2000

Timing of alveolar cleft bone grafting in maxillary alveolar cleft defects

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Timing of Alveolar Cleft Bone Grafting in Maxillary Alveolar Cleft Defects

THESIS

Submitted to the School of Dentistry

at

West Virginia University

In Partial Fulfillment of the Requirements

for the Degree of

Masters of Science
In
Orthodontics

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2000

Abstract

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Numerous methods have been attempted to identify the best time for secondary alveolar cleft bone grafting, including chronological age, skeletal age, and dental age. However, few studies have employed objective methods of assessment that would permit statistical analysis. Fifty-nine patients with clefts of the alveolus who acquired secondary alveolar cleft grafts at the Lancaster Cleft Lip and Palate Clinic were studied. A total of 74 affected areas from 15 bilateral and 44 unilateral alveolar cleft patients were available. Timing of the graft was determined utilizing root development of the involved canine, as compared to crown length, from a high quality pre-graft radiograph taken no more than six weeks prior to surgery. A Post-graph radiograph exposed approximately 2 years post-surgery was digitized to assess the final bony architecture.

To my wife, **Carmen**, who placed her law career on hold so I could fulfill my dream.

To my children, **Leigha and Mara**, your smiles are all I need for encouragement.

To my parents, **Dr. and Mrs. Richard J. Crout**, and my in-laws, **Dr. and Mrs. Elias G. Haikal**, whose love and support made this possible. Thank You!

ACKNOWLEDGEMENTS

My sincere appreciation to the following individuals:

Dr. Dennis Overman who tragically passed away before completion of my thesis.

Dr. Peter Ngan for his unparalleled example, clinical skills and leadership.

Dr. Hera Kim for a year of torture that gave me a great foundation in orthodontics.

Dr. Bryan Weaver for his assistance on this project.

Dr. Richard J. Crout for his knowledge of research and support.

Dr. Kavita Kohli for her willingness to assist with my project at the last moment.

My Fellow Residents for the friendship and memories.

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CHAPTER 1

Background

The level of the alveolar crest is a crucial component of the periodontal attachment process and the health of the periodontium. Despite all the advances in cleft palate treatment, periodontal problems are still quite prevalent in patients with cleft lip and palate (Andlin-Sobocki, Eliasson et al. 1995). In contrast to patients with clefts of the palate, patients with unilateral clefts of lip, palate and alveolus were found to have more periodontal destruction (Schultes, Gaggl et al. 1999). Sobocki (1995) found reduced marginal bone height, inadequate facial attached gingiva, and gingival recession of the teeth next to the cleft site in patients with unilateral and bilateral cleft lip and palate (Andlin-Sobocki, Eliasson et al. 1995). Several studies have examined the timing of the alveolar bone graft related to the periodontal health of the teeth erupting through the graft site. These results are varied and range from best periodontal result before canine eruption to after canine eruption (Boyne and Sands 1972; Hall and Posnick 1983; el Deeb, el Deeb et al. 1989; Long, Paterno et al. 1996).

The purpose of this study is to investigate if the timing of the alveolar bone graft has an effect on the periodontal health of teeth erupting through the graft site. This information will enable the "Cleft Palate Teams" to decide on the optimal timing for placement of bone grafts in patients with unilateral or bilateral alveolar clefts.

Statement of Problem

In spite of the recognition that teeth may form and erupt through newly grafted bone in an alveolar cleft site, the literature and current treatment protocols appear devoid of any systematic studies on the timing of the alveolar bone graft to maximize the periodontal health of surrounding teeth erupting through the bone graft.

Significance of Study

The results of this study will enable the "Cleft Palate Teams" to decide on the optimal timing for placement of bone grafts in patients with unilateral or bilateral alveolar clefts.

Hypothesis

In cleft palate patients, there is no difference in the final bony architecture of the graft sites when the secondary alveolar cleft graft was placed at different stages of canine development.

