteristics of the complete hard and soft palate cleft group. Landis and Cuc reported that the glottal stop and the pharyngeal fricative were not features of the pre-operative speech of the isolated palate only group (N=15), which they define as "unrepaired post alveolar isolated clefts of the palate". In contrast, the present study showed that more than 70% of this cleft group (N=15) presented with speech which is characterized by these compensatory articulations, compared with 30% of the lesser cleft group (N=13). Indeed, approximately 50% of the lesser cleft group presented with the speech characteristics of Speech Categories E and F. This is apparently similar to the findings of Fletcher (1985) in his single case study.

The differences between these results and those of Landis and Cuc may be accounted for by the wide variation observed in the width and configuration of complete clefts of the hard and soft palate group. Dorf and Curtin (1982) make the point that it may be appropriate to examine not only cleft type, but also cleft configuration and width. The median age in each study was similar, and therefore age was not a factor. These differences may reflect a high incidence of patients with 'lesser clefts' in the Landis and Cuc sample, but it is more likely that they are related to the different methods of speech analysis. It is also conceivable that the differences in the results of the two studies may be the effect of other variables which impinge on speech production, such as psychosocial factors, mental ability or hearing ability.

Law and Fulton (1959) reported near normal voice quality in adults with unrepaired cleft lip and palate, but greater nasality was characteristic of patients with unrepaired clefts of the soft palate only. In contrast, in the present study, the lesser cleft group had significantly less severe ratings of nasality at the pre-operative stage than the major clefts, where a complete cleft of the palate was involved.

Landis and Cuc reported that 53% of their group had severe nasality, 47% had moderate nasality, and no patients had slight nasality. However they made no attempt to describe nasality characteristics according to cleft type. The distinction between severe and moderate classifications of nasality was also used in the original rating scale in the present study. However, this distinction was not retained in the revised scale, as a result of the unsatisfactory level of inter- and intra-rater reliability achieved. Given the recognized difficulties of rating nasality in the presence of articulatory disorders (Bzoch, 1979), the appropriateness and necessity of distinguishing between severe and moderate nasality is questionable in a population with unrepaired cleft palate. Landis and Cuc did not report on reliability.

In terms of post-operative structural outcome, it was hypothesized that there would be a higher incidence of velopharyngeal closure and a lower incidence of palatal fistulae in the lesser cleft group. These hypotheses have been upheld.

More than 70% of the lesser cleft group have velopharyngeal closure according to the nasopharyngoscopy results. There is some variability in the incidence of adequate closure according to nasopharyngoscopy in the major cleft type groups, from 6% in the unilateral cleft lip and palate group to 28% in the hard and soft palate group.

Judged according to nasality, and the X-ray results, the incidence of oral or hyponasal speakers (nasality) and velopharyngeal closure (X-rays) is approximately 60% in the lesser cleft group, compared with no more than 25% for the major clefts.

Therefore, although the majority of patients with velopharyngeal closure are found in the lesser cleft group, adequate and borderline closure categories also occur in each of the major cleft groups. This corresponds to the findings of Morris (1978), who reported that the highest incidence of velopharyngeal closure occurred in patients with an inverted v-shaped cleft of the hard and soft palate, followed by the soft palate only group.

No other study has examined velopharyngeal function in relation to cleft type in a population undergoing late palatoplasty.

With regard to palatal fistulae, no fistulae occurred in patients with clefts of the posterior third of the hard and soft palate, or soft palate only. This finding corresponds to that of previous researchers, when surgery was performed in the West at conventional ages (Peer et al., 1954; Abyholm et al., 1979). These data support the statement by McWilliams et al. (1990) that one of the determining factors in the aetiology of palatal fistulae is the severity of the original defect. Fistulae in this study have occurred only in patients with complete clefts of the palate.

Therefore the lesser cleft group have better speech at all stages, and better post-operative structural results in terms of velopharyngeal function and fistulae than the other cleft groups. This seems to suggest that when two thirds of the hard palate at the minimum is intact, speech acquisition and surgery are facilitated. The observations by Landis and Cuc (1972) on post-operative articulation in relation to cleft type have been borne out by the present study.

When surgery has been performed at conventional ages, results have sometimes been reported for two categories: cleft lip and palate, and palate only (Byrne et al., 1961). The present study indicates that speech results should be reported separately for the lesser cleft group and complete clefts of the hard and soft palate, since important differences have been found.

The findings relating to the lesser cleft group in this study are similar to those findings of patients repaired at conventional ages in the West. The review by Moll (1968), subsequently supported by Morley (1970) and Fletcher (1978), suggested that patients with clefts of the soft palate only are likely to have less severe

articulation difficulties than patients with major clefts. However, as Fletcher (1978) found in his study, important individual differences did occur, such that some of the patients with major clefts did not behave in the ways anticipated. Indeed, one disadvantage of presenting these results according to different group criteria is the loss of important individual differences.

In contrast to the reported results in Western populations, differences in speech achievement between the three major cleft groups were not found. McWilliams et al. (1990) attributed speech differences between patients with complete cleft lip and palate, and patients with cleft palate only to dental problems, maxillary collapse, and protrusion of the premaxilla.

Maxillary hypoplasia, however, was not a feature of the population in this study (Mars and Houston, 1990). Features of palatalization and lateralization, which are often associated with it, were rare. In contrast, there was a high incidence of glottal and pharyngeal articulations. The place of articulation was therefore frequently posterior to the region of the alveolus, where the differences in speech related to cleft type have been described. Indeed, Karling (1989) specifically pointed out that glottal and pharyngeal articulation was infrequently found in the BCLP and UCLP groups which he studied (see Chapter 2: section II).

### **Age**

One of the aims of this investigation was to determine the effect of age on late palatal surgery. The literature suggested that the post-operative progress of adults would be disappointing (Ortiz-Monasterio et al., 1959, 1966, 1974; McWilliams et al., 1990; Wu et al., 1990).

It was hypothesized that adult patients would present with disordered articulatory patterns that were more resistant to change than those of adolescents or children, either spontaneously or with therapy.

Before comparing the three age groups, the adult group alone will be considered. Pre-operatively, although the adults were distributed across the range of speech categories, there was a very low percentage (5%) of patients presenting without compensatory articulations. In this study, only one adult (4%) presented pre-operatively in the highest Speech Category F. No adults presented at this stage in Speech Category E. Only three adults (12%) presented with pre-operative Speech Category D.

Post-operatively, speech was not significantly different, suggesting that there was no spontaneous improvement in articulation. Minimal changes were achieved with speech therapy, and importantly, these were not maintained. There was no statistically significant difference between pre-operative speech and speech assessed at 4/5 years post-operative follow-up.

With regard to nasality, 100% of the adults presented with severe hypernasality at the pre-operative stage. Post-operatively, all the adults were still hypernasal: 94% patients fell into the severe category and 6% were categorized as mildly hypernasal.

It has been stated by surgeons, and commented on in the literature anecdotally, that some adults with unrepaired palates often have a remarkably high standard of speech (Stenglehofen, 1989). The type of cleft



is usually not specified. It is possible that such comments appertain to adults with posterior clefts of the hard and soft palate, or soft palate only. Unfortunately, there were no adults with lesser clefts in this study. However, it is reasonable to assume that they would present similarly to the adolescents with this cleft type. This study shows that 50% of the adolescents with lesser clefts presented pre-operatively with normal or near normal speech, which would explain the observations of Stenglehofen. Fletcher (1985) also reported a high level of speech performance in the adult in his case study, who presented with an unrepaired cleft of the soft palate and a partial cleft of the hard palate.

The adult group was significantly different from the children's group, in that the children made some spontaneous improvement with surgery alone. The adult and adolescent groups behaved similarly post-operatively, despite the fact that approximately one third of the adolescent sample consisted of patients with the lesser cleft type. However, as has been shown, even patients in this cleft group did not make significant articulatory changes without speech therapy.

Following therapy, all three groups made changes that were statistically significant. The adults, however, differed from both the children and adolescent groups in the degree of change and its maintenance.

The changes in the adult group were minimal, and improvements were not maintained once speech therapy ceased. In contrast, the qualitative nature of the changes in both the adolescent and the children's groups were appreciably greater than that of the adults (Figure 46). These improvements were maintained over time, and indeed in the children's group there was the suggestion of continuing improvements in the absence of therapy.

The hypothesis has therefore been partly upheld. Post-operatively, adults presented with disordered articulatory patterns that were more resistant to change compared with those of the children, but not of the adolescents. Following therapy, the disordered articulatory patterns of each age group changed significantly. However, the nature of that change was less for the adults, and clinically irrelevant. If the maintenance stage of therapy had been included in the hypothesis, differences between the adults and the other two age groups would have been found. From these findings it is evident that the original hypothesis should be extended to include a clause addressing the question as to which of the age groups would be able to maintain any speech changes after therapy had ceased. These findings indicate that another variable, that of maintaining change, should have been examined.

It is noteworthy that there were differences between the age groups in the range of speech disorders pre-operatively, in particular a high percentage of children falling into Speech Categories A and B. Reasons for these differences need to be examined. It is possible that with increasing age, maturation of the anatomical, physiological and perceptual systems may have led to some of the adults and adolescents changing their speech patterns. In addition, the adolescent group is also influenced by the high incidence of the lesser cleft group in Speech Category E at the pre-operative stage.

These pre-operative and post-operative findings are exactly opposite to some of the anecdotal comments reported in the literature. Law and Fulton (1959) stated that adults with unrepaired clefts of the lip and palate had near normal voice quality. Ehmann and Schonenberger (1991, p.471) included adults in their group, about which they said at the post-operative stage,

*"despite the lack of speech therapy, the nasal speech had definitely improved."*

Our findings, however, are similar to those of Ortiz-Monasterio et al. (1959, 1966, 1971, 1974) and Wu et al. (1990). Despite the weaknesses in their methodology and framework of speech analysis (see Chapter 2: section IV), Ortiz-Monasterio et al. reported that speech results were consistently poor in individuals who underwent palatoplasty in adulthood. Even when speech therapy was given, they reported that "speech results are consistently poor in adult cleft palates" (1959, 1966), and in a later paper (1974) "no improvement in adults". Therefore, these were probably sound conclusions based on observation rather than scientific evidence.

Wu et al. (1990) reported on the speech results of a group of 25 adults, who underwent a combined palatoplasty and pharyngeal flap. The speech therapy provided in their study included sophisticated technological treatment methods for an intensive period. They found that articulation and compensatory patterns of articulation remained unchanged post-operatively. Wu et al. (1990, p.39) concluded that,

*"their conversational speech remained in the same habituated compensatory pattern and in need of continuing speech therapy."*

Unfortunately, no information is given regarding changes in articulation achieved in single word utterances, which would be comparable to the controlled speech sample used in the present study.

In an attempt to explain these results, other variables in relation to age were examined. Ward and James (1990) and Ortiz-Monasterio et al. (1966) suggested that surgical repair of adults and older children was more difficult than that of younger children and infants.

Older children and adults presented with unrepaired palates which were wider than those of the younger children. The palatal segments were more vertically displaced. Ortiz-Monasterio et al. (1966) attributed this to the continuous upward pressure of the tongue into the unrepaired palate. When the lip was unrepaired the lack of anterior muscular lip pressure also contributed to the distortion of the palatal shelves since the major spine pulled outwards away from the cleft side. Such palate displacements into the nasal cavity, associated with under-development of the soft palate muscles (such as fibrosis and shortening of the levator palatini muscle) were characteristic problems of surgery in the adults and older children. Ward and James (1990) also reported marked mucoperiosteal fibrosis, which hampered the dissection of the oral and nasal layers, causing excessive bleeding.

All these characteristics made it difficult to achieve a complete watertight and tension-free closure of the nasal and oral layers of the hard palate, with separate dissection and union of the levator palatini muscle sling.

Such observations gave rise to the hypotheses regarding post-operative structure. It was hypothesized that adult patients would exhibit a higher incidence of velopharyngeal insufficiency and palatal breakdown following palate repair than adolescents and children. As a consequence, their ability to improve their speech production would be severely impaired.

With regard to velopharyngeal insufficiency, this hypothesis was upheld. Using the measure of nasopharyngoscopy, the adult group has the highest incidence of velopharyngeal insufficiency (81%), compared with an incidence of 60% in the adolescent group, and 44% in the children between the ages of 8–10 years at surgery.

However, one third of the adolescent group had lesser clefts. This cleft group had a significantly greater incidence of velopharyngeal closure, and therefore the inclusion of this group may have skewed these results. When the major cleft groups only are compared, a similar incidence of velopharyngeal insufficiency is found for the adults (81%) and adolescents (86%). Nonetheless, the adults apparently were unable to make as much change in speech or maintain those changes in comparison with the adolescents. The adults only exhibit a higher incidence of velopharyngeal insufficiency compared with the children.

A difference is found between the adults and adolescents in relation to the degree of velopharyngeal insufficiency. The incidence of gross insufficiency is 31% for the adults, and 7% for the adolescents. Similarly, almost the same percentage of the adolescent and the adult groups remained severely hypernasal following therapy. 94% of the adults and 86 % of the adolescents with major clefts remained severely hypernasal at 4/5 years post-operative follow-up.

These findings probably reflect the fibrotic nature of the tissues, and the characteristic fibrosis and shortening of the levator palatini muscle in the adult and adolescent populations (Ward and James, 1990). In addition, the high incidence of gross insufficiency in the adults may be partly due to the natural involution of adenoidal tissue post-puberty, and the effect of the forward and downward growth of the maxilla at puberty. Siegel-Sadewitz and Shprintzen (1986) have shown that the closure pattern in normal speaking cleft palate children is velar-adenoidal, whereas after facial growth has occurred the adenoids are generally above the hard palate and are not involved in the closure pattern.

With regards to fistulae, the hypothesis that the adults exhibited the highest incidence and degree of palatal fistulae following surgery has been upheld.

The highest occurrence of fistulae did occur in the adults (37%), compared with the adolescents (24%) and the children aged between 8–10 years at surgery (11%). Even when adolescents with the same sized fistulae and major clefts only were considered, the incidence of fistulae in this age group was the same (25%).

When examining the fistulae that occurred following total palatal closure, indicating post-operative palatal breakdown, the highest incidence of acquired fistulae was in the adult group (61%), compared with 33% in the adolescent group, and 6% in the children aged between 8–10 years at surgery. All fistulae occurred within the major cleft groups. Furthermore, the highest incidence of the largest fistulae occurred in the adult group.

Interestingly, however, deliberate fistulae left at surgery were more common in the children below the age of eight years at surgery. It is possible that difficult access to the surgical site in small mouths may account for this finding. However, it is probable that it is also related to surgical technique in this age group, as this feature was almost exclusively observed in patients operated on by one of the surgical teams.

The expectation that deliberate fistulae would be unavoidable in the adult group has not been upheld. However, these results indicate that the scarred, fibrotic nasal and oral layers of the palate described by Ward and James (1990) did lead to post-operative palatal breakdown in this age group.

These findings, appertaining to velopharyngeal function and fistulae, lend support to the suggestion by Ward and James (1990) and Ortiz-Monasterio et al. (1966) that surgical repair of adults and older children is more difficult than that of younger children and infants. Ward and James (1990) do not specify an age range in their discussion of 'older children'. It is possible that surgical repair may be more successful in early adolescence compared with late adolescence. However, a disadvantage of analysing two separate age groups in the adolescent sample would have been the small sample size of each age group.

This study has attempted to describe the different variables which may account for the disappointing speech results in the adults. Without doubt, serious structural problems are found following late palatoplasty.

In addition, other factors such as the facility for learning need to be examined. Fletcher (1978) proposes the developmental hypothesis as an explanation of the benefits of early palatal repair for speech. He suggests that early surgery results in less permanent maladaptations in speech physiology, and that articulation movements and posture are more malleable at earlier ages. Indeed, most physiological functions are best learned at an early age. Neuromuscular control and integration into the neurological system should occur at the optimal time, otherwise ineffective coordination and abnormal compensation habits result. Kaplan (1981) makes an analogy with problems in childhood vision and hearing. The child deprived of light perception in early childhood persists with visual problems even when the anatomical abnormalities are corrected. The child who does not develop hearing during the first few years of life does not develop normal speech even though hearing is later corrected. The longer the period of sound deprivation, the greater the speech abnormality.

Kaplan hypothesizes that, in a similar way, it is probable that palatal speech functions have an optimal time for normal development, and "uncorrectable" abnormal patterns occur if the palate is repaired at a later age. The present study suggests that articulation patterns and "palatal speech functions" cannot easily be changed in adulthood, lending support to the hypotheses proposed by both Fletcher and Kaplan.

However, the same is not entirely true for the adolescents and children. For example, when examining the adolescents who had major clefts and velopharyngeal insufficiency as measured by nasopharyngoscopy, 18% (N=4) made significant changes in controlled speech following therapy, which were maintained over time. Such a finding suggests that there is some potential for change which can be maintained in some adolescent patients with major clefts and velopharyngeal insufficiency. The small sample size of the children's group

aged 8–10 years at surgery precluded a similar analysis. Therefore the prediction that the factors of age, extent of clefting and success of surgery would have considerable influence on speech attainment in the oldest age group has been supported. Adolescents are less predictable however.

These findings differ somewhat from those of Ortiz-Monasterio et al. (1974). They reported that patients over the age of twelve years did not benefit from speech therapy, their sample contained no normal speakers, and none of their patients were free of nasality despite the pharyngoplasties. Table 53 compares the results of this study for the two separate age groups of adults and adolescents with the Ortiz-Monasterio findings.

*Table 53. A Comparison of the Results of the Adults and Adolescents, with the Ortiz-Monasterio Findings.*

	<b>Ortiz-Monasterio % Patients</b>	<b>SLP Adults % Patients</b>	<b>SLP Adols. % Patients</b>
% > than twelve years who benefited from speech therapy	0%	12%	29%
% achieved 'normal speech'	0%	4%	38%
			64% of which were lesser clefts
% oral tone	0%	0%	34% all cleft groups 9% major clefts

NB. In the current study the following criteria are used:

'benefited from speech therapy' refers to a post-therapy improvement of two speech categories or more.

'normal speech' refers to patients who were in speech category F either immediately after speech therapy or 4/5 years post-operatively.

