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Traditional osteotomy versus distraction osteogenesis: Articulation changes in Cantonese patients with cleft palate

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Abstract

This study aimed to investigate the effect of maxillary hypoplasia correction by traditional osteotomy with that by distraction osteogenesis on the articulation changes in cleft patients. Twenty seven Cantonese cleft patients participated in this study. Some were subjects previously studied by Chanchareonsook (2004a). The Cantonese Osteotomy Deep Test (Whitehill, 1995) was used to investigate the phonemes that were vulnerable in patients with malocclusion; which were /s/, /f/, /p/, /p^h/, /ts/ and /ts^h/. Data was collected pre-operatively and post-operatively at 4 months, 1 year and 2 years after the surgery. The results of the study showed that there was no significant difference on the articulation performance of subjects undergoing osteotomy versus distraction across time.

Introduction

Individuals with repaired cleft lip and palate may develop maxillary hypoplasia, meaning the disproportional growth between the maxilla (upper jaw) and the mandible (lower jaw) with decreased maxillary growth resulted (Schwarz and Gruner, 1976). Facial profile, labial, dental, lingual and palatal relationships may therefore be adversely affected (Chanchareonsook, 2004b). Patients may request orthognathic surgery, for both aesthetic and functional reasons, to re-establish the maxillo-mandibular equilibrium. Articulation may be improved due to normalization of dental occlusion following maxillary surgery (Witzel, Ross, & Munro, 1980; Ruscello, Tekieli, Jakomis, Cook & Sickels , 1986). However, upon reposition of the maxilla to a more anterior position, the nasopharyngeal and oropharyngeal spaces would be widened which may worsen the existing velopharyngeal incompetence (VPI) in cleft patients (Chanchareonsook, 2004b).

Currently two basic orthognathic approaches are available for maxillary hypoplasia correction; they are the traditional osteotomy and the distraction osteogenesis. Osteotomy is a conventional surgery done with an immediate advancement of the maxilla. Distraction osteogenesis is a more recent surgical option for maxillary advancement, which is done on a gradual basis with slow advancement of the maxillary bone (Chanchareonsook, 2004a). Following the introduction of the

new surgical option to correct maxillary hypoplasia, comparison between the conventional and the recent surgical technique on the effect of articulation changes pre- and post-surgically may give contribution to clinical implications.

Literature Review

The effect on articulation caused by dental and occlusal abnormalities has been evaluated by many researchers (Ruscello, Tekieli & Sickels, 1985; Vallino, 1990). The results were not conclusive due to the differences in the subject groups and the methodologies employed. Some studies included patients with cleft palate while others examined patients with occlusal abnormalities alone. However, most studies found that patients with malocclusion demonstrated at least some articulation errors and their articulation may be improved after orthognathic surgery to correct the maxillary-madibular relationships (Schwartz & Gruner, 1976; Ruscello et al., 1986; Witzel et al., 1980).

Chanchareonsook (2004b) had reviewed studies conducted in past thirty years on the effect of speech and velopharyngeal function after advancement of the maxilla surgically by either traditional osteotomy or distraction osteogenesis. For the 41 articles reviewed, 22 studies included investigation on articulation changes after maxillary advancement. The results for the impact of maxillary advancement on

articulation have been varied. Most studies agreed that there was improvement of articulation following maxillary advancement. However, there are also some studies found that the surgery had no impact on speech performance (Chanchareonsook, 2004b).

According to Chanchareonsook (2004b), some researchers reported that improvement in articulation occurred in cleft and non cleft patients after maxillary advancement, of which their performance improved from 57% to 88.2%. Vallino (1990) reported that the sibilants vulnerable in malocclusion patients (/s/, /z/, /j/, /zh/, /ch/ and /sh/) improved in most of the patients after maxillary hypoplasia correction. Most patients had all of their articulation errors eliminated after surgery; those whose errors persisted showed a decrease in their number. Ko, Figueroa, Guyette, Polley and Law (1999) reported a reduction in articulation errors in 57% (12 of 21) of the patients after surgery, and this improvement could be explained by improved labial, dental, lingual and jaw relationship. Janulewicz, Costello, Buckley, Ford, Close and Gassner (2004) examined the errors by both place and manner of articulation. 65% of patients exhibited articulation errors pre-surgically declined to 47% three months after surgery. Upon the patients who had completed data collection at a six month follow up, only 22% of the patients continued to show the errors. In the study of Guyette, Polley, Figueroa and Smith (2001), a reduction of more than two errors was noted in

67% of patients after orthodontic correction by the one year follow up.