Definition of Terms

alveolus - The socket in the bone in which the tooth is attached.

attached gingiva - the portion of the gingiva extending from the free gingival groove to the mucogingival junction.

cleft - congenital abnormal space or gap, which may occur in the upper lip, alveolus, and/or palate.

graft - anything inserted into something else so as to become part of the latter.

Assumptions

1. All clefts were congenital in nature.
2. The cleft repair procedures were done correctly.
3. No extraneous factors (i.e. orthodontic appliances) were utilized to enhance or impede canine eruption prior to grafting.
4. After canine positioning, nothing was done to the canine to affect it in an adverse manner.

Limitations

1. Sample size (age, gender)
2. Limited pre-surgical records
3. Time between surgical treatment and evaluation
4. Single observer collecting records
5. Patients from similar geographical area (may not be representative sample)
6. Position of canine prior to grafting

Delimitations

1. All patients had bilateral or unilateral complete cleft lip and palate
2. No patients with known medical conditions
3. All patients had high quality pre-bone grafting radiograph taken no more than six weeks prior to surgery
4. All patients had a post-bone grafting film taken at least nine month following surgery

5. All patients had surgical repair at Lancaster Cleft Lip and Palate Clinic
6. All patients had autogenous cleft grafts
7. Patients with primary bone grafting in deciduous dentition excluded

CHAPTER 2

Prevalence

Clefts of the lip and palate are the most common serious congenital anomalies to affect the orofacial region, second only to clubfoot in the entire spectrum of congenital deformities (Thorton, Nimer et al. 1996). Their initial appearance may be grotesque and the birth of a baby with cleft lip and/or cleft palate is a shock to most families. Families must deal with the impact of the birth defect as a patient and family and, that on society as a whole.

In the United States, this birth defect affects approximately one in 750 newborns each year. Clefts exhibit interesting racial predilections, the frequency of cleft lip and palate in oriental or Asian population is about 1.5 times higher than whites, as contrasted to the prevalence in blacks which is much lower, occurring in 0.4 per 1000 births (Ross and Johnston 1972). Native Americans appear to have the highest frequency, around 3.6 per 1000 births (Ross and Johnston 1972). An isolated study in 1963 found a high incidence of clefting among eleven tribes of Indians in Montana having one affected child for every 276 births (Tretsven 1963).

Boys are affected more often by orofacial clefts than girls by a ratio of 3:2 and cleft of the lip are more common in boys, whereas isolated cleft palate are more common in girls (Thorton, Nimer et al. 1996). Boys tend to have more severe clefts than girls (Cooper and Harding 1979).

According to a study by Neville, about 80% of cleft lip cases were unilateral (70% appearing on the left side) and 20% were bilateral (Neville, Damn et al. 1995). Approximately onehalf of these infants had associated malformations, either minor or major, occurring in conjunction with the cleft (ACPA 1993).

Oral clefts occurring in association with a syndrome where there are other anomalous findings, accounts for approximately 3% to 18% of clefts (Fraser 1970; Bixler 1981). Some genetic syndromes routinely accompanied with cleft lip and palate include Pierre Robin sequence, Treacher Collins Syndrome, Nager acrofacial dysostosis, Wildervanck-Smith syndrome, and hemifacial microsomia. Genetics is said to play a role. Parents with a cleft child have a 5% increased risk of having another child with a cleft (Thorton, Nimer et al. 1996). If the parent and one child have a cleft the chance of another sibling having a cleft is increased by 15% (Peterson, Ellis et al. 1993). The more severe the cleft the greater the recurrence risk for other siblings or relatives (Jorde and Carey 1955). Environmental factors associated with cleft lip and palate include nutritional deficiencies, radiation, several drugs (alcohol, diazepam and other benzodiazepines, steroids, amphetamine, hydantoin, trimethadone), hypoxia, diabetes during pregnancy, viruses and vitamin excess of deficiencies (Thorton, Nimer et al. 1996).