### **Structural Issues**

McWilliams et al. (1990, p.68) emphasize that the aim of palate surgery as it relates to speech is to,

*"... close the hard palate so that the structures are not under undue tension, and to close the soft palate to ensure palate length, bulk, muscle arrangement and movement are sufficient to work cooperatively with the pharyngeal walls to gain velopharyngeal competence."*

This study is unique in its comprehensive attempts to determine the extent to which these aims can be realised in a population who undergo late palatoplasty.

With regard to the first part of the aims defined by McWilliams et al. (1990), the incidence of palatal fistulae was approximately 30% compared with an incidence of 9–47% in the literature, where surgery had been performed at a conventional time. Frequently, detailed information has not been provided as to how, and by whom, these fistulae have been judged. Ward and James (1990) state that this rate of 30% compares to an estimated 20% with a similar mix of cleft type in operations performed by the same surgeons in their

hospitals in the West. In the present study, they indicated that fistulae on some occasions were an unavoidable compromise. They attributed them to ischaemia, especially when working with both scarred and fibrotic nasal and oral layers of the palate.

The present study represents an in depth analysis of fistulae in a population undergoing late palatoplasty. Ortiz-Monasterio et al. (1974) only made two comments regarding fistulae. Their fistulae rate was 14%, and occurred most frequently at the junction of the hard and soft palate, and at the posterior border of the premaxilla. In the present study, the majority of fistulae occurred at the hard palate, postalveolus and alveolus, with a low incidence at the junction of the hard and soft palate.

Given the particular anatomical difficulties described by Ward and James (1990), the fistulae rate compares favourably with other series.

As outlined in Chapter 6, it was hypothesized that the degree of articulatory change in controlled speech is related to the degree of palatal post-surgical breakdown, irrespective of age. This issue was comprehensively discussed (see Chapter 6: section VIb), such that it is invalid to draw any conclusions of the relationship of speech outcome and fistulae in this population.

With regard to the second part of the aims defined by McWilliams et al. (1990), the overall incidence of velopharyngeal closure is extremely low in this population in comparison with other regimes of surgical timing.

The range of velopharyngeal closure is 18–23% according to the three different measures employed (nasopharyngoscopy: 23%, nasality: 18%, X-rays: 22%).

In a Western population, Spreistersbach et al. (1973) estimated that 75% of patients had velopharyngeal adequacy after primary surgery. McWilliams et al. (1984) indicated that the range of velopharyngeal closure was between 70–95%. Shprintzen (1990c) reported that approximately 87% of the individuals who had palate repair at approximately one year of age in his unit developed normal speech. This description presumably refers to normal resonance and, by implication, velopharyngeal function.

Looking at this information in a different way, the incidence of velopharyngeal insufficiency in the present population is virtually identical for each measure:– nasopharyngoscopy 67%, nasality 66%, and X-rays 66%. In the West, the incidence varies between 5% to 30%.

The incidence of velopharyngeal insufficiency is unacceptably high in all age groups, with the exception of patients with lesser clefts. One important finding from this study therefore is that palatoplasty is an inadequate surgical procedure for the patient who is more than eight years old at surgery.

No attempt was made to relate surgical technique to later velopharyngeal closure or speech results. The majority of the surgical procedures were the Von Langenbeck procedure. In a small percentage of operative reports it was unclear as to the specific surgical procedure used.

Furthermore, no attempt was made to relate outcome to the individual surgeon. Seven surgeons were

involved, and this therefore would not have been possible, because of the relatively small number of patients upon which each surgeon operated. Trost (1983) maintained that the use of two different surgical techniques and the involvement of more than one surgeon are weaknesses which preclude accurate analysis of surgical timing and type of intervention. She advocated that studies should endeavour to specify and control surgical procedure and surgeon. However, limiting the number of surgeons was not even a consideration, as one of the aims of the Sri Lankan project was to provide as much surgery as possible in a very limited intensive period. Furthermore, McWilliams (1960) pointed out that even when only one surgeon is included, his/her training, skill, and experience also have an appreciable influence on surgical outcome, regardless of the age at which surgery is undertaken. The outcome of surgery by a specific surgeon cannot necessarily be generalized to other surgeons. It is argued that even for the same surgeon there is variability in surgical procedure between operations. For example, degree of tension in a wound site, the exact extent of undermining of the bone which takes place and variations in incision site, are all unknown variables which influence outcome. Relating speech results to surgical procedure was not only inappropriate but impossible in this study.

The nasopharyngoscopy investigation permitted an examination of the patterns of velopharyngeal valving (see Chapter 2: section V). With regards to the movement characteristics of the pharyngeal walls and soft palate the distribution of the coronal, circular and sagittal patterns is similar to that found in the study of Croft et al. (1981). There are some differences, however, in the incidence of the circular pattern with Passavant's Ridge. The incidence of this pattern is much lower in this series compared with both Croft et al.'s normal and pathologic series. 19% (N=80) of Croft et al.'s normal speakers and 24% (N=500) of his pathological series had a circular pattern with Passavant's Ridge, in contrast to just 4% in this series. This indicates that Passavant's Ridge rarely develops in patients who establish their speech with an unrepaired palate, or subsequently following surgery. The reason for this is unknown.

Some authorities (Calnan, 1957; Dickson and Dickson, 1972; Piggott and McManamny, 1986) have attempted to explain Passavant's Ridge as a compensatory mechanism in cases of velopharyngeal insufficiency, or as occurring in individuals who would have velopharyngeal inadequacy if they did not have Passavant's Ridge. The present data, however, support the conclusion by Croft et al. (1981) and Glaser et al. (1979b), that Passavant's Ridge does not develop as a compensatory mechanism. If it were a compensatory mechanism, there would have been a much higher incidence of it in this population. Alternatively, it could be argued that in the unrepaired condition, Passavant's Ridge has no function, and therefore does not develop. Williams (1989), on the other hand, postulates that Passavant's Ridge develops as a result of the unusual compensatory adjustments of the vocal tract, associated with pharyngeal and laryngeal articulation. Again, the data in this study would appear not to support this hypothesis.

It was hypothesized that, irrespective of age, articulatory change in controlled speech would be related to the formation of an adequate or marginally adequate velopharyngeal mechanism. This hypothesis, however, was not upheld.

Speech improvement was not entirely restricted to individuals with velopharyngeal closure or borderline closure. Figure 46 displays the number of patients who made appreciable changes in their controlled speech. Out of a total of fourteen patients, seven had velopharyngeal insufficiency or gross insufficiency. Of the remaining seven patients two had borderline closure and three had velopharyngeal closure.

There has been considerable controversy regarding the advisability of speech therapy in the presence of velopharyngeal insufficiency. Van Demark (1974c) found that cleft palate children with velopharyngeal incompetence made minimal or no gains in articulation therapy. Riski and DeLong (1984) found in a longitudinal study of three to eight year olds that significant gains in articulation were only made once secondary pharyngeal surgery had taken place.

In contrast, authorities such as Trost-Cardamone (1986), Hoch et al. (1986), Coston (1986), and Shprintzen (1990c) maintained not only that articulatory change can occur in the presence of velopharyngeal insufficiency, but that it is crucial to effect these changes prior to the assessment of the velopharyngeal sphincter. This is to ensure that a valid assessment is made when secondary pharyngeal surgery is being considered.

Part of the reason for this controversy probably relates to the method of measuring articulation. In the type of traditional error analysis framework used by Riski and DeLong (1984), the use of a sound with correct manner, yet nasalized, would not be credited. In contrast, in the present study for example, the manner scale was designed to be able to detect improvements in the manner categories of plosion, frication and affrication with coexisting hypernasality and nasal air escape. Hence it was possible to identify positive speech changes in the presence of velopharyngeal insufficiency.

The findings of the present study are further evidence that articulation can change in the presence of velopharyngeal insufficiency.

## **VII. Minor Hypotheses**

### ***Surgical Observations at Palate Repair***

As described in Chapter 6 (see section VIc), it was hypothesized that speech outcome and post-operative velopharyngeal function were related to surgical observations at the time of palatal repair (Ward and James, 1990). Contrary to this prediction, it was found that judgements of the degree of fibrosis, muscle quality, and other surgical observations at palate repair, were unrelated to speech outcome and velopharyngeal function. This study shows similar findings to previous studies in this area (Van Demark, 1974a; Tobe and Salyer, 1989). Surgical observations at palate repair do not have any predictive value, regarding speech outcome and velopharyngeal function.



### ***Imitation of Singletons and Trisyllables***

Imitation of singletons and trisyllables were included in the assessment for three reasons. Firstly, it was assumed that it would only be possible to detect therapeutic effects on single consonant sounds or syllables, given the limited amount of speech therapy. Secondly, this information was useful in the planning of therapy (McWilliams et al., 1990). Thirdly, it was considered that performance on imitation tasks might be a predictive criterion in determining which patients were most likely to benefit from late palatal repair.

Two hypotheses were formulated with regard to the effects of surgery and therapy on imitation.

The initial hypothesis stated that surgery alone would not specifically affect a patient's ability to imitate singletons and trisyllables. It was predicted that therapy would facilitate this imitation skill. The second hypothesis was with regard to the effects of two types of therapy: articulation therapy and conversation therapy. It was hypothesized that patients who received palatal closure supported by subsequent articulation therapy would evidence positive changes in articulatory skills in imitation, compared with patients who received palatal closure supported by conversation therapy.

With regard to the effects of surgery and therapy, the results indicated that the first hypothesis has been upheld for singletons. Consonants in isolation do not change with surgery alone. When speech therapy is provided, there is a significant difference in the number of singletons correctly imitated.

With regard to the imitation of trisyllables, only part of the hypothesis has been upheld. Unexpectedly, trisyllable imitation did improve with surgery alone, although the amount of improvement with therapy was considerably greater than at the post-operative stage. The implication is that therapy made a considerable difference to the imitation of trisyllables.

With regard to the differential effects of articulation therapy and conversation therapy, again the second hypothesis has been upheld for singleton imitation. Singletons improved only with articulation therapy, but not with conversation therapy. The imitation of trisyllables unexpectedly improved with conversation therapy. No major differences were found between the improvements in imitation of singletons and trisyllables when the two therapies were compared. A closer analysis of the imitation of trisyllables suggests a pattern of slightly higher scores for the group who received articulation therapy compared with the conversational approach.

Therefore, the results of the imitation of singletons is as predicted. No appreciable changes occurred post-operatively. Appreciable changes occurred only with articulation therapy, but not with conversation therapy.

Contrary to expectation, the results of the imitation of trisyllables show statistically significant differences both post-operatively and with conversation therapy. Clinical interpretation, however, suggests that the changes are small, and clinically unimportant. It is probable that these results were affected by the coarse method of measuring trisyllable imitations. A correct/incorrect judgement was based on auditory impression, with no phonetic transcription. While these results suggest that the imitation of singletons is a more valuable assessment technique, the flaws mentioned above in the collection of information about trisyllable

production render a decisive conclusion about them unreliable.

Given that the results of the imitation of singletons behaved as predicted and therefore appeared reliable, the singletons task was selected to examine whether there was a relationship between imitation and speech outcome. As outlined in Chapter 6 (see section VIII), it was hypothesized that patients with low imitation scores on singletons at all the data points would not make significant changes in speech post-therapy. This hypothesis was upheld in that patients with poor imitation skills did not significantly change their speech, even after therapy. Such a result is to be expected: if patients are unable to imitate consonant sounds, it is unlikely that they will use them within their single word utterances.

However, the real issue was to determine how skills at the pre-operative stage related to speech outcome. Although it was hypothesized that patients with poor pre-operative imitation would not make significant changes to their speech, it was found contrary to this prediction, that 20% made appreciable changes. It would thus appear that low pre-operative imitation skills are not a reliable predictor of speech outcome following surgery and therapy.

These findings are similar to those with regard to stimulability, which has also been found not to provide a basis for predicting articulation change (McWilliams et al., 1990).

### ***Articulation and Conversation Therapy***

As outlined in Chapter 6 (see section VII), the point at issue here was to determine the differential effects of articulation and conversation therapy on speech performance following a brief intensive course of treatment. Based on evidence from such researchers as Chisum et al. (1969), Schendel and Bzoch (1970), McWilliams et al. (1984, 1990) and Van Demark and Hardin (1986), it was hypothesized that patients who received palatal closure supported by subsequent articulation therapy would result in positive changes in articulatory skills in imitation and single words, compared with patients who received palatal closure supported by conversation therapy. It was found that the imitation of singletons improved only with articulation therapy, but not with conversation therapy. Single word utterances behaved similarly to the imitation of trisyllables and improved with both articulation and conversation therapy.

When the two therapies were compared, no differences were found between the relative imitation of singletons, trisyllables, or single word utterances. Contrary to the prediction, patients who received palatal closure supported by subsequent articulation therapy did no better than those patients who received conversation therapy.

It could be argued, given the limited amount of therapy, that it is surprising that differences in articulation for single words were found at all after only ten days of intensive therapy. However, as predicted the imitation of singletons did improve with articulation therapy but not conversation therapy. It was not expected that any changes in speech would have taken place with the conversation approach, particularly given the high incidence of velopharyngeal insufficiency.

In the investigator's view, these results regarding single word utterances are a function of the method of measurement; viz. each group's accumulated raw scores of place, manner and voice. It is possible that differences of one point in each of these scales may have been sufficient to influence these results, leading to findings of statistical significance. Clinical interpretation suggests that the changes were clinically irrelevant in all patients, except one individual, who, as predicted, received articulation therapy. These results provide further evidence of the importance of interpreting speech results qualitatively, and not relying solely on outcomes of statistical significance. This study also supports the recent findings of Van Demark and Hardin (1986), who demonstrated the difficulties of controlling for the effects of therapy. Indeed, Van Demark and Hardin judged that it was an impossible task to match subjects adequately, and therefore chose a within subjects design for their study. This was not possible within the logistics of the Sri Lankan Project.

Although Van Demark and Hardin (1986) highlighted the psychological ramifications of therapy which occurs with minimal success, these problems did not arise given the brief duration of these intensive courses. Furthermore, the inclusion of the conversation approach not only helped relieve the pressures of working on articulation skills that were difficult to change, but also allowed discussion of the wider issues of communication, and the cleft condition.

### ***Years of Education***

Patients frequently reported difficulties with speech at the pre-operative stage, and often attributed leaving school early to not being understood. The results of this study indicate that approximately one third of patients attended school for less than two thirds of the time they could have done.

The three age groups differ in the number of patients who never attended school. This may be affected by the sample that the project attracted. It is possible that the small sample size of the youngest age group does not reflect the distribution in the population as a whole. In addition, it is conceivable that the presentation of this group and many of the adolescents to the project is indicative of motivated parents; i.e. the kind of parents who would encourage school attendance. The adults, on the other hand, were self-motivated to attend. This group possibly reflects the real picture of school attendance for a population with unoperated palates, compared with perhaps the rather biased two younger age groups. On the other hand, data on attendance at school by the adults were frequently dependent on the adult's own recall, and there is the possibility of inaccuracies in their statements.

As indicated in Chapter 6 (see section IX), it was intended to investigate whether the amount of schooling was related to speech. It was hypothesized that patients who received minimal education would have the more severe pre-operative speech disorders. Contrary to expectation, no such relationship was found. There are two possible explanations for this. It is possible that there was some positive change in the speech characteristics between the time of leaving school and pre-operative speech assessment. However, given the lack of change observed until speech therapy was provided, this is unlikely. Another possible explanation

is that the range of speech disorders at the pre-operative stage was small. Most patients had severely disordered speech: 81% of patients were found in Speech Categories A, B, and C, yet only 22% of patients attended school for less than 40% of the time. This suggests that many patients with severely disordered speech did continue to attend school, or at least did so for more than a minimal amount of time.

Finally, as part of determining predictive criteria, the number of years of education in relation to speech outcome was examined. The premise was held that patients who had had a minimal education would be unused to receiving instruction and possibly would not take full advantage of the therapy course. Conversely, patients who had completed their education might be able to benefit more from therapy, being used to receiving instruction from their education.

It was hypothesized, therefore, that patients who had received minimal education were less likely to benefit from subsequent speech therapy. A weak association was found, suggesting that the number of years of education does have some effect on how patients respond to therapy. Of the seventeen patients who made appreciable changes in speech, 47% attended school for the maximum amount of time, 35% attended for more than three quarters of the possible time, and 18% for less than this.

### **VIII. Other Factors**

One interesting aspect of these results is that there is a greater incidence of statistically significant findings associated with the major hypotheses than with the minor hypotheses. The major hypotheses have largely been upheld, in contrast to the minor hypotheses. This suggests that the assumption that certain hypotheses were more important has been substantiated. Furthermore, this concurs with the assumption that when the cleft palate is repaired at a conventional age, the important variables affecting outcome are cleft type, age at surgery, type of surgery, and other forms of intervention (McWilliams et al., 1990). In addition, the present study has shown that velopharyngeal function in the total population, and probably fistulae in the adults, are also important variables in this population.

The minor hypotheses were developed in an attempt to identify variables that might have predictive value for speech outcome following late palatoplasty.

Statistical methods were considered to examine the contribution of selected variables to the prediction of speech outcome. A multiple regression analysis was suggested as a possible technique to identify explanatory factors. However, the nature of the data and the level of measurement together with the difficulties of missing data, have precluded its use. Machine learning (neural networks) was considered, since this could be applied more satisfactorily to the categorical data in this study. The most "natural" attributes selected for study were those which were considered most likely to predict outcome. The measures that were selected as predictors were the imitation of singletons, imitation of trisyllables, years of education, cleft type, pre-operative speech pattern, audiological result in 1990, and characteristics of the surgeon's repair. The outcome measures were nasopharyngoscopy, speech patterns post-operatively and post-therapy, speech categories post-operatively,

post-therapy and at 4/5 years post-operatively, imitation skills, nasality, and fistulae. The neural network program divided these data into two sets. The program examined the first set of cases. As a consequence rules were induced. The rules were then applied to the second data set, in order to validate them. Unfortunately, this technique foundered because of the difficulties of missing data. This criterion was strict: where there was one occurrence of missing data for one case that case was no longer included in the analysis.

It was therefore necessary to extrapolate predictive criteria regarding speech outcome from the results (see Chapter 8).