On the contrary, two of the articles reviewed showed no statistically significant difference between articulation performance pre- and post-surgically. Dalston and Vig (1984) reported that no significant improvement was observed in the articulation in fourty adult women studied. Maegawa, Sells and David (1998) suggested that the articulation errors would not resolved spontaneously after orthognathic surgery, and facilitation on changing past habitual articulatory behaviors to adapt new structural relationships maybe needed.

Chanchareonsook (2004b) noted that among the past studies, there were great variations in terms of the design and the methodologies used. A number of problems were found in most of the studies which made them less robust; these included small sample size, lack of description of subjects (cleft versus non cleft), lack of operation details (the amount of maxillary advancement), lack of validity measures (inter- and intra-reliability) and unclear description of outcome measures (the method of assessment) (Chanchareonsook, 2004b). None of the reviewed articles compared both surgery groups (traditional osteotomy versus distraction osteogenesis) within a single study. Chanchareonsook (2004a) therefore conducted a pilot study with a follow up of three months postoperatively comparing osteotomy and distraction on the effect of speech and velopharyngeal function in cleft patients, using measures to overcome the

above limitations. In her study, the articulation performances of the subjects were not reported.

This study was an extension of Chanchareonsook's (2004a) study, with a follow up to 2 years postoperatively, focusing at comparing the effect of maxillary hypoplasia correction by osteotomy with that by distraction on the articulation changes in cleft patients. It has been suggested in the literature that gradual change of the maxillary position by distraction may result in less speech abnormality (resonance problem) in cleft patients. However, its relative impact on articulation has not known. The author now hypothesize that patients underwent distraction may have less articulation errors postoperatively than those underwent traditional osteotomy, due to the gradual adaptation to structural changes allowed by distraction.

Structural relapse may occur after the maxillary advancement was completed, which means the maxilla may move backward towards its pre-surgical position. The structural relapse could be very complex which may involve both anterior-posterior dimension and the vertical dimension. Relapse data would be considered in this study, which may be able to explain the possible articulation error changes over time. For simplicity, only the anterior-posterior dimension would be reported.

Research Questions

The research questions for this study were:

1. Are there significant differences in articulation performance pre-surgery versus 4 months and 1 year post-surgery between patients who underwent osteotomy and those who underwent distraction?
2. Are there significant changes in articulation (improvement or deterioration) in individual performance over time (4 months, 1 year and 2 year pos t-surgery)?

Methodology

This study was an extension study of the subjects investigated by Chanchareonsook (2004a). To be comparable with the pre-surgery data in Chanchareonsook's (2004a) project, similar procedures were used for the post-surgery data collection and analysis.

Subjects

There were 27 subjects in this study, with 22 subjects having participated in Chanchareonsook's (2004a) project and five subjects were later recruited to participate in the continuing project. The subjects' age ranged from 17 to 47 with a mean age of 22.6 years (SD= 6.34). There were 15 males and 12 females. All subjects had the diagnosis of maxillary hypoplasia associated with repaired cleft palate with or

without cleft lip. In order to be included into this research project, all subjects fulfilled the criteria listed in Chanchareonsook's (2004a) project: 1) Cantonese speaking 2) repaired unilateral cleft lip and palate, bilateral cleft lip palate or cleft palate only 3) palatal cleft repair and alveolar cleft bone grafting were done during childhood (except subject 5 whose cleft bone grafting was done in adulthood) 4) requiring 4 to 10mm of surgical advancement of the maxilla. None of the subjects had intellectual impairment or had a hearing loss.