Craniofacial Development

There are five principal stage in craniofacial development: (1) germ layer formation and initial organization of craniofacial structures; (2) neural tube formation and initial formation of the oropharynx; (3) origins, migrations, and interactions of cell populations (4) formation of organ systems; (5) final differentiation of tissues (Proffit and Fields 1993). Clefts arise during the fourth developmental stage. Exactly where they appear is determined by the locations at which fusion of the various facial processes failed to occur and this in turn is influenced by the time in embryologic life when some interference with development occurred.

During the fifth week of embryological development the lateral and medial nasal swellings are present and rapidly growing. The lateral swelling forms the alae of the nose and the medial swelling gives rise to the middle portion of the nose, the middle portion of the upper lip, the middle portion of the maxilla and the entire primary palate. Simultaneously the maxillary swellings will approach the medial and lateral nasal swellings but remain separated from them by the well-marked grooves (Figure 1-1 mouse embryo p. 42).

During the following two weeks the maxillary swellings begin to compress the medial nasal swellings, by growing in a medial direction. Subsequently, the nasomedial swellings simultaneously merge with each other and the maxillary swellings laterally. Hence, the two median nasal swellings and the two maxillary swellings form the upper lip.

The two medial swellings merge not only at the surface but also at deeper level. The structures formed by the two merged swellings are known together as the intermaxillary segment. It is comprised of a labial component, which forms the philtrum of the lip, an upper jaw component, which carries the four incisors and a palatal component, which forms the primary palate.

The secondary palate is formed by two shelf-like projections of the maxillary swellings. These palatine shelves appear in the sixth week of development and are directed obliquely downward on either side of the tongue. In the seventh week, however, the palatine shelves reorient to attain a horizontal position above the tongue, both begin to expand medially and fuse with each other, thereby forming the secondary palate. The palate shelves fuse with the triangular primary palate, anteriorly, the incisive foramen is formed at this junction. At the same time the nasal septum grows down and joins the superior surface of the newly formed palate. The palatine shelves fuse with each other and with the primary palate between the seventh to tenth week of development (Figure 1-2 palatal shelves p. 43).

Clefts of the primary palate result from a failure of mesoderm to penetrate into the grooves between the medial and maxillary processes, which prohibit their merging with one and other (Thorton, Nimer et al. 1996). Clefts of the secondary palate are caused by failure of the palatine shelves to fuse with one another. The causes for this are speculative and include failure of the tongue to descend into the oral cavity (Thorton, Nimer et al. 1996).

Cleft Classifications

Several classifications of oral clefting have been introduced in the past (Davis and Ritchie 1922; Veau 1931). Kernahan and Stark (1958) presented a classification system based on the incisive foramen, this is the classification system most commonly used today (Thorton, Nimer et al. 1996). Clefting of the palate may occur with or without clefting of the lip, and cleft lip may occur with or with out clefting of the palate. Dividing the anatomy into primary and secondary palates provides useful classifications. Unilateral cleft extending into nose; unilateral cleft involving lip and alveolus; bilateral cleft involving lip and alveolus; isolated cleft palate; cleft palate combined with unilateral cleft of the alveolus; and bilateral complete cleft of the lip and palate (Kernahan and Stark 1958).

Oblique facial clefts extend from the upper lip to the eye. It is almost always associated with cleft palate and severe forms are often incompatible with life. This cleft is rare, representing only one in 1300 facial clefts and may represent failure of fusion of the lateral nasal process with the maxillary process (Neville, Damn et al. 1995). Median clefts of the upper lip are extremely rare and result from failure of fusion of the median nasal processes. This is often associated with Ellis-van Creveld syndrome and oral-facial-digit syndrome.

Ear Problems

Children that are affected with cleft lip and palate are predisposed to middle ear infections. The levator veli palatini and tensor veli palatine are left unattached when the soft palate is cleft. These muscles are responsible for the opening of the ostium of the auditory tube to the nasopharynx. Disruption of these muscles leaves the ear without a mechanism for drainage allowing for fluid accumulation and possible bacterial infection. Tubes may be placed in the inferior aspect of the tympanic membrane facilitating drainage and thereby decreasing the risk of serous otitis media.