Although middle ear disease is universal in cleft palate infants resulting in conductive hearing impairment (McWilliams et al., 1990), no attempt was made to investigate the relationship between speech performance and hearing ability and the history of/or current ear disease within this study. Albert et al. (1990) reported on the otologic findings of some of the project patients, many of whom were subjects in this study. They found a high prevalence of effusion and perforation for patients with repaired and unrepaired cleft palate over the age of ten years. These findings suggest that effusion and perforation were long-term characteristics of the patients in this study. Most importantly however, the audiometric findings showed that there was no difference in pure-tone threshold between repaired and unrepaired subjects, with the implication that this variable was held constant throughout the duration of the study. Indeed, Albert et al. (1991) specifically reported that the hearing abilities of the adults did not change with palatal repair. In the main cohort, the distribution of hearing ability at the 4/5 years post-operative follow-up stage was as follows: 47% presented with normal hearing (less than a mean of 20 decibels), 24% presented with mild hearing loss (mean of 21-40 decibels) and 10% presented with a moderate hearing loss (mean of greater than 41 decibels). These preliminary findings suggest that hearing loss is a contributory factor in determining speech outcome, and further study is recommended.

Speech performance and response to therapy can be affected by intelligence. McWilliams et al. (1990) cite a number of studies which have shown that children with cleft lip and/or palate, particularly those with palatal clefts only, have mean IQs which place them in the low average classification rather than at the population mean. More recent studies suggest that children with cleft palate are not at increased risk of developmental problems, but there is a tendency for children with isolated palatal clefts to do less well, especially when there are associated additional anomalies (McWilliams et al., 1990).

Although it was recognised that intelligence should have been assessed, this was not achieved satisfactorily. There are no standardized tests of intelligence with age equivalent norms available for a Sri Lankan population. The Ravens Matrices, a British test of nonverbal intelligence, was undertaken in the initial stages, but unreliable administration by the medical students, with no British psychologist available to oversee the collection of this material, led to some rather dubious results. Therefore this procedure was abandoned.

In an effort to control for intelligence, all identifiable syndromic children were excluded from this study.

It is acknowledged that there are other variables that may have influenced these results. D'Antonio et al. (1990) asserted that interpretation of data must be undertaken within the context of its ascertainment. She

warned of the numerous uncontrolled variables in unfamiliar surroundings. The present study was undertaken in a developing world environment, against a background of a civil war, in a very different cultural and religious context. These factors remain indeterminate influences in this study. For example, many of the patients were Buddhist, and it would be interesting to examine the extent to which a fatalistic religion may affect response to surgery and speech therapy. Reincarnation is the central epistemological foundation of Buddhism. Whatever happens to a person in the present life is determined to a large extent by the merits and sins in his previous life, known as a person's Karma. As Malalasekera (undated) states,

*"The Law of Karma may be described as the Law of Cause and Effect. Everything that happens does so only by reason of some earlier cause, and when that stops so does the result."*

In simplistic terms, the birth of a baby with a cleft lip and/or palate is often interpreted as a punishment for ill deeds in an earlier life. However, since it is viewed as a privilege to have a disabled person in the family, "merit points" are gained, which will be in the person's favour in the next life. Within the present life, it is permissible to improve one's Karma, for example, within the context of this Project, by seeking surgery or by striving to improve speech. However, should this not be possible this would be accepted in a fatalistic manner.

The influence of religious beliefs in these patients is unknown. Given that there are differences in kinds and degrees of Buddhism around the world, a local study of religious beliefs and cultures would be needed. Furthermore, attributing fatalistic attitudes to religion may be too simplistic. Poverty can also lead to fatalism, in the sense that there is no choice. This population is generally a rural and poor population, who were unable to afford private surgery. Indeed, many of these families had never travelled into the capital city, Colombo, and frequently had never left their villages. 60% had had no previous opportunity to have surgery. Their understanding of the nature of the disorder and the accompanying problems was often extremely limited. For example, patients over the age of ten years, and the immediate families of the children below that age, were asked the cause of cleft lip and/or palate. Only 8% knew it was a congenital defect, with almost 20% attributing it to religious, magical or astrological reasons.

In addition to religious and social conditions, personality variables are also relevant in controlling outcomes, such as the need for achievement, defined as the desire to meet standards of excellence in performance. This is likely to be related to cultural influences. For example, in this culture aspirations for women are concerned primarily with marriage, child rearing and house care, with low expectations of working outside the family home. Men, on the other hand, have the traditional role of breadwinner. It may be expected that they would wish to improve their educational position as a means of raising their position in society. However, studies about need for achievement have primarily been based on male subjects, particularly in relation to entrepreneurial success in private enterprise and the reproducibility of such results has been poor. Thus, there are considerable problems in this area, which preclude its study within this project, but it is recognized as a possible variable.

This is not intended as an extensive discussion, but purely as an indication of some of the sociological and

philosophical issues that may have contributed, at least in some subjects, to the results profile.

Returning to the results of the major hypotheses, the results of post-operative velopharyngeal insufficiency do indicate that palatoplasty alone is an inadequate surgical procedure when patients with major clefts are repaired over eight years of age.

The possibility of undertaking a pharyngeal flap, the traditional treatment protocol in the West for velopharyngeal insufficiency, was raised and explored in depth amongst team members. In fact it was the subject of some contention.

A pharyngeal flap acts as a mechanical obturator, whilst the superior pharyngeal constrictor muscle and the levator palatine muscles help to close the lateral ports during speech.

Primary pharyngeal flap, where a pharyngeal flap is undertaken simultaneously with palatoplasty, is a surgical protocol advocated by some surgeons in the West. In her review, McWilliams (1990) concluded that a primary pharyngeal flap in infancy was often associated with "excellent speech". However, the probability that it is not necessary in 75% of any surgical series in this age group is a strong argument against its use.

In populations undergoing late surgery, the evidence does not support the benefits of pharyngeal flap (see Chapter 2: Part B). Furthermore, a pharyngeal flap has the disadvantage of altering speech and respiratory physiology, often resulting in adverse sequelae of hyponasality, habitual mouth breathing, and snoring.

Recent studies (Shprintzen, 1988; Benjamin and Lehman, undated; Drew et al., 1985) have drawn attention to the medical risks associated with pharyngeal flaps. Shprintzen (1988) highlighted obstructive sleep apnoea as a possible complication of pharyngeal flap. Prompted by the post-operative death of a patient, Shprintzen reviewed 300 patients and found the incidence of obstructive sleep apnoea was 10%. To engage on a safe pharyngeal flap procedure, it is now advised that patients are admitted to intensive care for forty-eight hours post-operatively, where they remain on a cardiopulmonary monitor for their entire hospital stay. Drew et al. (1985) recommended that fluids and electrolytes be monitored closely post-operatively. The medical facilities recommended in these studies were not available in Sri Lanka (Ward and James, 1990).

Given the lack of evidence of the benefit of pharyngeal flaps, the medical risks involved, and the medical facilities recommended, Mars (1991b) judged that it was an inappropriate surgical procedure to undertake in a developing world environment.

## ***IX. Further Research***

It would be interesting to study in more precise detail the width and configuration of the cleft palate in those patients with major clefts who made appreciable improvement. In depth study of the group who achieved velopharyngeal closure would also provide valuable information. These findings might have enabled the identification of any specific physical features which might account for the favourable outcome in these cases. Further study of the audiological and ENT characteristics of this population is also recommended. An

investigation of gender differences would also be appropriate.

Pre-operative nasopharyngoscopy study of lateral wall movement in relation to post-operative nasopharyngoscopy would determine the characteristic movements of the lateral pharyngeal walls under the two conditions. Such data may elucidate the reasons that account for the high incidence of velopharyngeal insufficiency in this population. For example, it would be particularly interesting to determine how much potential the lateral pharyngeal walls have to adapt. Witzel (1991) has recently suggested that they may have more adaptive potential than previously thought. Her observations however were in the different context of secondary surgery in adults.

Information from nasopharyngoscopy would be useful in more detailed studies of speech, in particular tongue patterns, movements of the epiglottis, and the arytenoid cartilages.

A primary area of research, however, is the longitudinal study of the children below the age of eight years at surgery, in order to determine the results of speech and velopharyngeal function in this age group, particularly in children repaired at ages equivalent to those in the West.



# Chapter 8

## Conclusion

This chapter summarizes the findings of this study. The aims of the investigation are reviewed, followed by a statement of the major conclusions and important variables. Predictive criteria regarding palatal repair are identified. The advantages of the method devised to analyse speech are briefly reviewed. This is followed by a brief discussion of the relationship of the speech results to those of facial growth in this population. Finally, the theoretical implications of both the post-operative speech results and post-operative velopharyngeal function, associated with this regime of surgical timing, are discussed.

The main aim of this investigation was to carry out an in depth study of the speech performance of a population who had established their speech in the presence of an unoperated cleft palate. Speech was examined pre-operatively, post-operatively and following therapy. This investigation was undertaken in the context of the developing world, where there had been no previous opportunity for either surgery or speech therapy.

The major conclusions are now outlined.

- ❑ Patients who have established their speech with an unrepaired palate usually have severely disordered speech, with the exception of some patients, particularly those with unrepaired clefts of the posterior one third of the hard palate and/or the soft palate.
- ❑ Palatal repair alone does not lead to significant changes in articulation when patients are over eleven years of age at surgery.
- ❑ Surgery supported by speech therapy can result in appreciable changes in articulation in controlled speech for some patients. However, maintaining the small gains achieved in therapy is usually very difficult for adults.
- ❑ Post-operatively, many patients retain these poor speech patterns, even with some speech therapy support. Only one third of the cohort had normal or near-normal speech. Only 20% of the cohort achieved post-operative velopharyngeal closure.
- ❑ The important variables affecting outcome were palatal repair, therapy intervention, age, cleft type, nature of pre-operative speech, nature of surgery, structural issues of velopharyngeal function, and possibly fistulae in the adult group.
- ❑ With regard to age, the adults made only small gains with speech therapy, which were not maintained. Structurally, they presented with the highest incidence of palatal fistulae, and the greatest degree of velopharyngeal insufficiency.

In contrast, some of the adolescents with equivalent major clefts made greater gains in therapy, which were maintained. The incidence and degree of fistulae were less in the adolescents. Although the incidence of velopharyngeal insufficiency was similar to that of the adults, the degree of insufficiency was less.

- ❑ Patients with unrepaired clefts of the posterior one third of the hard palate and/or soft palate demonstrated consistently better speech at all stages, with a considerably higher incidence of velopharyngeal closure, and no fistulae. This indicates that palatoplasty is an adequate surgical procedure in this group.
- ❑ In contrast, the high incidence of velopharyngeal insufficiency in patients with major clefts suggests that palatoplasty is an inadequate surgical procedure for the majority of patients in this group over the age of eight years at surgery.
- ❑ The nature of pre-operative speech determines to some extent the prognosis for improvement. Speakers with pre-operative Speech Categories A, B, or C usually do not make appreciable changes to their speech even with therapy. For example, it was found that adults who begin in pre-operative Speech Categories A and B do not significantly benefit from late palatoplasty, even if speech therapy support is provided. In general terms, the prognosis for change is directly related to the quality of pre-operative speech. Patients who are at the worse end of the scale tend to remain in that position. The average speakers stay the same or improve a little. Patients who are at the top end of the scale either remain in that position, or more usually improve with speech therapy.
- ❑ The surgeon's observations at the time of palatoplasty were not predictive of outcomes for either speech or velopharyngeal function.
- ❑ Skill at pre-operative singletons imitation is not indicative of speech outcome following therapy.
- ❑ The amount of education the patient has received may have some relationship with speech outcome.

It was hoped that this study would increase the understanding of the indications for particular types of palatal and velopharyngeal surgery in such populations (Ward and James, 1990). One of the clinical aims has been to identify some criteria that could inform decisions regarding palatal repair for visiting teams to the developing world (Law and Fulton, 1959; Keunen, 1966; Boo-Chai, 1971).

It is generally accepted that there is only one criterion for determining the benefits of late palatal surgery, that of age. McWilliams (1990), however, pointed out that, since age at surgery interacts with other variables, it is unrealistic to discuss age apart from other considerations. The present study has indeed shown that in addition to age other variables are also important. Cleft type, the nature of pre-operative speech, the availability of speech therapy, and possibly the amount of school attendance should also be taken into account in surgical decisions in this environment.

The following predictive criteria are general guidelines. Exceptions may be encountered.

If a palatoplasty is to be performed when the patient is more than eight years of age, the following guidelines are proposed:

1. Patients who present with pre-operative Speech Categories A, B, or C are unlikely to improve without continuing supportive speech therapy.

Adults with pre-operative Speech Categories A or B are unlikely to improve even with supportive speech therapy.

Adults with pre-operative Speech Categories A or B, who scored less than 26% pre-operatively on singletons imitation are unlikely to improve even with supportive speech therapy.

2. Patients who present with pre-operative Speech Category C are unlikely to improve with surgery alone. With speech therapy, there is a possibility of appreciable improvement.
3. Patients who present with pre-operative Speech Categories D or E may benefit without speech therapy support. With speech therapy there is usually appreciable improvement, particularly in patients with lesser clefts.
4. Patients over the age of eleven years at palatoplasty are unlikely to improve their speech with surgery alone, except if they have a lesser cleft and present with Speech Categories D or E.
5. Adults with major clefts are unlikely to improve their speech, even with speech therapy. They would probably demonstrate post-operative velopharyngeal insufficiency.
6. Patients with lesser clefts are most likely to gain velopharyngeal closure and normal speech with speech therapy support.
7. Patients with at least 75% school attendance are likely to benefit from therapy more than patients with minimal education.

As can be seen the list of criteria is limited, partly because a high proportion (76%) of the patients in this study have not benefited from surgery, even when using controlled speech.

Such limited criteria have serious implications for those teams visiting the developing world to perform surgery on older patients. The value of palatal closure is very limited if speech therapy is not available as a follow-up to surgery. Unfortunately, speech therapy services are usually not available in this context. Realistically this is unlikely to change in the foreseeable future, particularly with regard to the skilled speech therapy required in the treatment of this condition. Even when speech therapy is provided, it usually needs to be prolonged and intensive. With regard to speech, this study therefore casts considerable doubt on the value of palatal closure for all patients in this population.

This study has demonstrated that Western speech therapists are able to reliably assess controlled speech in this type of population. The broad system of measurement developed is appropriate and reliable, when used in an environment where there are constraints as a consequence of the visiting Western speech therapist not speaking the local language. A further factor is that speech and oral structure are both seriously deviant. Detailed phonetic transcription is not possible under these conditions, and is arguably contraindicated. Furthermore, such an approach is unlikely to meet the aims of this investigation.

The unique method of speech analysis devised in this research has several advantages, particularly in a developing world environment. Simplicity and speed of application by a trained speech therapist who does not speak the local language are particular advantages. Furthermore, this system has value in predicting to some extent speech outcome following surgery and speech therapy.

Hutters and Bronsted (1987) proposed that the active and passive coping strategies in cleft palate speakers are universal, related to the organic condition rather than language dependent. This study has found that the same strategies are evident in a population who had established their speech in the presence of an unoperated cleft palate. It is argued that, in a similar way, as a consequence of the cleft palate condition the articulatory activities evidenced in cleft palate speech are universal and not language dependent. It is suggested that the system of speech analysis is transferable across languages, with this type of population. It is also potentially useful in a population where there is earlier palatal closure.

The serious effects of an unoperated cleft palate on speech acquisition provide a balance to the results of the facial growth studies in this population, as stated by McWilliams et al. (1990) and Morris and Bardach (1989, 1990).

Facial growth studies have been undertaken in forty-six unilateral cleft lip and palate Sri Lankan males with unoperated palates. All subjects were more than thirteen years of age (Mars and Houston, 1990). The results showed that subjects have the potential for normal maxillary growth. This contrasts with the results of a study in two British centres, in which palatal repair occurred at a conventional age in infancy. 40–45% of this population exhibited maxillary retrusion severe enough to warrant major corrective facial surgery in late adolescence. Nevertheless, although the Sri Lankan males demonstrated normal facial growth, this study has shown that speech and velopharyngeal function are severely compromised in this situation. Before surgery 64% of this group presented in Speech Categories A or B, and 24% in Speech Category C. Following surgery, the incidence of velopharyngeal insufficiency is high (94%), with only 16% of this group making appreciable changes in articulation after speech therapy.

Therefore, in the unoperated condition, although facial growth is apparently satisfactory, speech is severely compromised. Furthermore, this effect is permanent for the majority of cases, even when some speech therapy support is provided. Work by Mars and Houston (1990) suggests that impaired facial growth following palatal repair is an iatrogenic deformity.

This study can address the two hypotheses which McWilliams et al. (1990) proposed (see Chapter 1). With regard to speech production skills, they hypothesized that,

*"...when palatoplasty and hence any possibility of normal velopharyngeal functioning is delayed until after the child has begun to talk, the resulting speech patterns are apt to be defective because of the abnormal velopharyngeal anatomy and physiology. A test of this hypothesis is to determine whether early palatoplasty results in normal patterns of speech more frequently than does later palatoplasty." (op. cit. p.62)*

The findings from the present study can be compared with the results of early palatoplasty reported in the literature. Although it is acknowledged that direct comparisons are problematic, because of different methodologies and methods of measuring speech, the disparity in the results of the two protocols of surgical timing are sufficiently great to overcome these problems. In the West, when surgery alone is provided, with no supportive speech therapy, it is estimated that approximately 50% of children develop normal speech spontaneously (Spreistersbach et al., 1973). In patients in this study who were over eight years old at palatoplasty, only 10% demonstrated normal or near-normal speech with surgery alone.

In the West, when speech therapy is provided, it is estimated that approximately 75–80% of children develop normal or near-normal speech (Spreistersbach et al., 1973). In this population in Sri Lanka, only 30% demonstrated normal or near-normal speech with speech therapy support.

This study has clearly shown that late palatoplasty does result in abnormal patterns of speech more frequently than that reported in the literature for early palatoplasty. This supports the hypothesis proposed by McWilliams et al. (1990) that, when surgery and hence any possibility of normal velopharyngeal functioning, is delayed until after speech has been established, speech patterns are usually seriously deviant because of the abnormal velopharyngeal anatomy and physiology.