Randomization of the subjects into the two surgery groups was then carried out. Based on the standard protocol used in the Oral and Maxillofacial Surgery Unit in the University of Hong Kong, patients who require surgical advancement of the maxilla of more than 10mm have to receive distraction and those requiring advancement of less than 4mm had to receive osteotomy. Therefore, only patients requiring maxillary advancement between 4-10mm could be selected for randomization across surgery groups. Subject details and the relapse data are shown in Table 1 and Table 2 respectively.

Table 1. Subject details.

Subject	Sex	Age	Surgery Undergone	Pre	Post 1 (1.5 – 8 month)	Post 2 (11month -1 year 3	Post 3 (2 year 1 month –

						month)	2 year 5 month)
1	F	21	Osteotomy	✓	✓		
2	F	20	Osteotomy	✓	✓		
3	M	47	Osteotomy	✓	✓		
4	M	22	Osteotomy	✓	✓		
5	M	38	Osteotomy	✓	✓		
6	M	22	Osteotomy	✓		✓	
7	M	17	Osteotomy	✓	✓	✓	
8	F	18	Osteotomy	✓	✓	✓	
9	M	23	Osteotomy	✓	✓	✓	
10	F	21	Osteotomy	✓	✓	✓	
11	F	21	Osteotomy	✓	✓		✓
12	M	19	Osteotomy	✓	✓	✓	✓
13	M	24	Osteotomy	✓	✓	✓	✓
14	F	17	Osteotomy	✓	✓	✓	✓
15	M	26	Osteotomy	✓	✓	✓	✓
16	F	20	Osteotomy	✓	✓	✓	✓
17	F	18	Distraction	✓	✓		
18	M	25	Distraction	✓	✓		
19	M	21	Distraction	✓	✓		
20	F	18	Distraction	✓	✓		
21	M	22	Distraction	✓	✓		
22	M	23	Distraction	✓		✓	
23	M	19	Distraction	✓		✓	

24	F	19	Distraction	✓	✓	✓	
25	F	24	Distraction	✓	✓	✓	
26	M	24	Distraction	✓	✓	✓	
27	F	22	Distraction	✓	✓	✓	✓

Table 2. Relapse data

Subject	Relapse after 3 months (mm)	Relapse after one year (mm)	Relapse after two years (mm)
4	No relapse		
5	1.33		
9	1.40	2.69	
13	2.51	3.23	2.84
14	2.40	2.40	2.52
23	Not reported		
26	Not reported		

Surgical procedure

All surgery was conducted by the surgical staff and the postgraduate trainees under the supervision of faculty surgeons in the Department of Oral and Maxillofacial Surgery, Prince Philip Dental Hospital, University of Hong Kong.

Speech evaluation

All subjects took part in both pre-surgery and post-surgery data collection. The post-surgery data were planned to be taken in three timeslots, namely four months, one year and two years after the patient had undergone the surgery. However, due to the availability of the subjects, postoperative data could not be collected as planned. Re-scheduling was done for subjects who failed to attend the appointments at specific times. At the end, post 1 data was collected within 1.5 to 8 months; post 2 data was collected within 11 months to 1 year 3 months and the post 3 data was collected within 2 year 1 month to 2 year 5 months after surgery. Since this is a longitudinal study and the recruitment of subjects was on an ongoing basis, the number of post-surgery data for the patients varied depending on the time the patients participated in this research project.

The speech evaluation was carried out at the Division of Speech and Hearing Sciences, University of Hong Kong. The evaluation included hypernasality, nasal emission and articulation assessments. For this study, only the articulation of the subjects was investigated.

The articulation assessment was conducted in a quiet room by a qualified speech-language therapist who was not the author of this article. Speech samples were both audio- and videorecorded. For audiorecording, a Sony TCD-D3 Digital (DAT) tape recorder was used and a Sony ECM-909 microphone was maintained at a

distance of 10cm between the mouth and the microphone. A JVC GR-AX7E video camera was used for videorecording and it was positioned to allow maximum view of the mouth during assessment. Speech analysis was conducted by a native Cantonese speaker (a final year speech-language pathology student, the author) trained in IPA phonetic transcription. Ten percent of the data (including all the data found by the author to be in error plus a portion of normal data) was then re-transcribed by an experienced speech-language pathologist (a doctor student). To avoid any bias occurred during transcription, the two judges were blinded to all information that could identify the subjects; these included the surgical group (osteotomy versus distraction), time of assessment (pre-surgery versus post-surgery) and other subject identifying information. This was done by preparing randomized tracks on MDs.