Nutritional Aspects

Feeding of cleft palate patient creates a different collection of problems. Babies with cleft lip and palate can swallow normally after food reaches the hypopharynx. These children are unable to create the negative pressure required for nursing. Infants have the normal sucking and swallowing reflexes but due the underdevelopment or improper arrangement of the musculature their sucking ability is ineffective. The use of enlarged nipples that extend further into the baby’s mouth or the use of syringes or eyedroppers easily overcomes these problems. The effective feeding methods have a downside of increased air swallowing and more frequent burping is required.

Speech Difficulties

Four speech problems are usually evident in cleft lip and palate patients. Retardation of the consonant sounds (p,b,t,d,k and g) is the most common finding. Hypernasality is usual in the patient with cleft of the soft palate and may remain after surgical correction. Dental malformation, malocclusion, and abnormal tongue placement may develop before the palate is closed and thus produce an articulation problem. Hearing problems contribute significantly to the many speech disorders common in patients with clefts.

The efforts to relate speech outcome to the age at which palatal surgery is performed dates back at least as far as the famous French surgeon Victor Veau, who in 1933 reported normal speech in 75% of children who underwent surgery before twelve months of age, 60% of those who underwent surgery between 2 to 4 years of age, and 28% of patent who underwent surgery and were older than 9 years (Veau, 1966). More than 60 years later, the inexperienced clinician may be surprised to learn that despite Veau's conclusion and despite multiple studies of the question there is still much disagreement about the age at which surgical closure of a palatal cleft should be accomplished in a normally developing child (Peterson-Falzone, 1996)

Nasal Deformities

Cleft palate abnormalities are not confined to the oral structures. Deformities of the nasal architecture are routinely seen in persons with cleft lip and palate. Despite the advantage of cleft grafting, some degree of hypoplasia and focal dysmorphia remains in all patients with cleft after either primary or secondary grafting when performed by conventional means (Rosenstein, Kernahan et al. 1991). The cleft site in unilateral cases is usually more hypoplastic, resulting in a lack of underlying bony support to the base of the nose, than the contralateral side. The alar cartilage on the cleft side is flared and the columella of the nose is pulled toward the non-cleft side. The overall result is the deficient piriform rim and adjacent paranasal area of the maxilla. Iliac apophyseal cartilage augmentaion of the deficient maxilla contributes to retained bulk and improved esthetics for the cleft palate patients (Kokkinos, Ledoux et al. 1997).

Treatment

Although the treatment of children with cleft lip and/or palate has improved dramatically, many children still receive substantially inferior care to what can or should be provided. Inadequate treatment results from diagnostic errors, failure to recognize and treat the full spectrum of health problems associate with the cleft, unnecessary and poorly timed treatment, and inappropriate or poorly performed procedures (ACPA 1993). Because they are deformities that can be seen, felt, and heard, they constitute a serious affliction physically, psychologically as well as emotionally to those who have them.

Treatment of the cleft palate patient is a multidisciplinary process involving several diversified fields of medicine and dentistry. Children with cleft lip and palate are monitored at regular intervals from infancy to adulthood. The extent of specialists to examine a cleft palate patient includes: oral surgeon, restorative dentist, pediatric dentists, orthodontist, ENT, pediatrician, speech pathologist, audiologists, nutritionists, child psychologists, parental psychologists, genetic counselors, and plastic surgeons. The coordination of these specialists and timing of their particular therapy is a vital link in the outcome of cleft palate treatment (Waite and Waite 1996). An example of the possible sequential treatment of a unilateral cleft palate patient is as follows (Valchos 1996):

Initial treatment of the cleft palate patient begins around three months after birth with closure of the lip. The cleft of the upper lip disrupts the important orbicuralis oris musculature. The lack of continuity of this muscle allows the developing parts of the maxilla to grow in an uncoordinated manner, so the cleft of the alveolus is accentuated. This is followed by closure of the soft palate at around twelve months of age. At six years of age a clinical cleft lip and palate conference appointment should set for the “cleft palate team”. The “teams” agenda will be:

1. Derive complete team diagnosis
2. Team assembly to discuss all treatment plans
3. Individual letters of treatment plan are distributed to all patients

Dentofacial orthopedics including transverse expansion, anterior protraction and fix retention are evaluated at six to seven years of age. Investigators have found significantly better skeletal response with maxillary protraction started at age 6.3 (Rygh and Tinlund 1982).