Evidence from this study can also be used to address the second hypothesis put forward by McWilliams et al. (1990) (see Chapter 1). With regard to velopharyngeal function, they suggested that,

*"...the physiologic potential of the muscles comprising the velopharyngeal valving mechanism may be irretrievably lost by delay in moving them into a normal relationship. This hypothesis can be tested by determining whether early palatoplasty results in physiological velopharyngeal competence more frequently than later palatoplasty." (op. cit. p.62)*

In the West, estimates of velopharyngeal closure following primary palatoplasty vary between 70% to 95% (McWilliams et al. 1990). In this population in Sri Lanka, only 20% demonstrated post-operative velopharyngeal closure.

This study has clearly shown that late palatoplasty does result in physiological velopharyngeal incompetence more frequently than that reported in the literature for early palatoplasty. The suggestion is borne out that

the physiological potential of the muscles comprising the velopharyngeal valving mechanism may be irretrievably lost by delay in moving them into a normal relationship.

In conclusion, these results clearly indicate the inadequacy of speech and velopharyngeal function in the late operated Sri Lankan population at all stages of the investigation.

## References

- Abyholm FE, Borchgrevink HH, and Eskeland G. (1979) Palatal fistulae following cleft palate surgery. *Scand. J. Plast. Reconstr. Surg.* 13: 295–300.
- Albert DM, Garrett J, Specker B, and Ho M. (1990) The otologic significance of cleft palate in a Sri Lankan population. *Cleft Palate J.* 27: 155–161.
- Albery E, and Enderby P. (1984) Intensive speech therapy for cleft palate children. *Brit. J. Dis. of Commun.* 19: 115–124.
- Albery E. (1991) Consonant articulation in the different types of cleft lip and palate. Paper presented at the annual meeting of the Craniofacial Society of Great Britain, Leicester.
- Backus P, Clancy J, Henry L, and Kemper J. (1943) The child with a cleft palate. Ann Arbor: Univ. Michigan Press.
- Ball MJ. (1989) Phonetics for speech pathology. London: Taylor and Francis.
- Bardach J, Morris HL, and Olin WH. (1984) Late results of primary veloplasty: the Marburg project. *Plast. Reconstr. Surg.* 73: 207–215.
- Bardach J, and Kelly KM. (1991) Reflections on research. *Cleft Palate J.* 28: 130–135.
- Benjamin C, and Lehman JA. (undated) Speech results and complications following pharyngeal flap surgery: 1972–1988. Unpublished data.
- Bernthal JE, and Weiner FF. (1976) A re-examination of the sound omission – preliminary considerations. *J. Child Commun. Dis.* 1: 132–139.
- Berry MF. (1928) Correction of cleft palate speech by phonetic instruction. *Quart. J. Speech* 14: 523–531.
- Bill AH, Moore AW, and Coe HE. (1956) The time of choice for repair of cleft palate in relation to the type of surgical repair and its effect on bony growth of the face. *Plast. Reconstr. Surg.* 18: 469–473.
- Bishara SE, Jakobsen JR, Krause JC, and Sosa-Martinez R. (1986) Cephalometric comparisons of individuals from India and Mexico with unoperated cleft lip and palate. *Cleft Palate J.* 23: 116–125.
- Boo-Chai K. (1971) The unoperated adult bilateral cleft of the lip and palate. *Brit. J. of Plast. Surg.* 24: 250–257.
- Bowman SA, and Shanks JC. (1978) Velopharyngeal relationships of /i/ and /s/ as seen cephalometrically for persons with suspected incompetence. *J. Speech Hear. Dis.* XL111: 185–191.
- Brooks AR, Shelton RL, and Youngstrom KA. (1965) Compensatory tongue-palate-posterior pharyngeal wall relationships in cleft palate. *J. Speech Hear. Dis.* 30: 166–173.
- Brooks R, Shelton RL, and Youngstrom KA. (1966) Tongue-palate contact in persons with palate defects. *J. Speech Hear. Dis.* 31: 15–25.
- Brown SL, Laskin R, Margar-Bacal F, Witzel MA, and Bedder-Manley C. (1990) The laryngeal fricative in cleft palate speech: description and diagnosis. Paper presented at the American Cleft-Palate-Craniofacial Association Meeting, Missouri.
- Buck M. (1960) Velopharyngeal movements and tongue carriage during speech in adults with unrepaired incomplete cleft palates. *Cleft Palate Bull.* 10: 8–10.

- Byrne MC. Shelton RL. Diedrich WM. (1961) Articulation skill, physical management and classification of children with cleft palate. *J. Speech Hear. Dis.* 26: 326–333.
- Bzoch KR. (1965) Articulatory proficiency and error patterns of preschool cleft palate and normal children. *Cleft Palate J.* 2: 340–349.
- Bzoch KR. (1979) Measurement and assessment of categorical aspects of language, voice and speech disorders. In: Bzoch KR. Ed. *Communicative Disorders Related to Cleft Lip and Palate*. Boston: Little, Brown and Company. 161–191.
- Calnan J. (1953) Movements of the soft palate. *Brit. J. Plast. Surg.* 5: 286–296.
- Calnan J. (1957) Modern views on Passavants Ridge. *Brit. J. Plast. Surg.* 10: 89–113.
- Chisum L. Shelton RL. Arndt WB. and Elbert M. (1969) The relationship between remedial speech instruction activities and articulation change. *Cleft Palate J.* 6: 57–64.
- Coates WA. and DeSilva MWS. (1960) The segmental phonemes of Sinhalese. *University of Ceylon Review.* 18: 163–175.
- Cohn E. and McWilliams BJ. (1983) Early cleft palate repair and speech outcome. *Plast. Reconstr. Surg.* 71: 442–443.
- Cosman B. and Falk AS. (1980) Delayed hard palate repair and speech deficiencies: a cautionary report. *Cleft Palate J.* 17: 27–33.
- Coston GN. (1986) Therapeutic management of speech disorders associated with velopharyngeal incompetence. *J. Child Commun. Dis.* 1: 75–85.
- Counihan DT. (1960) Articulation skills of adolescents and adults with cleft palates. *Cleft Palate J.* 25: 181–187.
- Cullihan WL. and Counihan DT. (1971) Ratings of vowel representatives. *Percept. Mot. Skill* 32: 395–401.
- Croft CB. Shprintzen RJ. and Rakoff SJ. (1981) Patterns of velopharyngeal valving in normal and cleft palate subjects: a multiview videofluoroscopic and nasendoscopic study. *Laryngoscope* 91: 265–271.
- Crystal D. (1981) *Clinical linguistics*. Wien: Springer Verlag.
- Curtis JF. (1968) Acoustics of speech production and nasalization. In: Ed. Spreistersbach DC. and Sherman D. *Cleft Palate and Communication*. New York: Academic Press. 45–62.
- D'Antonio LL. Marsh JL. Province MA. Muntz HR. and Phillips CJ. (1989) Reliability of flexible fibreoptic nasopharyngoscopy for evaluation of velopharyngeal function in a clinical population. *Cleft Palate J.* 26: 217–225.
- Dalston RG. Marsh JL. Vig KW. Witzel MA. and Bumstead MA. (1988) Minimal standards for reporting the results of surgery on patients with cleft lip, cleft palate or both: a proposal. *Cleft Palate J.* 25: 3–7.
- Davis AD. (1951) Unoperated bilateral complete cleft lip and palate in the adult. *Plast. Reconstr. Surg.* 7: 482–491.
- DeJesus JA. (1959) Comparative cephalometric analysis of nonoperated cleft palate adults and normal adults. *Am. J. Orthod.* 45: 61–62.
- DeSilva MWS. (1979) *Sinhalese and other island languages in South Asia*. Pub. Gunter Narr Verlag Tubingen.
- Dickson DR. and Dickson WM. (1972) Velopharyngeal anatomy. *J Speech. Hear. Res.* 15: 372–381.
- Disanayake JB. (1985) *Say it in Sinhala*. Colombo: Lake House Investments Ltd.



- Disanayake JB. (undated) National Languages of Sri Lanka –1 Sinhala. Sri Lanka: Dept. of Cultural affairs. 3–37.
- Dorf DA. and Curtin JW. (1982) Early cleft palate repair and speech. *Plast. and Reconstr. Surg.* 70: 74–79.
- Drew GS. Tripathi S. and Lehman JA. (1985) The syndrome of inappropriate secretion of antidiuretic hormone in the pharyngeal flap operation. *Cleft Palate J.* 22: 88–92.
- Edwards M. (1980) Speech and Language Disability. In: Edwards M. and Watson ACH. Eds. *Advances in the Management of Cleft Palate*. Edinburgh: Churchill Livingstone. 83–96.
- Ehmann G. and Schonberger AM. (1991) Late results of one-stage primary surgery in 118 adult Africans with clefts of lip, alveolus, and palate using the wave-line procedure and bridge-flap technique. In: Pfeifer G. Ed. *Craniofacial Abnormalities and Clefts of the Lip, Alveolus and Palate*. 4th Hamburg International Symposium. Stuttgart: Thieme. 468–471.
- Ellis RE. (1979) The Exeter nasal anemometry system. In: Ellis RE. and Flack FC. Eds. *Diagnosis and Treatment of Palato Glossal Malfunction*. Monograph no. 2 in association with the Brit. J. Commun. Dis. London: The College of Speech Therapists.
- The Eurocleft Speech Group: Grunwell P. Bronsted K. Henningsson G. Jansonius K. Karling J. Meijer M. Ording U. Sell D. Wyatt R. and Vermeij-Zieverink E. (1991). A methodology for the cross-linguistic investigation of cleft palate speech. Paper presented at the Fourth European Craniofacial Congress, Holland.
- Evans D. and Renfrew C. (1974) The timing of primary cleft palate repair. *Scand. J. Plast. Reconstr. Surg.* 8: 153–155.
- Fletcher SG. (1978) *Diagnosing speech disorders from cleft palate*. New York: Grune and Stratton.
- Fletcher SG. (1985) Speech production and oral motor skill in an adult with an unrepaired palatal cleft. *J. Speech Hear. Dis.* 50: 254–261.
- Gair JW. (1989) Personal communication.
- Geiger W. (1938) "A grammar of the Sinhalese language". Colombo: Royal Asiatic Society.
- Gillies HD. and Fry KW. (1921) A new principle in the surgical treatment of congenital cleft palate. *Brit. Dent. J.* 42: 293–299.
- Glaser ER. McWilliams BJ. and Skolnick L. (1979a) Letter to the editor: response to Bowman and Shanks. *J. Speech Hear. Dis.* 34: 557–558.
- Glaser ER. Skolnick ML. McWilliams BJ. and Shprintzen RJ. (1979b) The dynamics of Passavant's Ridge in subjects with and without velopharyngeal insufficiency – a multi-view videofluoroscopic study. *Cleft Palate J.* 16: 24–33.
- Golding-Kushner KJ. Argamaso RV. Cotton RT. Grames LM. Henningsson G. Jones DL. Karnell MP. Klaiman PG. Lewin ML. Marsh JL. McCall GN. McGrath CO. Muntz HR. Nev Dahl MT. Rakoff SJ. Shprintzen RJ. Sidoti EJ. Vallino LD. Volk M. William WN. Witzel MA. Dixon Wood VL. Ysunsa A. and four corresponding participants: D'Antonio L. Isberg AM. Piggott RW. Skolnick LM. (1990) Standardization for the reporting of nasopharyngoscopy and multiview videofluoroscopy: a report from an international working group. *Cleft Palate J.* 27: 337–348.
- Greene MCL. and Canning A. (1959) The incidence of nasal and lateral defects of articulation in cleft palate. *Folia Phontia.* 11: 208–216.
- Greene MCL. (1960) Speech analysis of 263 cleft palate cases. *J. Speech Hear. Dis.* 25: 43–48.

- Grundy K. (1989) Developmental speech disorders. In: Ed. Grundy K. *Linguistics in Clinical Practice*. London: Taylor & Francis.
- Grunwell P. (1987) *Clinical Phonology*. 2nd ed. London: Croom Helm.
- Grunwell P. and Russell VJR. (1987) Vocalizations before and after cleft palate surgery: a pilot study. *Brit. J. of Dis. of Commun.* 22: 1–17.
- Grunwell P. and Dive D. (1988) Treating 'cleft palate speech': combining phonological techniques with traditional articulation therapy. *Child Language, Teaching and Therapy* 4:193–210.
- Hagerty RF. and Hill MJ. (1963) Facial growth and dentition in the unoperated cleft palate. *J. Dent. Res.* 42: 412–421.
- Harding A. Sell DA. and Grunwell P. (1990). Perspectives on cleft palate speech assessment: part two, a video presentation. Paper presented at the annual meeting of the Craniofacial Society of Great Britain, East Grinstead.
- Henningsson G. Karling J. and Larson O. (1990) Early or late surgery of the hard palate? A preliminary report on the comparison of speech at four years of age. Paper presented at the First International Meeting of the Craniofacial Society of Great Britain, 1985. In Huddart A. and Ferguson M. Eds. (1990) *Cleft Lip and Palate: Long-term Results and Future Prospects*. Manchester: Manchester University Press. 402–411.
- Henningsson G. and Isberg AM. (1986) Velopharyngeal movement patterns in patients alternating between oral and glottal articulation: a clinical and cineradiographic study. *Cleft Palate J.* 23: 1–9.
- Henningsson G. and Isberg AM. (1987) Influence of palatal fistulae on speech and resonance. *Folia Phoniat.* 39: 183–191.
- Henningsson G. (1988) Impairment of velopharyngeal function in patients with hypernasal speech. A clinical and cineradiographic study. Stockholm: Karolinska Institutet.
- Henningsson G. and Isberg A. (1990) Oronasal fistulas and speech production. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate*. Philadelphia: Saunders. 787–791.
- Henningsson G. and Isberg AM. (1991) A cineradiographic study of velopharyngeal movements for deviant versus nondeviant articulation. *Cleft-Palate-Craniofac. J.* 28: 115–118.
- Hodson BW. Chin L. Redmond B. and Simpson R. (1983) Phonological evaluation and remediation of speech deviations of a child with a repaired cleft palate: a case study. *J. Speech Hear. Dis.* 48: 93–98.
- Hoch L. Golding-Kushner K. Sadewitz VL. and Shprintzen RJ. (1986) Speech Therapy. *Seminars in Speech and Language*. 7: 311–323.
- Honigsmann K. (1991) Speech development after the two stage closure of complete uni- and bilateral CLP. Paper presented at the Fourth European Craniofacial Congress, Holland.
- Hotz MM. Gnoinski WM. Nussbaumer H. and Kistler E. (1978) Early maxillary orthopedics in CLP cases: Guidelines for surgery. *Cleft Palate J.* 15: 405–411.
- Huber MW. (1957) A clinical approach to cleft palate speech therapy. *West Speech.* 21: 30–36.
- Huskie C. (1979) Intensive therapy – Glasgow experience. In Ellis RE. and Flack FC. Eds. *Diagnosis and treatment of palato glossal malfunction*. Monograph no.2 in association with Brit. J. Dis. of Commun. London: The College of Speech Therapists. 71–75.
- Hutters B. and Bronsted K. (1987) Strategies in cleft palate speech – with special reference to Danish. *Cleft Palate J.* 24: 126–136.

- I.P.A. (1979) Principles of the International Phonetic Association. London, I.P.A.
- Innis CO. (1962) Some preliminary observations on unrepaired hare lips and cleft palates in adult members of the Dusan Tribes of N. Borneo. *Brit. J. Plast. Surg.* 15: 173–181.
- Isberg AM. and Henningsson G. (1987) Influence of palatal movements on velopharyngeal movements: a cineradiographic study. *Plast. and Reconstr. Surg.* 79: 525–530.
- Isberg AM. and Williams WN. (1990) Radiographic examination of velopharyngeal function. In Delbalso AM. Ed. Maxillofacial Imaging. Philadelphia: Saunders. 721–733.
- Jackson JT. (1972) Closure of secondary palatal fistulae with intra-oral tissue and bone grafting. *Brit. J. Plast. Surg.* 25: 93–105.
- Jackson MS. Jackson JT. and Christie FB. (1976) Improvement in speech following closure of anterior palatal fistulas. *Brit. J. Plast. Surg.* 29: 295–296.
- Jackson I. McLellan G. and Schecker LR. (1983) Primary veloplasty or primary palatoplasty: some preliminary findings. *Plast. Reconstr. Surg.* 72: 153–157.
- Jolleys A. (1954) A review of the results of operations on cleft palates with reference to maxillary growth and speech function. *Brit. J. Plast. Surg.* 7: 229–241.
- Jones D. (1950) The phoneme: its nature and use. Cambridge: Heffer & Sons.
- Jones MC. (1988) Etiology of facial clefts. *Cleft Palate J.* 25: 16–20.
- Kaplan E.N. (1981) Cleft palate repair at three months? *Annals of Plastic Surgery* 7: 179–190.
- Karling J. (1989) Panel discussion – Bilateral Cleft Lip and Palate. Sixth International Congress on Cleft Palate and Related Craniofacial Anomalies, Jerusalem, Israel.
- Karnell MP. Ibuki K. Morris HL. and Van Demark DR. (1983) Reliability of the nasopharyngeal fibroscope (NPF) for assessing velopharyngeal function: analysis by judgement. *Cleft Palate J.* 20: 199–208.
- Kawano M. Isshiki N. Harita Y. and Tanokuchi F. (1985) Laryngeal fricative in cleft palate speech. *Acta Otolaryngol (Supp.)* 419: 180–188.
- Keunen HF. (1966) Plastic Surgical Safari with A.M.R.F. in E. Africa. *Plast. Reconstr. Surg.* 37: 72–80.
- Krause CJ. Tharp RF. and Morris HL. (1976) A comparative study of results of the von Langenbeck and the V–Y pushback palatoplasties. *Cleft Palate J.* 13: 11–19.
- Lamabadusuriya SP. Mars M. and Ward CM. (1988) Sri Lankan cleft lip and palate project: a preliminary report. *J. Roy. Soc. of Med.* 81: 705–709.
- Landis P. and Cuc T. (1972) Articulation patterns and speech intelligibility of 54 Vietnamese Children with unoperated oral clefts: clinical observations and impressions. *Cleft Palate J.* 12: 234–243.
- Law FE. and Fulton JT. (1959) Unoperated oral clefts at maturation. *Annu. J. Publ. Health* 49: 1517–1524.
- Lawrence CW. and Philips BJ. (1975) A telefluoroscopic study of lingual contacts made by persons with palatal defects. *Cleft Palate J.* 12: 85–94.
- Loney R. and Bloem T. (1987) Velopharyngeal dysfunction: recommendations for use of nomenclature. *Cleft Palate J.* 24: 334–335.
- Lonnen DM. McLennan JG. Mars M. and Plint DA. (1991) The Goslon Yardstick applied to a UCL&P sample from the West of Scotland. Paper presented at the British Craniofacial Meeting, Leicester.