According to Ruscello et al. (1986), speech errors were easier to be identified in word stimuli than in sentence and paragraph stimuli, word list stimuli were therefore selected for the articulation assessment of the subjects. The Cantonese Osteotomy Deep Test (CODT) (Whitehill, 1995) was selected rather than the Cantonese Segmental Phonology Test (CSPT) (So, 1993). Whitehill, Samman, Wong, and Ormiston (2001) found that traditional articulation screening test such as CSPT, which each phoneme was sampled with limited trials, may not be sensitive enough to identify articulation errors in the population with dentofacial abnormalities. CODT

was therefore used in this project. CODT is a deep test that contains six initial phonemes which are most vulnerable in the population with dentofacial abnormalities: /s/, /ts/, /ts^{h}/, /f/, /p/, /p^{h}/ (Ruscello, Tekieli and Sickels, 1985; Vallino & Tompson, 1993; Witzel, Ross, and Munro, 1980). Each phoneme is sampled twenty times in varying phonetic contexts in both consonant-vowel and consonant-vowel-consonant structures. The word list was read aloud by the subjects and narrow transcription was made for the erroneous productions. The total correct score was counted and errors were categorized into substitution, omission, or distortion. Free variation such as final /ŋ/ to final [n] and homophones (such as /ts^{h}iŋ$_{2}$/ and /ts^{h}ɛŋ$_{2}$/ of “請”) were counted as correct. If the subject self corrected or repeated the targeted stimuli upon request, only the last trial of production would be considered.

Statistical analysis

Descriptive statistics of mean, range and standard deviation were calculated for the articulation scores. A two-way repeated measures analysis of variance (ANOVA) was conducted to determine if there are significant differences in the percentage accuracy in articulation scores among pre-surgery and 4 months post-surgery between the two surgery groups (osteotomy versus distraction). Since only a few subjects had completed the 1 year post-surgery data collection, non-parametric tests was used since

the assumption of homogeneity of variance was violated. The Mann-Whitney U test was used to examine if there are any significant differences in the percentage accuracy in articulation scores between the two surgery groups 1 year post-surgically. The Wilcoxon test was used to determine if there are any significant differences in the percentage accuracy in articulation scores pre-surgically and one year after surgery within each surgery group. The data obtained 2 years post-surgically were evaluated qualitatively due to the relative small sample size.

Reliability

In order to establish reliability, a study of inter-rater reliability and intra-rater reliability was conducted. An experienced speech-language pathologist (a doctor student) was invited to be the inter-rater and ten percent of the data (including all the data found by the author to be in error plus a portion of normal data) was re-transcribed as mentioned before. Any difference among the judgments was considered as disagreement. The reliability was calculated by dividing the total number of agreements by the total number of judgments. Inter-rater reliability reached 85.2% level of agreement and intra-rater reliability reached 96.3% level of agreement. Discrepancy between the author and the inter-rater mainly came from one error pattern from one of the speakers. Among the discrepancies found, the author’s

decision was followed.

Results

The results of the CODT of subjects in both surgery groups were analyzed following the protocol mentioned before.

Table 3 showed the mean, range and standard deviation (SD) of the percentage accuracy in articulation scores achieved by patients underwent osteotomy and those underwent distraction across time. The results were reported to post 2 timeslot since most of the subjects hadn't completed the post 3 data collection. As shown, the mean percentage accuracy for patients underwent osteotomy decreased slightly from 95.01% pre-surgery to 93.07% four months post-surgery; then increased to 99.25% one year after surgery. For patients who underwent distraction, the mean percentage accuracy increased slightly from 93.65% pre-surgery to 94.44% four months post-surgery; then decreased to 88.88% one year after surgery.