Orthodontic treatment begins around eleven to thirteen years followed by a second team evaluation at fifteen years.

Between fifteen and nineteen years the cleft palate patients may pursue selective plastic surgery for facial esthetics and possibly preprosthetic orthodontics (bridgework, implants) or presurgical orthodontics.

History of Alveolar Bone Grafting

Lexer (1908) and Drachter (1914) performed the inaugural attempts at bone grafting in developing cleft palate patients. Since then, opinions continue to differ on the indications and management of maxillary bone grafting. Early bone grafting in the primary dentition has received wide spread support in the literature of the 60's and 70's (Backdahl and Nordin 1961; Stellmack 1963; Muir 1966; Monroe, Griffith et al. 1968; Robinson and Wood 1969; Nylen, Korlof et al. 1974; Schmid, Widmaier et al. 1974). However, deleterious effects of early intervention on the subsequent growth of the maxillary complex were noted by various investigations (Pickrell, Quinn et al. 1968; Robertson and Jolleys 1968; Troxell, Fonseca et al. 1982). Pruzansky, Robertson and Jolley, and Epstein and colleagues believe that bone grafting in infants is not indicated. Reason for not grafting bone in the infant group include: combined soft tissue and bone grafting is too time consuming for an infant; constriction of the maxilla in later life occurs as the grafted bone does not grow compatibly with the surrounding bone; esthetic deformities and their extent cannot be predicted in the infant; an adequate alveolar ridge cannot be constructed, as proliferation of the alveolar process does not occur until the eruption of the permanent dentition; it is not possible in the infant to predict the future need for the maxilla orthodontics and subsequent bone grafts for arch stabilization (Broude and Waite 1974). Opponents of primary bone grafting also claim that long-term results showed more unfavorable facial growth pattern and development of the dentition with treatment than without treatment (Helms, Speidel et al. 1987).

Bone grafting delayed until after eruption of the permanent dentition is now a more widely accepted procedure (Stenstrom and

Thilander 1963; Boyne and Sands 1972; Hogeman, Jacobsson et al. 1972; Johanson, Ohlsson et al. 1974; Hall and Posnick 1983; Hinrichs, el-Deeb et al. 1984; Turvey, Vig et al. 1984). From a dental perspective, two of the most important benefits of secondary bone grafting are the improved bone support for teeth adjacent to the cleft site and the elimination of the notched alveolar ridge (Long, Paterno et al. 1996). Bone grafting performed after the development of the permanent dentition is usually referred to as “secondary” bone grafting. According to previous investigators, it has been described as “early secondary” bone grafting, taking place between 5 and 6 years; “secondary” bone grafting taking place between 9 and 11 years or before permanent canine eruption; and “late secondary” or “delayed” bone grafting, taking place after eruption of the permanent canine (Helms, Speidel et al. 1987).

Opponents of secondary grafting state that bone does not show apposition on the graft surface, which results in the graft’s inability to keep pace with vertical alveolar development and subsequent compromised support of the adjacent teeth (Pickrell, Quinn et al. 1968; Rehrmann, Koberg et al. 1970; Schmid, Widmaier et al. 1974; Helms, Speidel et al. 1987)

Much of the disagreement on timing of alveolar cleft bone grafting appears to be the result of numerous factors. Primarily, the terms used to define the stages for bone grafting are imprecise because they describe a range of chronological age rather than a precise developmental stage. Also, different clinicians may assess success of grafting procedures differently. There is little published data to support preference for bone grafting at one time versus another.

Wait and Kersten (1980) implied that the permanent teeth bordering the nongrafted cleft area are often deficient in bone support along the root surface proximal to the cleft and have deficient periodontal support for the tooth’s normal longevity (Bell, Proffit et al. 1980). This was a deterrent to delayed bone grafting.