- Lynch JL, Fox DR, and Brookshire BL. (1983) Phonological proficiency of two cleft palate toddlers with school age follow up. *J. Speech Hear. Dis.* 48: 274–85.
- McComb H. (1989) Cleft lip and palate: new directions for research. *Cleft Palate J.* 26: 145–147.
- McGrath CO, and Anderson MW. (1990) Prosthetic treatment of velopharyngeal incompetence. In: Bardach J, and Morris HL, Eds. *Multidisciplinary Management of Cleft Lip and Palate*. Philadelphia: Saunders. 809–814.
- McWilliams BJ. (1958) Articulation problems of a group of cleft palate adults. *J. Speech Hear. Res.* 1: 68–74.
- McWilliams BJ. (1960) Cleft palate management in England. *Speech pathology and therapy.* 3: 3–7.
- McWilliams BJ, Morris HL, and Shelton RL. (1984) *Cleft Palate Speech*. Philadelphia: BC, Decker.
- McWilliams BJ, Morris HL, and Shelton RL. (1990) *Cleft Palate Speech*. Philadelphia: BC, Decker. 2nd edition.
- McWilliams BJ. (1990) The long-term speech results of primary and secondary surgical correction of palatal clefts. In: Bardach J, and Morris HL, Eds. *Multidisciplinary Management of Cleft Lip and Palate*. Philadelphia: Saunders. 815–819.
- Mahler H. (1981) The meaning of "health for all by the year 2000". *World Health Forum.* 2: 5–22.
- Malalasekera GP. (undated) *Buddhism in Sri Lanka*. Sri Lanka: State Printing Corporation.
- Mars M, Plint DA, Houston WJB, Bergland O, and Semb G. (1987) The Goslon Yardstick: a new system of assessing dental arch relationships in children with unilateral clefts of the lip and palate. *Cleft Palate J.* 24: 314–322.
- Mars M, James DR, and Lamabadusuriya SP. (1990) The Sri Lankan Cleft Lip and Palate Project: The unoperated cleft lip and palate. *Cleft Palate J.* 27: 3–6.
- Mars M, and Houston WJB. (1990) A preliminary study of facial growth and morphology in unoperated male unilateral cleft lip and palate subjects over 13 years of age. *Cleft Palate J.* 27: 7–10.
- Mars M. (1991a) A study of intrinsic facial morphology in unoperated cleft lip and palate subjects, and the effects of lip/palate surgery on facial growth. *Work in progress*.
- Mars M. (1991b) Panel Discussion. The Fourth European Craniofacial Congress, Holland.
- Mars M, Asher-McDade C, Brattstrom V, Dahl E, McWilliam J, Molsted K, Plint DA, Prah Andersen B, Semb G, Shaw WC, and The RPS. (in press, 1992) The six-centre international study of treatment outcome in patients with clefts of the lip and palate 3: dental arch relationships. *Cleft Palate J.*
- Moll KL. (1968) Speech characteristics of individuals with cleft lip and palate. In Spreistersbach DC, and Sherman D, Eds. *Cleft Palate and Communication*. New York: Academic Press. 61–118.
- Moore WH, and Sommers RK. (1975) Phonetic contexts: their effects on perceived intelligibility in cleft-palate speakers. *Folia Phoniat.* 27: 410–422.
- Morley ME. (1970) *Cleft Palate and Speech*. Baltimore: Williams and Wilkins. 7th edition.
- Morris HL, Spreistersbach DC, and Darley FL. (1961) An articulation test for assessing competency of velopharyngeal closure. *J. Speech Hear. Res.* 4: 48–55.
- Morris HL. (1962) Communication skills of children with cleft lips and palates. *J. Speech Hear. Res.* 5: 79–90.
- Morris HL. (1968) Etiological bases for speech problems. In Spreistersbach DC, and Sherman D, Eds. *Cleft Palate and Communication*. New York: Academic Press. 119–168.

- Morris HL. (1973) Velopharyngeal competence and primary cleft palate surgery, 1960–1971: a critical review. *Cleft Palate J.* 10: 62–71.
- Morris HL. (1978) Velopharyngeal competence and the Demjen W/VY technique. In Morris: HL. Ed. *The Bratislava Project: some results of cleft palate surgery.* Iowa City: Univ. of Iowa Press. 49–62.
- Morris HL. (1979) Evaluation of abnormal articulation patterns. In: Bzoch KR. Ed. *Communicative Disorders Related to Cleft Lip and Palate.* Boston: Little, Brown and Company. 192–201.
- Morris HL. (1981) The child with cleft lip and palate: 20 years of progress. *Int. J. of Paed. Otorhinolaryng.* 3: 93–99.
- Morris HL. and Bardach J. (1989) Cleft lip and palate and related disorders: issues for future research of high priority. *Cleft Palate J.* 26: 141–144.
- Morris HL. (1990) Surgery, Speech and Growth. Paper presented at the First International Meeting of the Craniofacial Society of Great Britain, 1985. In Huddart A. and Ferguson M. Eds. (1990) *Cleft Lip and Palate: Long-term Results and Future Prospects.* Manchester: Manchester University Press. 420–429.
- Morris HL. (1990b) Clinical assessment by the speech pathologist. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: Saunders. 757–762.
- Morris HL. and Bardach J. (1990) Directions for future research. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: Saunders. 848–850.
- Noordhoff MS. Kuo J. Wang F. Huang H. and Witzell MA. (1987) Development of articulation before delayed hard-palate closure in children with cleft palate: a cross-sectional study. *Plast. and Reconstr. Surg.* 80: 518–524.
- Noordhoff MS. Shing Huang C. and Wu J. (1990) Multidisciplinary management of cleft lip and palate in Taiwan. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia: Saunders. 18–26.
- O’Riain S. and Hammond BN. (1972) Speech results in cleft palate surgery. *Brit. J. Plast. Surg.* 25: 380–387.
- Ortiz-Monasterio F. Rebeil AS. Valderrama M. and Cruz R. (1959) Cephalometric measurements on adult patients with nonoperated cleft palates. *Plast. Reconstr. Surg.* 4: 53–61.
- Ortiz-Monasterio F. Serrano RA. Barrera GP. Rodriguez-Hoffman H. and Vinageras E. (1966) A study of untreated adult cleft palate patients. *Plast. Reconstr. Surg.* 38: 36–41.
- Ortiz-Monasterio F. and Serrano RA. (1971) Cultural aspects of cleft lip and palate treatment. In: Grabb WC. Bzoch KR. Rosenstein S. Eds. *Cleft Lip and Palate.* Boston: Little, Brown and Company. 130–141.
- Ortiz-Monasterio F. Olmeda A. Trigos I. Yudovich M. Velazquez M. and Fuente-del-Campo A. (1974) Final results from the delayed treatment of patients with clefts of the lip and palate. *Scand. J. Plast. Surg.* 8: 109–115.
- Pannbacker M. Lass NJ. Middleton GF. Crutchfield E. Trapp DS. and Scherbick KA. (1984) Current clinical practices in the assessment of velopharyngeal closure. *Cleft Palate J.* 21: 33–37.
- Peer LA. Hagerty RF. and Hoffmeister FD. (1954) An evaluation of the Warren Davis osteoplastic technique in the cleft palate repair. *Plast. Reconstr. Surg.* 14: 1–9.
- Peet EW. (1961) The Oxford technique of cleft palate repair. *Plast. Reconstr. Surg.* 28: 282–294.
- Perera HS. and Jones D. (1938) The Application of World Orthography to Sinhalese. *Bulletin of the School of Oriental Studies.* London University. 9: 705–707.

- Philips BJ. and Harrison RJ. (1969) Articulation patterns of preschool cleft palate children. *Cleft Palate J.* 6: 245–253.
- Philips BJ. and Bzoch KR (1969b) Reliability of judgements of articulation of cleft palate speakers. *Cleft Palate J.* 6: 24–34.
- Piggott RW. Bensen JF. and White FD. (1969) Nasendoscopy in the diagnosis of velopharyngeal incompetence. *Plast. Reconstr. Surg.* 43: 141–147.
- Piggott RW. and McManamny DS. (1986) The management of cleft palate. In Evans JNG. Ed. Paediatric Otolaryngology. London: Butterworths. 6: 310–333.
- P.R.D.S. (1983) The Phonetic Representation of Disordered Speech. London: The King's Fund Centre.
- Pitanguy I. and Franco T. (1967) Nonoperated oral facial fissures in adults. *Plast. Reconstr. Surg.* 39: 569–577.
- Pruzansky S. and Aduss H. (1964) Arch form in the deciduous occlusion in complete unilateral cleft. *Cleft Palate J.* 1: 411–418.
- Rajapaksa RMW. (1988) personal communication.
- Reid DAC. (1962) Fistulae in the hard palate following cleft palate surgery. *Br. J. Plast. Surg.* 15: 377–384.
- Reynolds CHB. (1980) Sinhalese – An Introductory Course. University of London: School of Oriental and African Studies.
- Riski JE. and DeLong E. (1984) Articulation development in children with cleft lip / palate. *Cleft Palate J.* 21: 57–64.
- Rollnick BR. and Pruzansky S. (1981) Genetic services at a centre for craniofacial anomalies. *Cleft Palate J.* 18: 304–313.
- Russell VJR. (1991) Speech development in children with cleft lip and palate. Doctoral dissertation, Leicester Polytechnic.
- Schendel LL. and Bzoch KR. (1979) Advantages of intensive summer programmes. In: Bzoch KR Ed. Communicative Disorders Related to Cleft Lip and Palate. Boston: Little, Brown and Company. 318–327.
- Schweckendiek W. (1978) Primary veloplasty: longterm results without maxillary deformity, a 25 year report. *Cleft Palate J.* 15: 268–274.
- Sell D. and Grunwell P. (1990) Speech results following late palatal surgery in previously unoperated Sri Lankan adolescents with cleft palate. *Cleft Palate J.* 27: 169–173.
- Selley WG. Zananiri M-C. Ellis RE. and Flack FC. The effect of tongue position on division of airflow in the presence of velopharyngeal defects. *Brit. J. Plast. Surg.* 40: 377–383.
- Shelton RL. and Blank JL. (1984) Oronasal fistulas, intraoral air pressure and nasal airflow during speech. *Cleft Palate J.* 21: 91–99.
- Shelton RL. and McReynolds LV. (1979) Functional articulation disorders – preliminaries to treatment. In Lass. NJ. Ed. Speech and Language: Advances in Basic Research and Practice. New York: Academic Press. 1–102.
- Sherman D. (1954) The merits of backward playing of connected speech in the scaling of voice quality disorders. *J. Speech Hear. Dis.* 19: 312–321.
- Sherman D. Spreistersbach DC. and Noll JD. (1959) Glottal stops in the speech of children with cleft palates. *J. Speech Hear. Dis.* 24: 37–42.

- Shprintzen RJ, Lewin ML, Croft CB, Daniller AI, Argamaso RV, Ship AG, and Strauch B. (1979) A comprehensive study of pharyngeal flap surgery: tailor made flaps. *Cleft Palate J.* 16: 46–55.
- Shprintzen RJ, Siegel-Sadewitz A, Amato J, and Goldberg R. (1985) Anomalies associated with cleft lip, cleft palate, or both. *Am. J. Med. Genet.* 20: 585–595.
- Shprintzen RJ. (1986) Evaluating velopharyngeal insufficiency. *J. of Child Commun. Disorders.* 10: 51–66
- Shprintzen RJ. (1988) Pharyngeal flap surgery and the paediatric upper airway. *Int. Anaesthesiology Clinics.* 26: 79–88.
- Shprintzen RJ, and Golding-Kushner KJ. (1989) Evaluation of velopharyngeal insufficiency. *Otolaryngologic Clinics of North America.* 22: 519–536.
- Shprintzen RJ. (1989) Nasopharyngoscopy. In: Bzoch KR Ed. Communicative Disorders Related to Cleft Lip and Palate. Boston: Little, Brown and Company. 3rd edition. 212–239.
- Shprintzen RJ. (1990a) Editor's commentary on the papers from the Sri Lankan Cleft Lip and Palate Project. *Cleft Palate J.* 27: 174–175.
- Shprintzen RJ. (1990b) The conceptual framework for pharyngeal flap surgery. In: Bardach J, and Morris HL, Eds. Multidisciplinary Management of Cleft Lip and Palate. Philadelphia: Saunders. 806–809.
- Shprintzen RJ. (1990c) Surgery for Speech: The planning of operations for velopharyngeal insufficiency with emphasis on the preoperative assessment of both pharyngeal physiology and articulation. Paper presented at the First International Meeting of the Craniofacial Society of Great Britain, 1985. In Huddart A, and Ferguson M, Eds. Cleft Lip and Palate: Long-term Results and Future Prospects. Manchester: Manchester University Press. 430–477.
- Shprintzen RJ. (1991) Fallibility of clinical research. *Cleft-Palate-Craniofac. J.* 28: 136–140.
- Shriberg LD, and Kwiatkowski J. (1982) Phonological Disorders II: a conceptual framework for management. *J. Speech Hear. Dis.* 47: 242–256.
- Siegel-Sadewitz VL, and Shprintzen RJ. (1982) Nasopharyngoscopy of the normal velopharyngeal sphincter: an experiment of biofeedback. *Cleft Palate J.* 19: 194–200.
- Siegel-Sadewitz VL, and Shprintzen RJ. (1986) Changes in velopharyngeal valving with age. *Int. J. Ped. Otorhinolaryngol.* 11: 171–182.
- Skolnick ML. (1969) Video velopharyngography in patients with nasal speech, with emphasis on lateral pharyngeal motion in velopharyngeal closure. *Radiology* 93: 747–755.
- Skoog T. (1965) The pharyngeal flap operation in cleft palate. *Brit. J. of Plast. Surg.* 18: 265–282..
- Soderpalm E, Jorgensen I, and Lohmander-Agerskov A. (1991) Scandinavian comparison of UCLP patients. Preliminary speech results. Poster session at the Fourth European Craniofacial Congress, Holland.
- Spreistersbach DC, Darley FL, and Rouse V. (1956) Articulation of a group of children with cleft lips and palates. *J. Speech Hear. Dis.* 21: 436–445.
- Spreistersbach DC, and Powers G. (1959) Articulation skills, velopharyngeal closure and oral breath pressure of children with cleft palates. *J. Speech Hear. Res.* 2: 318–325.
- Spreistersbach DC, Moll KL, and Morris HL. (1961) Subject classification and articulation of speakers with cleft palates. *J. Speech Hear. Res.* 4: 362–372.
- Spreistersbach DC, Moll KL, and Morris HL. (1964) Heterogeneity of the 'cleft palate population' and research designs. *Cleft Palate J.* 1: 210–216.

- Spreistersbach DC, Dickson DR, Fraser FC, Horowitz SL, McWilliams BJ, Paradise J, and Randall P. (1973) Clinical research in cleft lip and cleft palate: the state of the art. *Cleft Palate J.* 10: 113–165.
- Stengelhofen J. (1989) Cleft palate. The nature and remediation of communication problems. Edinburgh: Churchill Livingstone.
- Subtelny JD. and Subtelny JD. (1959) Intelligibility and associated physiological factors of cleft palate speakers. *J. Speech Hear. Res.* 2: 353–360.
- Subtelny JD, Koepp-Baker H. and Subtelny JD. (1961) Palatal function and cleft palate speech. *J. Speech Hear. Dis.* 26: 213–224.
- Subtelny JD, Van Hattum RJ, and Myers BB. (1972) Ratings and measures of cleft palate speech. *Cleft Palate J.* 9: 18–27.
- Takagi Y, McGlone RE, and Millard RT. (1970) Speech disorders of individuals according to the type of cleft. *Cleft Palate J.* 7: 271–274.
- Tobe J. and Salyer KE. (1989) Factors which may play a role at time of palatoplasty in predicting ultimate velopharyngeal competence. Paper presented at the Sixth International Congress on Cleft Palate and Related Craniofacial Anomalies, Israel.
- Trost JE. (1981) Articulatory additions to the classical description of the speech of persons with cleft palate. *Cleft Palate J.* 18: 93–203.
- Trost JE. (1983) Discussion of early cleft palate repair and speech outcome by Dorf and Curtin. *Plast. Reconstr. Surg.* 70: 80–81.
- Trost-Cardamone JE. (1986) Effects of velopharyngeal incompetency on speech. *J. Child. Commun. Disor.* Special issue: 10: 31–49.
- Trost-Cardamone JE. (1989) Coming to terms with VPI: a response to Loney and Bloem. *Cleft Palate J.* 26: 68–70.
- Trost-Cardamone JE. (1990a) Speech: anatomy, physiology and pathology. In: Kernahan DA, and Rosenstein SN, Eds. Cleft lip and palate: a system of management. Baltimore: Williams & Wilkins. 91–103.
- Trost-Cardamone (1990b) The development of speech: assessing cleft palate misarticulations. In: Kernahan DA, and Rosenstein SN, Eds. Cleft lip and palate: a system of management. Baltimore: Williams & Wilkins. 227–235.
- Trost-Cardamone JE. (1990c) Speech in the first year: a perspective on early acquisition. In: Kernahan DA, and Rosenstein SN, Eds. Cleft lip and palate: a system of management. Baltimore: Williams & Wilkins. 204–213.
- Van Demark DR. (1964) Misarticulations and listener judgements of the speech of individuals with cleft palates. *Cleft Palate J.* 1: 232–245.
- Van Demark DR. (1969) Consistency of articulation of subjects with cleft palate. *Cleft Palate J.* 6: 254–262.
- Van Demark DR. (1971) Clinical research methodology in evaluating the therapeutic process. *Cleft Palate J.* 8: 26–35.
- Van Demark DR. (1974a) Assessment of articulation for children with cleft palate. *Cleft Palate J.* 11: 200–208.
- Van Demark DR. (1974b) Assessment of velopharyngeal competency for children with cleft palate. *Cleft Palate J.* 11: 310–316.