Table 3. Mean, range and standard deviation of percentage accuracy in articulation scores achieved by patients underwent osteotomy and those underwent distraction across time

	Osteotomy	Distraction

	Mean%	Range	SD	Mean%	Range	SD
Pre-surgery	95.01	32.5-100	16.74	93.65	50-100	15.12
4 months post-surgery	93.07	33.3-100	17.39	94.44	50-100	16.67
1 year post-surgery	99.25	95.8-100	1.45	88.88	50-100	20.19

Performance of subjects between osteotomy and distraction across time

A two-way repeated measures analysis of variance (ANOVA) was used to study the changes in percentage accuracy of articulation performance of patients in the two surgery groups pre-surgery and 4 months post-surgery. The two factors studied were the surgery group (osteotomy and distraction) and the time (pre-surgery and 4 months post-surgery). The results showed that both the main effect of surgery group ($F(1, 22) = 0.002$, $p = 0.967$) and the main effect of time ($F(1, 22) = 0.329$, $p = 0.572$) were not significant. The interaction effect of surgery group x time was not significant ($F(1, 22) = 1.342$, $p = 0.259$).

Since the assumption of homogeneity of variance was violated, non-parametric tests (The Mann-Whitney U test and The Wilcoxon test) were used to examine results involving data collected 1 year post-surgically. The Mann-Whitney U test was used to examine if there are any significant differences in the percentage accuracy in articulation scores between the two surgery groups (osteotomy and distraction) 1 year

post-surgically. The results showed no significant difference ($p > 0.05$) was observed. The Wilcoxon test was used to determine if there are any significant changes in the percentage accuracy in articulation scores pre-surgically and one year after surgery within each surgery group. No significant difference ($p > 0.05$) was observed pre-surgically and one year post-surgically within the osteotomy group. Similar results were shown for the distraction group, no significant difference ($p > 0.05$) was found. Figure 1 showed the mean percentage accuracy in articulation scores for the two groups (osteotomy and distraction) over time.

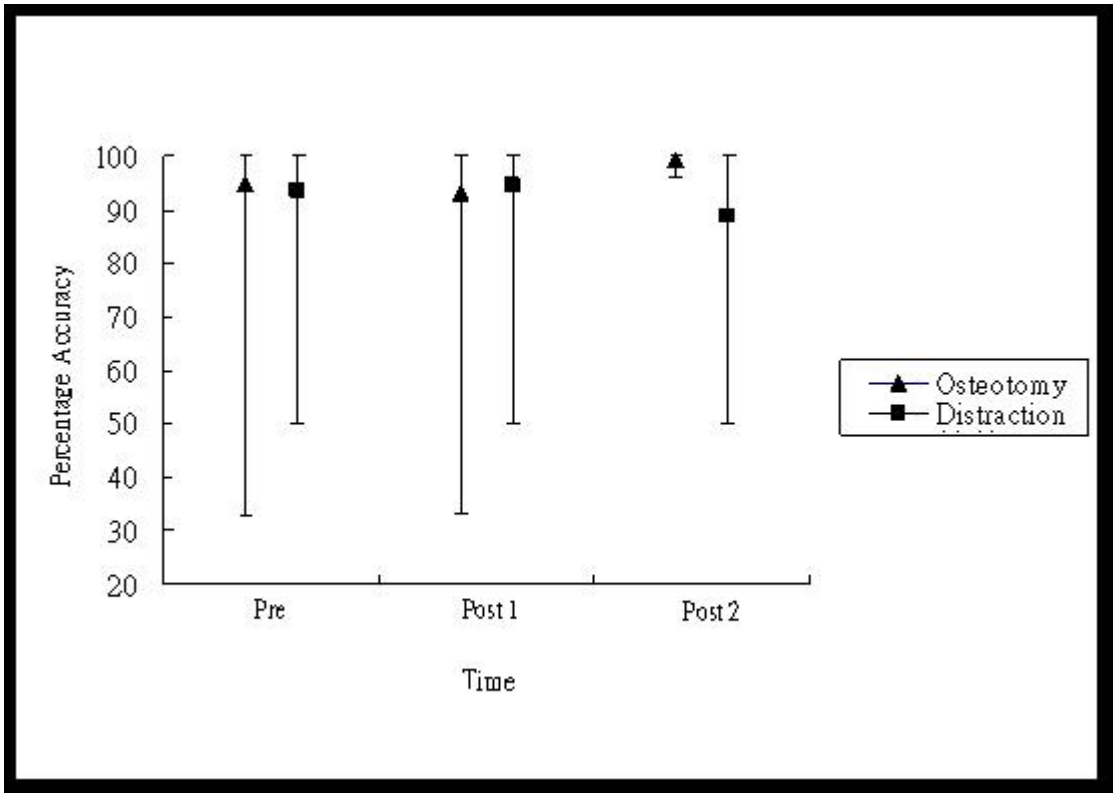

Figure 1. Mean percentage accuracy in articulation scores for the two groups (osteotomy and distraction) over time