El deeb (1986):

- Found increased plaque index for canines erupting through the normal alveolar bone in the non-cleft side in patient with unilateral clef lip and plate than in control, non-cleft patients.
- Recorded a statistically significantly greater amount of attachment loss was found on the mesiofacial, facial and mesiopalatal surfaces for canines erupted through grafted alveolar clefts when compared to contralateral canines.
- Discovered a greater width of labial attached gingiva was found over the facial surfaces of canines erupted through normal alveolus in the non-cleft control patients and contralateral side of unilateral cleft patients.
- Reported no differences between the overall periodontal status between the non-cleft control and unilateral or bilateral patients with grafted alveolar clefts.

- Found the use of mucogingival flap design more attached gingiva at the mesiofacial and facial surfaces of the erupted canines than did the mucobuccal flap design.

One factor that may affect the outcome of successful grafting is the location of the teeth in the cleft site, prior to grafting, usually the permanent canine (Long, 1996).

The timing of alveolar bone grafting may be a primary factor influencing the periodontal health of teeth erupting through the grafted site. The purpose of this study is to investigate if the timing of the alveolar bone graft has an effect on the periodontal health of teeth erupting through the graft site.

Chapter 3

Methods and Materials

This retrospective study involved 59 patients, who underwent secondary alveolar cleft bone grafting at the Lancaster Cleft Lip and Palate Clinic in Lancaster, PA. Clefts included fifteen bilateral and forty-four unilateral cleft lip and palate patients for a total of 74 sites in the sample. The patients were selected according to the following criteria:

- Patients with complete unilateral or bilateral cleft lip and palate
- Patients must not have any other craniofacial anomalies
- Canine which erupted through graft must be completely erupted and without prosthesis (crown)
- Patients must have high quality pre-(no more than six weeks prior to surgery) and post-graft radiograph of the cleft site

- Patients with previous bone grafting such as primary bone grafting or multiple bone grafts will be excluded
- Grafts utilizing only autogenous iliac crest or calvaria bone
- Grafts surgery performed at the Lancaster Cleft Lip and Palate Clinic utilizing surgical techniques of Broude and Waite (1974)

Analysis of Pre-surgical Radiograph

The pre-surgical radiograph was utilized to assess the stage of canine development. An acetate tracing was made of each radiograph. Root development was evaluated using a modification of the radiographic scoring systems of El Deeb (1982). The apparent length of root calcification was measured with digital calipers to the nearest .01 mm and compared to crown length on the same radiograph. A score of 0-6 was assigned in accordance with the criteria shown in Figure 1-3 on page 44. A canine was considered within a given stage until it reached the beginning of the next stage.

Analysis of Post-surgical Radiograph

Post-surgical radiographs were used to assess final bony architecture and root support in the grafted area. Eleven points were digitized from acetate tracings of the radiograph (figure 1-4 p. 45). These allowed for determination of root lengths of teeth adjacent to the cleft (points 1, 2, 3, 7, 10, 11), the location of the alveolar crest (points 4, 8), the apical most level of bone support (points 5, 9) and the degree of ridge notching.

Alveolar bone architecture and root support in the grafted area were determined using ratios of bone height (figure 1-4 p. 36) measurements B, C, F, G divided by the anatomical root lengths of the adjacent teeth on the mesial and distal side of the previous cleft (B/A, C/A, D/A, F/E, G/E). The higher the ratios of B/A and F/E, and the lower the ratios of C/A and G/E, the more the graft resulted in favorable bone support for the adjacent teeth. Smaller ratios of D/A have less notching of the alveolus following the graft. All variables were continuous in nature and assigned a value between zero and one.

CHAPTER 4

Results

ANOVA, Pearson correlation, partial correlation and pair-wise correlations were performed.

The intraclass correlation was .9985 (average correlation between and 2 measurements of the same specimen) (Dowdy, 1995). The R-square value (plot of each measure vs. the average of the two measures of the same specimen) formed nearly a straight line. If repeatability had been perfect all values would fall exactly on a straight line.