- Van Demark DR. (1974c) Some results of speech therapy for children with cleft palate. *Cleft Palate J.* 11: 41–49.
- Van Demark DR. Morris HL. and Vandehaar C. (1979) Patterns of articulation abilities in speakers with cleft palate. *Cleft Palate J.* 16: 230–239.
- Van Demark DR. Bzoch KR. Daly D. Fletcher S. McWilliams BJ. Pannbacker M. and Weinberg B. (1985) Methods of assessing speech in relation to velopharyngeal function. *Cleft Palate J.* 22: 281–285.
- Van Demark DR. Gnoinski WM. Hotz MM. Perko M. and Nussbaumer H. (1989) Speech results of the Zurich approach in the treatment of unilateral cleft lip and palate. *Plast. Reconstr. Surg.* 83: 605–613.
- Van Demark DR. and Hardin MA. (1986) Effectiveness of intensive articulation therapy for children with cleft palate. *Cleft Palate J.* 23: 215–224.
- Van Demark DR. and Morris HL. (1990) The relationship between age of surgery and velopharyngeal competency. Paper presented at the American Cleft Palate-Craniofacial Association Meeting, Missouri.
- Van Demark DR. and Hardin MA. (1990) Speech therapy for the child with cleft lip and palate. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate*. Philadelphia: Saunders. 799–805.
- Van Hattum RJ. (1958) Articulation and nasality in cleft palate speakers. *J. Speech Hear. Res.* 1: 383–387.
- Veau V. (1931) Division palatine. In *Anatomie, Chirurgie, Phonetique*. Paris: Masson. p.85.
- Ward CM. and James I. (1990) Surgery of 346 patients with unoperated cleft lip and palate in Sri Lanka. *Cleft Palate J.* 27: 11–14.
- Warren DM. (1986) Compensatory speech behaviours in individuals with cleft palate: a regulatory control phenomenon. *Cleft Palate J.* 23: 251–260.
- Warren D. (1979) PERCI: A method for rating palatal efficiency. *Cleft Palate J.* 16: 279–285.
- Watson AC. (1980) The cleft palate dilemma: speech or beauty. *J. R. Coll. Surg. Edin.* 25: 425–435.
- Williams WN. and Eisenbach CR. (1981) Assessing velopharyngeal function: the lateral still technique versus cinefluorography. *Cleft Palate J.* 18: 45–50.
- Williams W. (1989) Radiographic assessment of velopharyngeal function for speech. In: Bzoch KR. Ed. *Communicative Disorders Related to Cleft Lip and Palate*. Boston: Little, Brown and Company. 3rd. edition. 195–210.
- Wirt A. Wyatt R. Sell D. Grunwell P. and Mars M. (1990a) Training counterparts in cleft palate speech therapy in the developing world: a report. *Cleft Palate J.* 27: 169–173.
- Wirt A. Wyatt R. Sell D. Grunwell P. and Mars M. (1990b) Training counterparts in cleft palate speech therapy in the developing world: an extended report. *Brit. J. Dis. Commun.* 25: 355–367.
- Witzel MA. Salyer KE. and Ross BR. (1984) Delayed hard palate closure: the philosophy revisited. *Cleft Palate J.* 21: 263–269.
- Witzel MA. Tobe J. and Salyer K. (1988) The use of nasopharyngoscopy biofeedback therapy in the correction of inconsistent velopharyngeal closure. *Int. J. Ped. Otorhinolaryng.* 15: 137–142.
- Witzel MA. Ross B. and Posnick J. (1989) Management of cleft lip and palate and craniofacial disorders. Presentation by the Craniofacial Team, The Hospitals for Sick Children, Toronto. Institute of Child Health, London.

- Witzell MA. and Posnick JC. (1989) Patterns and location of velopharyngeal valving problems: atypical findings on video nasopharyngoscopy. *Cleft Palate J.* 26: 63–67.
- Witzel MA. and Wu J. (1989) Compensatory articulation – techniques for assessment and treatment. Paper presented at the Sixth International Congress on Cleft Palate and Related Craniofacial Anomalies, Jerusalem, Israel.
- Witzel MA. (1990) Craniofacial Anomalies. *Seminars in Speech and Language* II: 145–156. Thieme.
- Witzel MA. and Stringer DA. (1990) Methods of assessing velopharyngeal function. In: Bardach J. and Morris HL. Eds. *Multidisciplinary Management of Cleft Lip and Palate*. Philadelphia: Saunders. 763–776.
- Witzell MA. (1991) Commentary on pharyngeal flap surgery in adults by Hall CD. Golding-Kushner K. Argamaso RV. and Strauch B. *Cleft-Palate-Craniofac. J.* 28: 182–183.
- Wijayaratne DJ. (1956) History of the Sinhalese Noun. A Morphological Study based on Inscriptions. University of Ceylon. iii–viii.
- Wu J. Chen KT. Ray Chen Y. Huang CS. and Noordhoff MS (1990) Adult unrepaired cleft palate: speech characteristics, management, and prognosis. Paper presented at the American Cleft Palate-Craniofacial Association Meeting, Missouri.
- Yules RB. Chase RA. Blocksma R. and Lang BR. (1971) Secondary techniques for correction of palato-pharyngeal incompetence. In: Grabb WC. Bzoch K. and Rosenstein S. Eds. *Cleft Lip and Palate*. Boston: Little, Brown and Company. 451–489.

**PAGES  
NOT SCANNED  
AT THE REQUEST OF  
THE UNIVERSITY**

**SEE ORIGINAL COPY  
OF THE THESIS FOR  
THIS MATERIAL**

## **Appendix III – The Language of Sinhala**

### ***History***

Sinhala is known to be over two thousand years old, and yet its exact origins have been the subject of considerable controversy. Research has centred round two main issues – one seeking the phylogenetic affinity of Sinhala to other languages, and the other the original home of the earliest Sinhalese ancestors.

With regard to the phylogenetic theory, there are at least four different schools of thought: the Indo-Aryan, the Dravidian, the Polynesian, and the Indigenous.

From the evidence of linguistic records of Sinhala dating from the third century B.C, it is believed that the language belongs phylogenetically to the Indo-Aryan, or Indic, group of languages. This is a subfamily of the larger Indo-European family to which most of the languages of Europe and India belong. Therefore, Sinhala is allegedly immediately related to the modern Aryan languages of North India, such as Hindi, Bengali, Marati, Assamese and Oriya, and distantly related to European languages.

One school of thought considered Sinhala to be related to the Dravidian family of languages; those languages from Southern India of which Tamil is thought to be the oldest. It is now generally accepted that the close affinity between Sinhala and Tamil is not due to phylogenetic factors, but to the 'constant contact between the two languages.

Another school claimed that Sinhala belonged to the Polynesian family of languages, owing to the affinity of Sinhala to Maldivian, the language spoken in the Maldivian Islands in the Indian Ocean 400 miles to the south east of Sri Lanka. This has now been disproved, and Maldivian is considered to be an historical dialect of Sinhala.

Finally there was a school of thought that believed Sinhala was an independent language with no phylogenetic affinities with any ancestor-language.

Enquiry into the ancestry of the Sinhalese people did not produce conclusive evidence about the more exact origins of Sinhala. This has become the subject of considerable controversy, such that the "Western and Eastern" hypothesis evolved. The debate has centred on whether the earliest migrants to Ceylon belonged to the West or East of North India. Researchers studied place names and stories, but there remains inconclusive historical and linguistic evidence to this question (DeSilva, 1979).

Evidence about the history of Sinhala has also been sought from the literature. Like all Indian scripts, Brahmi script evolved into the current script during the eighth and tenth centuries with influences from Southern India. This was introduced by Buddhist Missionaries and dates from the third century B.C. Written Sinhala is based on Sanskrit, the written vehicle of classical Indian literature. Descended from this is Pali, the language in which the Buddhist scriptures were written. Interestingly Sinhalese writing is akin to South Indian scripts in shape and phonographic correspondence.

Wijayaratne (1956) considers that the literary evidence pertaining to the origins of the language only serves to confuse the picture. The literary form is archaic and has been artificially preserved, whilst the spoken language has gone through a normal course of evolution.

Although digressing from tracing the history of the language, it is relevant to illustrate some of the differences between written and spoken Sinhala that exist today. Such differences are particularly found in vocabulary and grammar. The literary form is characterized by many inflectional endings so that there is agreement between nouns, pronouns, and verbs. For example, written Sinhala contains many verbal suffixes so that the simple verb / *lijanawā* / (meaning to write in spoken Sinhala) has at least six different renderings dependent on person and number. There are many words that occur in the literary form that do not have spoken equivalents. Alternatively they may occur in a slightly altered form in certain contexts.

In written Sinhala, there are additional symbols resulting in more than fifty different letters. For example the allophonic variants such as alveolar and velar nasals are written differently in word final position. The retroflex, aspirated and non-aspirated plosives each have a separate symbol. Written Sinhala is characterized by clusters such as 'ks' and 'ts'. These do not occur in spoken Sinhala but become modified to 'kk' and 'ss', i.e. geminated. Interestingly, vowel letters are written separately from consonants only when they occur at the beginning of a word. Otherwise they are combined with a neighbouring consonant, by adding a stroke or diacritical mark. Thus the basis of writing in Sinhala is more syllabic than alphabetic.

Returning to the discussion of Sinhala's origins, early linguistic enquiry has shown that modern Sinhala has evolved differently from other Indo-Aryan languages. For example, in the other Indic languages, there is a phonemic difference between aspirated and non-aspirated plosives. This is known to have disappeared long ago from spoken Sinhala, but as previously indicated, such distinctions are still signalled in the literary form.

Sinhala has also been subject to the more recent European influences of Portuguese, English, and Dutch. Western colonization of Ceylon began at the beginning of the sixteenth century. Prestige was naturally accorded to the languages of the rulers. The 'borrowed' vocabulary that has entered modern day Sinhala is largely spoken. The great majority of European words are inadmissible into literary Sinhala in their present form. The borrowed vocabulary has generally been nouns, pertaining to the new cultural items introduced by the Western powers.

An example of this is Sinhala's contact with Portuguese in the sixteenth century, which led to the introduction of vocabulary relating particularly to Western food, trades, religion, law, and dress. Words such as the following: *kamise* – *camisa*, *koontare* – *contra*, *jeesus* – *jesus*, entered the language.

In the eighteenth century Dutch exerted an influence on the vocabulary, particularly in the field of law e.g. *adwekat* – *advocaat*, *takseeru* – *taxeren*.

The biggest impact, however, was from English which was introduced at the beginning of the nineteenth century. Indeed English was the official national language of Sri Lanka until 1956, when it was replaced by Sinhala. English is still taught in schools as a compulsory second language.

DeSilva's (1979) review refers to Gunasekara's work dated 1891, which gives the following proportion of words that have entered Sinhala: 400 from Tamil, 220 from Portuguese, 100 from Dutch, and 75 from English. There has apparently been no more recent work in this area, although Rajapaksa (personal communication, 1988) estimates that 40% of the vocabulary of colloquial Sinhalese consists of Tamil vocabulary. He states there is increasing use of both Tamil and English words.

Wijayarathne (1956) proposes that there may have been a number of Sinhalese dialects that have contributed to the formation of present day Sinhala. DeSilva (1979) commented that all Sinhalese dialects are mutually intelligible. Although there are some intonational differences, the main difference between dialects is in the lexis. An example of the latter is as follows. In standard Sinhala, father is referred to as 'taatta', grandfather as 'siyya' and grandmother as 'aacci', whereas in the Highland dialect, father is 'appacci', grandfather is 'atta', 'kiri atta', or 'loku atta'. Grandmother is 'attamma' 'kiri amma' or 'hiin attta'. An example of differences in the grammatical structure is as follows. In standard Sinhala the past tense form of a verb is signalled by the suffix 'uwa', whereas in the Highland dialect, this is formed by adding 'awwa'. These regional varieties have not been defined with any dialectological precision.

Since becoming the national language, Sinhala has undergone a period of considerable change, so as to become a more efficient medium for communication in the modern world. One example of this is given by Disanayake (undated). He describes the trend for traditional Sinhalese adjectives to be transferred into nouns — for example, the adjective /*atika* / meaning 'economic' has been changed into a noun by adding a suffix / *atikaja* /.

Therefore to summarize the history of Sinhala, it is quite possible that there was presinhalese speech of the aboriginal inhabitants, on which Indo-Aryan languages have been superimposed by immigrants from different parts of Northern India. Buddhism has exerted a considerable influence, with vocabulary entering the language from Pali. The language has also been directly influenced by its contact with the Dravidian language Tamil, and in relatively recent times Portuguese, Dutch and English.

DeSilva's literature review quotes how the German researcher Geiger (1938) came to the following conclusion,

*"Owing to the geographical location and peculiar development of the Sinhalese language, it is extremely difficult and perhaps impossible to assign it a definite place among the Modern Indo-Aryan dialects. It has a decidedly composite character".*

### ***Phonology of Sinhala***

There have been a variety of studies but this review centres on those which have used a phonemic framework (DeSilva, 1979). There is no known research into the acquisition of phonology in children. Studies carried out have focused on a particular phonological problem, in the context of a specific framework (Gair, 1989). For example, DeSilva carried out a phonological investigation of the verb.

The key contributors to the phonetic research have been Perera (1938) a native phonetician, Jones (1950), and Coates and DeSilva (1960), all of whom wrote phonetic descriptions of the language. The Coates and DeSilva work is described by Gair (1989) as,

*"generally accurate, and a good overview with some phonetic detail."*

The few relevant observations on the phonological aspects are now summarized.

The most frequently used phonotactic structure of the language is that of consonant-vowel. It also occurs as the basic structure for polysyllabic words. Words are typically polysyllabic, ending in an open syllable.

One feature of Sinhala, described by Reynolds (1980) and Coates and DeSilva (1960), is the "doubling of consonants". When a word ends in a consonant, and the following word begins with a vowel, the consonant is "pronounced double". This phenomenon describes the gemination of consonants occurring across word boundaries. For example, in the expression, /ekæk æti /, meaning 'there is one thing', the pronunciation is /ekæk<sup>7</sup> kæti ʔ.

Gemination of consonants also occurs in the middle of words. It results in two phonotactic structures that may function contrastively with each other: that of vowel consonant, consonant vowel (VC,CV) and vowel consonant, consonant vowel:vowel consonant vowel (VC,CV:VCV). For example, a consonant lengthened in the syllable final within word position can function as a phonological contrast with the same consonant occurring in the same position, but one which is not given extra length, e.g. /<sup>ʌ</sup>tə: / <sup>ʌ</sup>t:tə /  
VCV VC,CV

This process can occur with all consonants except /h/ and the halfnasals.

Another process reported by Reynolds (1980), and Coates and DeSilva (1960) is assimilation, e.g. /mɔkəkɔdɔ / becomes /mɔkɔdɔ / or /mahætmea / becomes /mahættea /.

The Portuguese, Dutch and early English borrowed vocabulary are described by Coates and DeSilva (1960) as being almost fully assimilated into the Sinhalese sound system. This is illustrated by the way in which initial clusters are dealt with. Initial clusters do not occur in pure Sinhala. Borrowed words, which contain clusters, have entered the language by various processes of vowel addition, for example, inserting a vowel before or between the elements of the cluster. For example the cluster 'st' has entered Sinhala by adding the vowel /i/ to become the permissible /ist/.

Words that originate from Pali and Sanskrit are also assimilated by many speakers. Some educated speakers who use many more such words may however pronounce them in a way that is closer to the pronunciation in the original language.

### ***The Consonants and Vowels of Sinhala***

The sound system has naturally been influenced by the use of borrowed words. When loan words enter a language, they may change their form in a way suited to the borrowing language. Alternatively, their foreign character may introduce new phonological patterns. The following changes have been incurred in Sinhala:

1. The new sound /f/ has been introduced.

2. Sounds that occur only rarely in original Sinhalese words are used more frequently, for example, the sounds /tʃ, dʒ, ʃ /.

3. Sounds that occur in traditional Sinhalese have been used in new combinations.

The exact number of phonemes that are said to occur in Sinhala varies depending on the source. Coates and DeSilva (1960) maintain there are 28 segmental phonemes – 21 consonants, and 7 vowels. Disanayake (1985), on the other hand, describes 21 consonants and 14 vowels, whilst Perera and Jones (1938) describe 19 consonants and 7 vowels. Reynolds (1980) lists 23 consonants and 12 vowels. Rajapaksa (1988) states there are 24 consonants and 7 vowels. These disagreements result from differences in classification of the nasal and half-nasal phonemes, the approximants, and long and short vowels. Table 54 shows the consonant sound system.

Table 54. The Consonant Sound System of Sinhala.

	bilabial	dental	alveolar	retroflex	palatal	velar	glottal
Plosive	p b	t̪ d̪ n̪ ɳ		t̠ d̠		k g	
Fricative			s				h
Affricate					tʃ dʒ		
Nasal	m		n	ɳ	(ɟ)	ŋ	
Flap							
Lateral			l				
Semivowel	w ɣ				j		

(Coates and DeSilva 1960).

In the description of the sound system, the terms initial, medial and final are used in the original sources, hence the same system will be used here. In some instances the original sources have not been sufficiently detailed. However, the information will be interpreted as fully as possible.

**Plosives.**

The voiceless plosives have only slight aspiration in initial position, in contrast with English. In medial position they are unaspirated. These phonemes are usually not released in final position, although when they are released, they may be aspirated. Coates and DeSilva (1960) do add,

*“some speakers when trying to speak very distinctly or when citing forms in isolation, not only explode them but pronounce them with strong aspiration”. (op. cit. p.169)*

The voiced plosives are fully voiced in all positions.



### ***Distribution***

All plosives may occur initially and medially. In medial position, the voiceless velar plosive may be omitted or can occur in free variation with the voiceless glottal fricative (Reynolds, 1980).

In syllable final word final position, only the voiceless cognates /p t k/ are found, although in loan words any of the plosives may appear.

Retroflex plosives never occur in the final position, and seldom in initial position. They function phonemically in an intervocalic position e.g. /a t̠ə / meaning 'eight' contrasts with /a t̠̠ə / meaning 'hand'.

### ***Fricatives***

There are only two fricatives found in traditional Sinhalese — /s h/. There are no voiced equivalents.

In medial position the phoneme /h/ may replace /s/.

In final position /h/ never occurs.

### ***Loan Words***

The phonemes /f/ and /ʃ/ are found in vocabulary that has English origins. Reynolds (1980T, Coates and DeSilva (1960) and Perera and Jones (1938) describe how the phoneme /f/ is frequently replaced by /p̪/, and in the author's experience the voiceless bilabial fricative  $\text{Ḷ}$  too. Since the phoneme /f/ does not feature in the Sinhalese sound system, speakers use a sound that is approximate to it. All three sounds are voiceless and involve articulation with the lower lip.

The phoneme /ʃ/ is a marginal phoneme and occurs in free variation with /s/ by some speakers.

### ***Distribution***

The fricatives /f s h /occur in initial and medial position: only /s/ occurs finally.

### ***Affricates***

There is a pair of palatal stops, or palatal affricates, that are used increasingly in Sinhala. This may be attributable to the lexical factor of the increased number of loan words, but also to phonetic evolution.

There is some disagreement amongst researchers as to the manner of these palatal articulations. Coates and DeSilva (1960) describe this pair of cognates as palatal affricates, whereas Reynolds (1980) describes them as palatal stops. Perera and Jones (1938) describe them as being similar to the palato-alveolar affricates of English. Jones (1960) states that when affrication is only very slight, then the sound should be classified as a plosive.

### ***Loan Words***

These sounds occur almost exclusively in loan-words from Sanskrit and English.

### ***Distribution***

The affricates occur in initial and word medial position, but not in final position.

### ***Approximants***

There are four approximants /r l j ʋ/.

The /r/ phoneme has two allophones. In word initial position, the post alveolar or alveolar approximant [ɻ] is used; in all other positions /r/ is realized as the voiced flap [ɾ]. In initial position /r/ may be produced as voiceless and breathy. In pure Sinhalese words [ɻ] does not occur finally.

The voiced alveolar lateral /l/ is always nonvelarized, and has a dental allophone [l̪] occurring before dental stops, and a retroflex allophone [ɭ] occurring before retroflex plosives (Coates and DeSilva, 1960). This phoneme occurs in all positions. Coates and DeSilva describe a "labial semivowel", which has two allophones — the labiodental approximant [ʋ] and bilabial approximant, both of which are described as having a midcentral tongue position.

### ***Distribution***

Initially these two allophones occur in free variation, whereas [ʋ] occurs only medially. This phoneme does not occur in word final position.

Alternatively Reynolds (1980) describes this phoneme as a very lax fricative, resembling something between an English /v/ and /w/. He maintains that this consonant does occur finally.

The palatal approximant /j/ occurs only initially and medially, and never occurs next to the vowel /i/ (Coates and DeSilva 1960).

### ***Nasals***

Most sources identify the nasals in Sinhala as /n m ŋ/, although the phonemic situation is somewhat unclear. There is a tendency for vowels following and preceding nasal consonants to be nasalized (Reynolds 1980).

Jones (1950) points out the difference between formal Sinhala (usually spoken by the better educated people) and the colloquial forms of the language. In formal Sinhala the retroflex and velar nasals are separate from /n/. The retroflex nasal occurs before vowels, and the alveolar nasal occurs in final position. As stated previously, such distinctions are made in literary Sinhala. In contrast, in colloquial speech, the retroflex nasal occurs before the retroflex plosives, and the velar nasal occurs in word final position, before velar plosives and glottal fricatives. The alveolar nasal does not occur in these positions. The velar nasal is the only nasal

which occurs in word final position. It would therefore appear that the retroflex and velar nasals are allophones of the alveolar nasal.

There is some debate about the status of the palatal nasal [ɲ]. The palatal nasal /ɲ/ is described as an allophone of /n/ by Reynolds (1980), and an allophone of /ŋ/ by Coates and DeSilva (1960). The latter writers state that [ɲ] and [ŋ] are in complementary distribution. Initially only /ɲ/ is found, and finally only /ŋ/ occurs.

Medially both nasals occur before plosives but [ɲ] occurs before palatal plosives, and [ŋ] occurs before velar plosives. Only the palatal nasal occurs medially between vowels, and only the velar nasal occurs before consonants other than plosives.

Therefore, it would appear that these two nasals are in complementary distribution. It should be noted that most of the words in which [ɲ] occurs are loan words, and therefore the palatal nasal is of relatively infrequent occurrence.

The velar nasal, in contrast, has a fairly frequent occurrence, but limited distribution. Indeed, Coates and DeSilva (1960) describe the velar nasal as almost occurring in complementary distribution with both /n/ and /m/. This may quite probably be the case in the speech of uneducated speakers.

The 'half nasals' are unique to Sinhala. These are perceived as a short nasal sound occurring before voiced plosives in the medial position only, viewed by the majority as unitary sounds. Voicing is maintained throughout. Jones (1950) discusses the status of the half nasals in the Sinhalese sound system. Since the Sinhalese people regard the half nasals as indivisible, he discusses whether they should be signalled with a new diacritic. Traditional Sinhalese orthography does have special signs for the half nasals. Jones concludes however, that the half nasals are correctly considered as single phonemes and that it is convenient to represent these phonemes by digraphs made up of letters representing other phonemes, with use made of diacritics.

The half nasals function contrastively with the nasal continuants when followed by the voiced plosives /b d d̪ g/ in word medial position. Reynolds (1980) describes the half nasal as the nasalization of the preceding vowel. This implies that there is a contrast in the phonotactic structure too. In nasal combinations the phonotactic structure is vowel consonant, consonant vowel (VC,CV) whereas in the half nasal combination the structure is vowel consonant vowel (VCV).

### **Clusters**

Clusters do not occur in words from Sinhalese stock, no doubt in part related to the preferred phonotactic structure of the language. Therefore, most of the words in which clusters occur are loan words. The clusters usually consist of only two consonants. Clusters are found in initial and in medial position only, e.g. /sɪrɪ:/ meaning 'woman'. (Coates and DeSilva, 1960).

In the initial cluster the first sound is pronounced very short, whereas the first sound of the medial cluster

is always long (Coates and DeSilva, 1960). However, the detailed description of medial clusters by Coates and DeSilva (1960) casts doubt that these are in fact true clusters. Their work describes elements as clusters that occur across the syllable boundary, so that the first element occurs in a syllable final within word position, and the second element of the cluster stands in a syllable initial within word position.

It is quite possible that there are very few medial clusters in Sinhala, and probably those that do exist have been modified to the favoured phonotactic structure by insertion of vowels e.g. /aprið / becomes /appirið / meaning 'displeased'. In this way, many speakers are regularly simplifying initial clusters. Clusters with /j/ as the second element are simplified by substituting the corresponding vowel /u/ or /i/ respectively. Most other clusters are simplified by the insertion of a vowel similar to that of the following syllable. e.g 'snehe' becomes /senehe/ meaning 'affection'. Initial clusters beginning with /ss/ are simplified by inserting the vowel /i/. For example, in the word for bath /sɳa ne/ becomes /isɳa ne/. Coates and DeSilva (1960) describe how uneducated speakers, in particular, simplify clusters. Educated speakers may do so in ordinary conversation, but pronounce them in more formal speech.

### The Vowel System

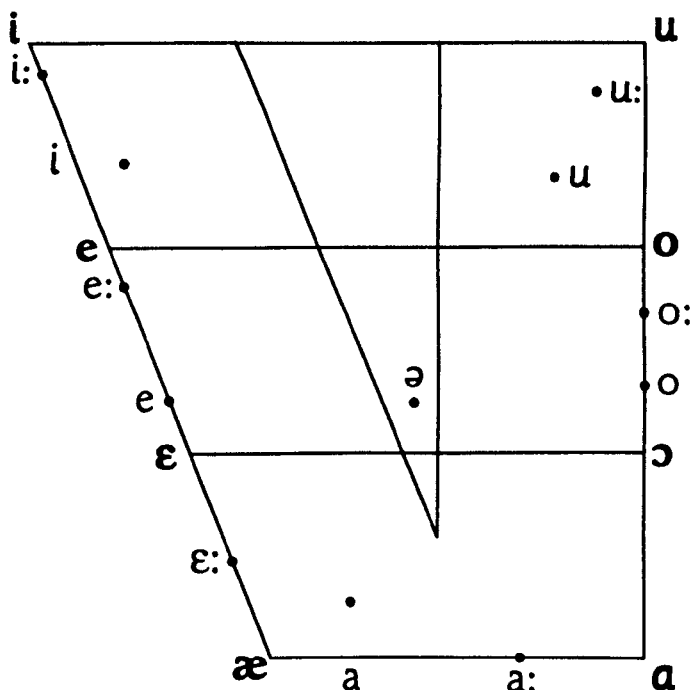
Colloquial Sinhalese contains 12 paired vowels /i e ε a o u / (Jones 1950). Coates and DeSilva (1960) also include the vowel /ɔ/. All may occur either short or long, and each pair may have a contrastive function with each other. The schwa vowel however occurs outside this system. For example, the difference between /ma|ə / meaning 'flower' and /ma:|ə / meaning 'necklace', and /kude / meaning 'umbrella' and /ku:de / meaning 'basket' is signalled by vowel length. The vowel /ə/ is usually short except in some words that are borrowed from English.

Jones (1950) states that in a system in which vowel length is significant, there is often some perceptible quality difference between the long and the short pairs of vowels. However this is usually slight and unimportant compared with length. The slightly different qualities can be observed in the Table below. Table 55 shows the Sinhalese vowels in relation to the cardinal vowels. Reynolds (1980) states how important it is to maintain the vowel quality of /æ / in initial syllables, when the second syllable is a closed one, and advises against the use of the schwa in such cases.

In final position, unstressed long vowels may be shortened, except for a few words in which length is phonemically significant and cannot be shortened, e.g. /gərnə:/ meaning 'bull' (Jones 1950).

There are no diphthongs in formal Sinhala, and no unanimity as to the number of diphthongs in colloquial Sinhala. Two vowels frequently come together in Sinhalese words, particularly when the sound is elided. Coates and DeSilva (1960) argue that these should be considered as combinations of vowel phonemes and not diphthongs, but Perera and Jones (1938) consider otherwise.

Table 55. The Sinhalese Vowels in relation to the Cardinal Vowels.



## Appendix IV – The speech sample

### NUMBERS

1	'ekə	2	'd̥ekə
3	't̥una	4	'h̥l̥t̥əɾə
5	'p̥h̥h̥	6	'h̥aɪjə
7	'h̥æɬ̥ə	8	'æɬ̥ə
9	'n̥l̥meɪjə	10	'd̥l̥'h̥aɪjə
11	e'k̥əʋl̥əh̥	12	'd̥əʋl̥əh̥
13	d̥ə'h̥l̥'t̥una	14	'd̥l̥'h̥æɬ̥əɾə
15	p̥ə'h̥l̥əʋə	16	'd̥l̥h̥'seɪjə
17	'd̥l̥h̥ə'h̥æɬ̥ə	18	'd̥əh̥l̥'æɬ̥ə
19	'd̥ə'h̥æ̃n̥l̥'meɪjə	20	'vi:sə

### DAYS

SUNDAY	's̃n̥'d̥ud̥l̥	MONDAY	'æŋgə'h̥aɾu'wad̥l̥
TUESDAY	'bi'd̥a:d̥l̥	WEDNESDAY	brə'h̥æsp̥ət̥ɪnd̥ə
THURSDAY	sɪk̥v̥ɾad̥ə	FRIDAY	'sene'surad̥l̥
SATURDAY	'ɪ'ɪ'd̥l̥		

### MONTHS

JANUARY	'd̥ʒənəʋn̥ɪ	FEBRUARY	'p̥ɛb̥əɾʋʋn̥ɪ
MARCH	'mɑɾt̥u	APRIL	'l̥'p̥rel
MAY	'meɪ	JUNE	'd̥ʒuni
JULY	'd̥ʒuli	AUGUST	'l̥'g̥ʋʒt̥u
SEPTEMBER	'sɛp̥'tɛmb̥əɾ̥ <sup>u</sup>	OCTOBER	'ɔk̥'t̥ɔ̃mb̥əɾ̥ <sup>u</sup>
NOVEMBER	'nəʋ'v̥ɛmb̥əɾ̥ <sup>u</sup>	DECEMBER	'd̥ɪ'sɛmb̥əɾ̥ <sup>u</sup>

**WORD LIST**

1. NEWSPAPER	'pæɪt̩ərəɪ	2. TEA	't̩eɪ
3. DOOR	'dɔːə	4. HOUSE	'geɪdʌsə
5. TYRE	't̩aɪːrəkə	6. RAIN	'reɪn
7. UMBRELLA	'kʌdʒə	8. BABY	'bæbi
9. GRANDFATHER	'grɑːndfɑːðə	10. GRANDMOTHER	'grɑːndmʌðə
11. MAN	'mæn	12. WALL	'wɔːl
13. RIVER	'rɪvə	14. WATER	'wɔːtə
15. WINDOWS	'wɪndəʊz	16. LORRY	'lɒrɪ
17. BUSES	'bʌsɪz	18. COWS	'kaʊz
19. ELEPHANTS	'ɛləfənts	20. CAT	'kæt
21. DOG	'dɒg	22. COCONUT	'kɒknʌt
23. MEAT	'miːt	24. TREE	'triː
25. HOLE	'həʊl	26. CHAIR	'tʃeə
27. PENCIL	'pɛnsəl	28. PARCEL	'pɑːsəl
29. KING	'kɪŋ	30. TRAIN	'treɪn
31. HAMMER	'hæmər	32. BOOKS	'bʊks
33. SHOE	'ʃəʊ	34. CLOCK	'klɒk
35. TABLE	'teɪbəl	36. MILK	'mɪlk
37. PLATE	'pleɪt	38. SPOON	'spuːn
39. SPOONS	'spuːnz	40. CLEAN	'kliːn
41. DIRTY	'dɜːti	42. SHOP	'ʃɒp
43. FLOWER	'flaʊə	44. FINGER	'fɪŋgə
45. RED	'rɛd	46. HORSE	'hɔːs

**SENTENCES**

- 'pɪːz: 'pæɪt̩ə 'meɪt̩et̩ə 'pæɪnələ 'kæmə 'kʌn. The kitten jumped on the table and ate the food.
- mʌ'hæft̩ə 'kɑːrɪl 't̩æmbəlɪ 'geɪt̩ t̩uːnɪk 'kæpɪz. The fat boy ate three coconuts.
- 'ɑːsə 'lɒrkɪu 'sɪdʌ 'gɔːmɪ æpə. Our big white bull.

**IMITATION OF SINGLETONS**

p b t̄ d̄ k g s ʃ ʒ ʒ

**IMITATION OF TRISYLLABLES**

p<sup>h</sup>a p<sup>h</sup>a p<sup>h</sup>a  
p<sup>h</sup>i p<sup>h</sup>i p<sup>h</sup>i

t̄<sup>̄</sup>a t̄<sup>̄</sup>a t̄<sup>̄</sup>a  
t̄<sup>̄</sup>i: t̄<sup>̄</sup>i: t̄<sup>̄</sup>i:

k<sup>h</sup>a k<sup>h</sup>a k<sup>h</sup>a  
k<sup>h</sup>i k<sup>h</sup>i k<sup>h</sup>i

sa sa sa  
si si si

ʃa ʃa ʃa  
ʃi ʃi ʃi

tʃa tʃa tʃa

dʒa dʒa dʒa



## Appendix Va – Oral-Motor Assessment

Lips: describe position at rest			
Lips spread (smile):	No abnormality	1	
	Some limitation	2	
	Severe limitation	3	
	Asymmetry	4	
Lip purse:	No abnormality	1	
	Some limitation	2	
	Severe limitation	3	
Lips: Spread/purse on 'oo-ee' in 10 seconds	Normal (5 or more)	1	
	Slow but accurate (-5)	2	
	Slow but inaccurate	3	
	Could not attempt	4	
Lips: Movement in speech	Normal	1	
	Affected by occlusion	2	
	Affected by dentition	3	
	Asymmetry	4	
Tongue: Position at rest	Normal	1	
	Possible abnormality	2	
	Definite abnormality	3	
Tongue: Protrusion	Protrusion achieved	yes/no	
	Point achieved	yes/no	
	Protrude/retract	Normal (5 in 4 secs)	1
		Slow but normal	2
		Abnormal	3
		Not attempted	4
Tongue: Elevation – raised/lower	Normal (5 in 5 secs)	1	
	Slow but normal	2	
	Abnormal	3	
	Not attempted	4	
Tongue: Lateral	Normal (5 in 3 secs)	1	
	Slow but normal	2	
	Abnormal	3	
	Not attempted	4	
Velum: Present/absent/cleft	Movement	1	
	No movement	2	
	Asymmetry	3	
Length – adequate/short			
Pharyngeal wall:	Movement seen	1	
	No movement seen	2	
	Not possible to see	3	

# Appendix Vb – Palatal Surgery Rating Scale

(NB. completed by the surgeons.)

## ***Section 1: Degree of fibrosis***

Dissection:	Easy	1
	Moderately easy	2
	Difficult	3
Bleeding:	Light	1
	Moderate	2
	Heavy	3
Mucosa:	Normal	1
	Moderately Fibrotic	2
	Very Fibrotic	3

## ***Section 2: Degree of muscle quality of the velum***

Mobilization of levator palatini muscle:	Easy	1
	Moderately difficult	2
	Difficult	3
Quality of Levator Muscle:	Normal	1
	Moderately fibrotic	2
	Very fibrotic	3
Tensor Palatini:	Not mobilized	1
	Mobilized but hamulus intact	2
	Mobilized, hamulus fractured	3

## ***Section 3: Miscellaneous section***

Greater palatine vessels:	right preserved / not preserved	1/2
	left preserved / not preserved	1/2
Nasal Layer Closure:	Complete	1
	Complete, but fenestrated	2
	Incomplete (identify site in drawing)	3
Oral Layer Closure:	Complete	1
	Incomplete (identify in drawing)	2
Estimate of Tension Velar Repair:	Little tension	1
	Moderate tension	2
	Great tension	3

## Appendix Vc – Nasopharyngoscopy Speech Sample and Framework of Analysis

① Counting from 1-20 (see Appendix IV)

② Repetition of:

pa pa pa  
pi pi pi

ba ba ba  
bi bi bi

ma ma ma  
mi mi mi

ta ta ta  
ti ti ti

da da da  
di di di

ka ka ka  
ki ki ki

ga ga ga  
gi gi gi

sa sa sa  
si si si

sa sa sa

fa fa fa

ga ga ga

③ Repetition of:

ee, s, u

④ Repetition of Sentences (see Appendix IV)

# THE SRI LANKAN PROJECT 1990

## Nasendoscopy

Name: .....