Significant correlations (p = 0.0085) were found between the stage of root formation and alveolar notching or V shaped bone loss between the central and canine in the area of grafting. Less alveolar bone was noted in this area in patients who received secondary alveolar cleft bone grafts in later stages of canine development as compared to those who received grafts in the earlier stages.

No significant correlations were found with any other variables.

CHAPTER 5

Discussion

This study set out to determine if the timing of the alveolar bone graft has an effect on the periodontal health of teeth erupting through the graft site. A total of 74 sites were examined from 59 patients. Fifteen bilateral cleft lip and palate patients and 44 patients with unilateral cleft lip and palate.

With increased age, bony healing is impaired and graft success diminishes (Jia, James et al. 1998). This could be caused by changes in the healing potential with increasing age (Sindet-Pedersen and Enemark 1985). In the current study, the average time of bone grafting according to canine stage of development was 3.35. The average chronological age of bone graft placement was 10 years 6 months. This is in accordance with the optimal age of bone graft placement (8-12 years) as utilized by most institutions (Boyne and Sands 1972; El-Deeb

1982; Hall and Posnick 1983; Bergland, Semb et al. 1986; Paulin, Astrand et al. 1988; Kortebein, Nelson et al. 1991; Freihofer, Borstlap et al. 1993). In order to avoid interfering with maxillary growth it is recommended not to perform the osteoplasty before eight years of age (Bergland, Semb et al. 1986). One exception is, if the lateral incisor tooth is present, then earlier grafting may be considered (El Deeb, Waite, 1982).

The mean age of patients at time of post bone-grafting radiograph was 12.7, which translates to an average of 2.1 year following the grafting procedure. The minimum observational period in this study was one year. The osseous healing of transplants evaluated on intra-oral radiographs may be regarded as terminated within 6 months post-operatively in 80 per cent of the patients (Johanson 1988). Therefore sufficient time had lapsed for adequate post-surgical radiographic assessment of the 74 sites involved.

The findings indicated there was no significant correlation between the stage of canine development and the final bony architecture. Less alveolar bone was noted between the central incisor and canine in the patients who received secondary alveolar cleft bone grafts in later stages of canine development. These findings are in agreement with results reported by Helms (Helms, Speidel et al. 1987), who found increased incidence of graft failure in late secondary and delayed grafting groups. Helms (1987) also reported the lack of ridge height on the delayed graft patients appeared to increased with time.

The presence of a bony bridge alone for esthetic prosthodontic reconstruction is of questionable importance because the height and mass of the bridge are often of no clinical value. However if implants are a consideration or if the bony defect is compromising the support of abutment teeth the bony bridge is of the utmost importance.

The optimal timing for post-surgical success of secondary alveolar bone grafting may be difficult to identify based on dental maturity as determined by stage of canine development in this study. However when it comes to the alveolar support between these teeth, grafting early may be advantageous particularly when future implant placement is a consideration.

Another important aspect of this study is the use of stage of canine development for timing of graft placement. Stage of canine development is a more reliable indicator of time of graft placement than chronological age. A random assessment of amount of root formation is a haphazard and sometimes a guess by a surgeon. Using stage of canine development when indicating time of graft placement gives a more accurate representation of the time of graft placement in a quick and precise procedure.

The limited studies on periodontal condition in subjects with cleft of the lip and palate may be due to many factors, such as small numbers of patients, changes is treatment routines over the years, short observation times, lack of details of cleft diagnosis, widely spaced age distribution at completion of treatment, difficulties in tracking the patients and low patient participation.

The conclusions are presented with recognition of the limitation of the study. It is extremely difficult to attain a large sample with a minimum of variable and adequate records over an extended time period. Future studies need to be planned in which additional populations will be evaluated and sample size increased.

Conclusion

Although no significant correlations were found between time of bone grafting and bony support of surrounding teeth, less alveolar bone was noted between these teeth in the patients who received secondary alveolar cleft bone grafts in later stages of canine development.

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