Number: .....

Age: .....

Cleft Type: .....

Examiner: .....

Date: .....

Cooperation .....

Insertion	R	L
	successful	unsuccessful

Visualization	Total	Partial
	Good	Poor

### ANATOMY:

#### 1. Soft Palate:

Hump:		yes / no
Prominent Musculus Uvulae:		yes / no
Notching:		yes / no
Flat:		yes / no
Fistula:		yes / no
Other abnormality:		yes / no

#### 2. Pharynx:

Adenoid:	Large	Average	Small	None
	Irregular	Projection		Indentation
Pharyngeal Pulsations:	No	Yes	R	L
Other Abnormality:				Midline

#### 3. Tonsils:

Palatine Tonsils:	R Large	L	R Average	L	R Small	L	R None	L
-------------------	---------	---	-----------	---	---------	---	--------	---

### FUNCTION:

#### 1. Velopharyngeal Valve:

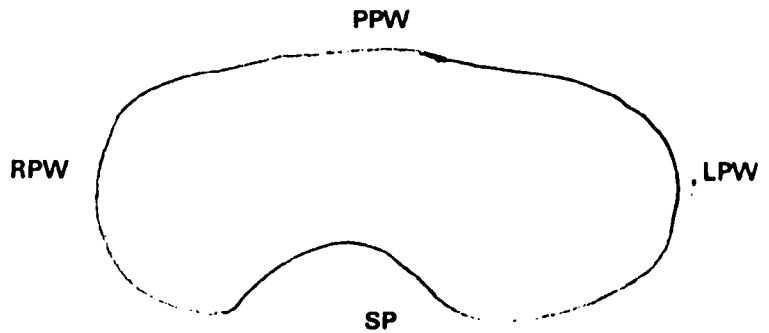
Closure		yes / no
	Consistent	Inconsistent

	Marked	Moderate	Slight	None	Symmetrical/ asymmetrical	Consistent/ inconsistent
Soft palate						
LPW						
RPW						
PPW						

Valving Pattern:	Coronal	Circular	Circular + P R	Sagittal
Gap location:	Central	R Lateral	L	Bilateral
Gap Size:	Large	Moderate	Small	Pinhole
Stimulable:				yes / no
Biofeedback Potential:				yes / no

Movement grade: 0 — none  
6 — maximum

PPW —  
SP —  
RPW —  
LPW —



**2. Tongue:**

Tongue dorsum backing: yes / no  
 Tongue visible through fistula: yes / no  
 Biofeedback potential:

**3. Larynx:**

Vocal cord abduction:	R Normal L	R Abnormal L
Vocal cord adduction	R Normal L	R Abnormal L
Arytenoid abduction	R Normal L	R Abnormal L
Arytenoid adduction	R Normal L	R Abnormal L
Ventricular band adduction		yes / no
Biofeedback potential		yes / no
Epiglottis		

**SUMMARY**

VP Closure	Laryngeal Function	Tongue Function
Definitely Adequate	Normal	Normal
Probably Adequate	Hyperfunction	Abnormal
Borderline	Hypofunction	
Probably Inadequate	Other Abnormality	
Definitely Inadequate		

## **Appendix Vd – Psychosocial Forms**

**Psycho social  
Unoperated Patients**

Form to be completed by patient / relative  
(specify)

Name: .....

No M90 ..... M-F

1. Why do people have clefts?
  
  
  
  
  
2. Have you had the opportunity to have surgery before now? yes / no  
If yes, why was it not possible for you to receive treatment at that time?
  
  
  
  
  
3. Do friends understand you when you talk to them?
  
  
  
  
  
4. Do your family understand you when you talk to them?
  
  
  
  
  
5. Do strangers understand you when you talk to them?
  
  
  
  
  
6. How do you feel if people don't understand you?
  
  
  
  
  
7. How do you feel about your speech?

**For patients with unoperated lip & palate**

8. We have two problems with you, your palate and the effects it has on your speech, your lip and how you look -  
Which worries you the most?

**Relatives only (for child patient)**

9. How do others in the family react when people don't understand patient?
  
  
  
  
  
10. Has having a cleft lip / palate affected your child's life in any way?  
If so, how?

**Adult patients only**

11. Has having a cleft lip / palate affected your life in any way? If so, how?
  
  
  
  
  
12. Will your life be different after your cleft lip / palate is repaired? If so, how?

**SPEECH PROJECT 1988**

**Psycho social**

For patients over 10 years

Name \_\_\_\_\_

No G/86/ \_\_\_\_\_ M-F

Pre-operative assessment completed by patient / relative (specify)

**FORM A**

happy at home |-----| sad at home

happy at work at school |-----| sad at work at school

stupid |-----| clever

poor |-----| rich

good looking |-----| ugly

has lots of friends |-----| has few friends

speech much worse now |-----| speech much better now



## Appendix VI – Early Results based on Quantitative Data

The initial approach to the hypotheses with regards to age was to use the quantitative data available from the rating scale in the statistical analysis. The combined scores for place, manner and voice for each age group in the main cohort were calculated at three data points ie. at the pre-operative stage, post-operatively without therapy, and then immediately following therapy (Summer 1988). Table 56 shows the average amount of post-operative change and post-therapy changes, range of scores and standard deviations for each age category.

*Table 56. Descriptive Statistics of the Post-operative and Post-therapy Scores of each Age Group.*

### **CHILDREN AGED 8–10 YEARS AT SURGERY**

	<b>Post-operative Changes</b>	<b>Post-therapy Changes</b>
N	10	10
Minimum	-1.0	1
Maximum	6.0	8.0
Mean	2.8	4.2
Standard deviation	2.486	2.1

### **ADOLESCENT GROUP**

	<b>Post-operative Changes</b>	<b>Post-therapy Changes</b>
N	30	29
Minimum	-3.0	0.0
Maximum	11.0	9.0
Mean	0.767	3.672
Standard deviation	2.979	3.042

### **ADULT GROUP**

	<b>Post-operative Changes</b>	<b>Post-therapy Changes</b>
N	25	24
Minimum	-4.0	-2.0
Maximum	3.0	6.0
Mean	0.16	2.6
Standard deviation	2.075	2.267

### ***Speech results within each age group***

The combined place, manner and voice ratings at the pre-operative data points were compared with the post-operative ratings for each age group.

In the adult and adolescent groups, using the Wilcoxon Signed Ranks Test, there were no significant differences between the articulation ratings pre-and post-operatively (adults:  $p = 0.596$ , adolescents:  $p = 0.38$ ). In contrast a significant difference was found in the children's group ( $p = 0.015^*$ ).

The combined place, manner and voice ratings at the post-operative data points were then compared with those gained after therapy for each age group. Significant differences were found in all the age groups: adults  $p < 0.001^*$ , adolescents  $p < 0.001^*$  and children aged 8–10 years at surgery  $p < 0.025^*$ .

The articulation ratings at the pre-operative stage were compared with the ratings post-therapy: the difference was significant for all age groups (adults  $p < 0.001^*$ ; adolescents  $p < 0.001^*$ ; children aged 8–10 years at surgery  $p = 0.005^*$ ).

These findings suggest that the adults and adolescents do not improve their articulation without therapy, unlike the children's group. All the age groups make significant changes with speech therapy. Further examination of the qualitative changes is required, in particular the adult group.

Given that a significant difference was found between post-operative and post-therapy speech, when speech was rated immediately after a therapy course, an examination was undertaken to determine if this difference was maintained over time. In other words, were the differences still significant between the post-therapy course ratings and those gained at the subsequent data point to the therapy course? This was examined at two points in time. Ratings taken after the July 1986 therapy course were compared with those ratings taken four months later prior to the start of the November therapy course. Ratings taken after the November 1986 therapy course were compared with those taken 20 months later prior to the start of the 1988 therapy courses.

For the total group, using the Wilcoxon Signed Ranks Test (one tailed test) the following levels of significance were found:

#### **Post July course**

November (4 months later)  $p = 0.03^*$

#### **Post November course**

1988 (20 months later)  $p = 0.08$

The adults and adolescents were examined separately. In the adult group using the Wilcoxon Signed Ranks Test (one tailed test), the following levels of significance were found:

#### **Post July course**

November (4 months later)  $p < 0.01^*$

#### **Post November course**

1988 (20 months later)  $p = 0.04^*$

In the adolescent group using the Wilcoxon Signed Ranks Test (one tailed test), no significant differences were found.

**Post July course**

November (4 months later)  $p = 0.21$

**Post November course**

1988 (20 months later)  $p = 0.3$

Therefore, for the total group of patients, the results overall suggest that there was a deterioration in speech between July and November 1986. Although the same picture was not found with the second set of measurements they almost reach significance (0.08). These results suggest that the group as a whole did not maintain the gains it made in therapy. However, these results need to be interpreted within the context of the variable of age. These data indicated that the gains made by the adults in therapy were not maintained over time, in contrast to the adolescents, who appeared to maintain the improvements.

***Speech Results between Age Groups***

Based on the speech recordings of the adults, adolescents and children aged 8–10 years at surgery, at the pre-operative and post-operative data points, ( $N = 65$ ) and using the Kruskal-Wallis one-way analysis of variance, there was a significant difference ( $H=7.305$ ,  $p = 0.026^*$ ) in the amount of spontaneous change between these age groups.

The Mann-Whitney test was used to directly compare two age groups for post-operative spontaneous change. There was no significant difference between the adults and adolescents ( $N = 55$ ,  $U = 363.5$ ,  $p = 0.843$ ) but a significant difference between the children and adolescents ( $N = 40$ ,  $U = 227.5$ ,  $p = 0.014^*$ ) and the children and adults ( $N = 35$ ,  $U = 193.5$ ,  $p = 0.011^*$ ) was found.

Based on the speech recordings of the adults, adolescents and children aged 8–10 years at surgery, at the pre-operative and post-therapy data points, ( $N = 62$ ) and using the Kruskal-Wallis one-way analysis of variance, there was no significant difference ( $H= 3.912$ ,  $p = 0.141$ ) in change after therapy between the age groups.

The Mann-Whitney test was used to directly compare two age groups following therapy. No significant difference was found between the adults and adolescents ( $N = 52$ ,  $U = 393.5$ ,  $p = 0.287$ ). Quantitatively, the amount of change post-therapy that the adult and adolescent groups made is seen in Table 57. There was no longer any significant difference between the children and the adolescents ( $N = 38$ ,  $U = 167.5$ ,  $p = 0.358$ ). However, a significant difference was found between the children and adults ( $N = 34$ ,  $U = 175.5$ ,  $p = 0.034^*$ )

*Table 57. Amount of Change Post-therapy of the Adult and Adolescent Groups.*

<b>Points Changed</b>	<b>Adults</b>	<b>Adolescents</b>
	N=24	N=31
0	5	4
1	4	6
2	2	4
3	6	4
4	3	0
5	2	1
6	1	3
7	0	2
8	0	3
9	0	9

These data suggest that children aged between 8–10 years at the time of palatal surgery made spontaneous improvements in speech without therapy intervention. In contrast, there was no significant difference between the adults and adolescents in degree of spontaneous change, or in the amount of change after therapy. Following therapy the differences between the adolescent and children's groups were no longer significant: the children's group was however still significantly different from the adult group.

Although there was no significant difference in the speech of adolescents and the adults when compared at the post-operative and post-therapy stages, quantitatively the adolescents made greater changes. A description is required of the qualitative nature of the changes.

The children's group, on the other hand, was significantly different from the adult and adolescent groups post-operatively, but only from the adult group post-therapy.

It is quite possible that the lack of difference from adolescents following therapy may be attributable to the presence of the higher number of lesser cleft subjects in the adolescent group. Adolescents with lesser clefts following therapy made appreciable changes in speech compared with those with major clefts (Chapter 6). Therefore the presence of a higher proportion of the lesser cleft group within the adolescent age group may have minimized the differences between the two age groups. It should be pointed out, however, that there was also a significant difference in articulation at the post-operative stage between the lesser cleft group and the other combined cleft groups within the adolescent age group.

Therefore although these results provide some statistical information based on quantitative results, the need for an explanation through an examination of the qualitative results is underlined.

### ***Speech results within each cleft group related to age***

The next stage in the analysis was to determine if there were significant differences within each cleft group related to age.

Based on the quantitative data available from the rating scale, the three age groups were compared within cleft type, using the Kruskal-Wallis one-way analysis of variance test. As can be seen from Table 58, there were no significant differences in spontaneous change between the age groups in any of the cleft groups.

*Table 58 Post-operative Results between Age Categories of the Same Cleft Group.*

	<b>BCLP</b>	<b>UCLP</b>	<b>H&amp;S</b>
Chd. 8–10 yrs. (N=10)	2	5	3
Adolescents (N=20)	4	11	5
Adults (N=24)	4	16	5
H statistic	3.0	3.838	3.026
probability	0.28	0.147	0.22

The three age categories were then compared following therapy within each cleft group. As can be seen from Table 59, there were no significant differences in amount of change following therapy between the age groups in any of the cleft groups.

*Table 59. Post-therapy Results between Age Categories of the Same Cleft Group.*

	<b>BCLP</b>	<b>UCLP</b>	<b>H&amp;S</b>
Chd. 8–10 yrs. (N=10)	2	5	3
Adolescents (N=19)	4	10	5
Adults (N=24)	4	15	5
H statistic	0.446	4.131	1.622
probability	0.8	0.127	0.44

When the results were compared of the same cleft group across the age categories, no significant differences in spontaneous improvement or improvement with therapy were found. Nonetheless, with the exception of the UCLP group, it should be noted that the sample size of each cleft group within each age category was very small making them very difficult to meaningfully compare. In addition, there were no adults or children aged 8–10 years at surgery with lesser clefts in the sample where, as reported previously, significant differences were found.

**PAGES  
NOT SCANNED  
AT THE REQUEST OF  
THE UNIVERSITY**

**SEE ORIGINAL COPY  
OF THE THESIS FOR  
THIS MATERIAL**

**Table 27a. Summary of Table 27: the Seventeen Speech Patterns**

<p><b>Pattern 1.</b> Place 1 or 0 Substitutions involving no attempt or a very limited attempt at oral lingual placement with the main place of articulation as glottal. Applicable to Patterns 1, 2 and 8. <i>No detectable use of the voiced/voiceless contrast. Very poor imitation, scoring 0 or 1 only on each of the imitation tasks.</i></p>	<p>Manner 1 or 0 Vowel-like approximations only, nasals and approximants.</p>
<p><b>Pattern 2.</b> Place 2 Attempts at oral lingual placement were made especially detectable on targets /td /. <i>See Pattern 1: voicing and imitation</i></p>	<p>Manner 0 or 1 Manner as for Pattern 1</p>
<p><b>Pattern 3.</b> Place 1 or 2 Place as for Pattern 1.</p>	<p>Manner 2 Some modification of the airstream, usually occasional detectable friction.</p>
<p><b>Pattern 4.</b> Place 1* Favourite back place of articulation, often pharyngeal/uvular.</p>	<p>Manner 3* Favourite manner type often nasalized plosion, usually associated with an open velopharyngeal port.</p>
<p><b>Pattern 5.</b> Place 1 or 2 Attempts made at oral lingual placement, but the main place of articulation remained glottal and pharyngeal.</p>	<p>Manner 3 Sounds that are intermediate between oral stops and nasals, e.g. heavily nasalized plosion and nasalized friction.</p>
<p><b>Pattern 6.</b> Place 3 Substantial number of oral lingual placements, with some glottal/pharyngeal placements.</p>	<p>Manner 2 Minimal modification of the airstream resulting in only occasional friction, nasal equivalents or approximants, with many omissions or air stopped at the glottis.</p>
<p><b>Pattern 7.</b> Place 3 Place as for Pattern 6.</p>	<p>Manner 3 or 4 Nasalized oral plosion and oral friction present, but were not fully established. No affrication was detected.</p>
<p><b>Pattern 8.</b> Place 4 Mainly oral placements with minimal glottal/pharyngeal placements. <i>No detectable use of the voiced/voiceless contrast for oral lingual targets.</i></p>	<p>Manner 1 or 2 Mainly nasals and approximants, with minimal modification of the oral airstream.</p>
<p><b>Pattern 9.</b> Place 4 Place as for Pattern 8, but with errors of intra-oral substitution, omission and distortion.</p>	<p>Manner 3 or 4 Varying degrees of nasalized oral plosion and oral friction occurred but no affrication.</p>
<p><b>Pattern 10.</b> Place 3 or 4 Place as for Pattern 6.</p>	<p>Manner 5 Plosion friction and affrication achieved with/without nasalization, but not established at all targets.</p>
<p><b>Pattern 11.</b> Place 5 Place as for Pattern 8, but with errors of intra-oral substitution and distortion type.</p>	<p>Manner 4 or 3 Manner as for Pattern 9.</p>
<p><b>Pattern 12.</b> Place 5 Place as for Pattern 11.</p>	<p>Manner 5 Plosion friction and affrication achieved with/without nasalization and nasal air escape.</p>
<p><b>Pattern 13.</b> Place 6 Oral placements only. Neither place or manner characteristics were fully established throughout the possible targets.</p>	<p>Manner 4 Nasalized oral plosion, and oral friction were found.</p>

**Pattern 12.** Place 5  
Place as for Pattern 11.

**Manner 5**  
Plosion friction and affrication achieved with/without nasalization and nasal air escape.

**Pattern 13.** Place 6  
Oral placements only.

**Manner 4**  
Nasalized oral plosion, and oral friction were found.

Neither place or manner characteristics were fully established throughout the possible targets.

**Pattern 14.** Place 6  
Place as for Pattern 13.

**Manner 5 or 6**  
Plosion friction and affrication were achieved with/without nasalization and nasal air escape with differing degrees of establishment.

**Pattern 15.** Place 7  
Full range and correct use of expected placements.

**Manner 5 or 6**  
Manner as for Pattern 14.

**Pattern 16.** Place 7  
Place as for Pattern 13.

**Manner 7**  
Normal manner of plosion, friction and affrication fully established throughout the possible targets.

**Pattern 17.** Place 6  
Place as for Pattern 15.

**Manner 7**  
Manner as for Pattern 16.