Individual changes

Twenty patients did not have articulation errors both pre-operatively and post-operatively. Among the seven patients who showed articulation errors in either one of the assessments (pre-surgically, 4 months after surgery, 1 year after surgery or 2 years after surgery), five patients underwent osteotomy while two patients underwent distraction. Out of these seven patients, six patients showed distortion errors while one patient showed substitution and omission errors. Table 4 showed the type of articulation errors, number of errors and changes occurred in these seven patients over time.

Table 4. Type of articulation errors, number of errors and changes over time

Subject	Pre-Op	Post 1	Post 2	Post 3
4	Gliding of fricative and affricate (51) Labialization of fricative (14) Omission of fricative and affricate (15)	Gliding of fricative and affricate (49) Labialization of fricative (7) Omission of fricative and affricate (24)		

	Omission of bilabial (1)			
5	NA	Nasal Emission with plosive (6)		
9	NA	Lateralization of fricative and affricate (25)	NA	
13	NA	Nasal Emission with plosive (7)	Nasal Emission with affricate (5)	Nasal Emission with affricate (4)
14	Weak fricative (7)	NA	NA	NA
23	Lateralization of fricative (18)	Lateralization of fricative (20)		
26	Velopharyngeal friction with fricative (60)	Velopharyngeal friction with fricative (60)	Velopharyngeal friction with fricative (60)	

Among the seven patients who had articulation errors, one patient (subject 14) showed slight improvement in articulation with reduced number of errors post-surgically, and this improvement maintained till two years after surgery. On the other hand, two patients (subject 5 and 13) showed deterioration in their articulation after surgery. Both of them had normal articulation pre-surgically; however articulation errors emerged after surgery. For the patients 4, 23 and 26, the articulation

errors found pre-surgically persisted after surgery. No change in their error pattern was noted. One patient (subject 9) who had normal articulation before surgery was found to have articulation errors emerged 4 months after surgery. However, all the errors resolved one year after the surgery.

Discussion

Orthognathic surgery to correct maxillary hypoplasia was reported to favor the articulation performance postoperatively in many studies (Schwarz et al., 1976; Witzel et al., 1980; Ruscello et al, 1986; Kummer, Strife, Grau, Creaghead and Lee, 2003; Guyette et al., 2001). The improved articulation after the advancement of the maxilla could be explained by the improved labial, dental, lingual and palatal relationships. With the introduction of a recent surgical technique, distraction osteogenesis, to correct maxillary hypoplasia, comparison between the traditional osteotomy and this new surgical technique on the change of articulation would be of great interest. This study was a follow up of the subjects who participated in Chanchareonsook's (2004b) research; they were all Cantonese cleft patients who were randomized to receive either osteotomy or distraction to surgically advance their maxilla. It was hypothesized gradual change of the maxillary position by distraction may allow time for adaptation or compensation for structural changes and therefore

result in less articulation errors.

The aim of this study was to compare the impact of these two surgeries on the change of articulation pre- and post-surgically. Follow ups to two years postoperatively were carried out. Information about the patients' articulation performance using CODT was collected and investigated pre-surgically, four months, one year and two years after the surgery was done.

Performance of subjects between osteotomy and distraction across time

Among the 16 patients who underwent traditional osteotomy and the 11 patients who underwent distraction osteogenesis, the percentage accuracy of their articulation scores did not differed significantly between surgery groups and across time. This may be due to the large number of patients having normal articulation in both groups before surgery. The study would therefore look at individual performances, to investigate possible changes in error pattern and the number of errors over time.

Individual performances

In this study, we only targeted at the six phonemes that were vulnerable in cleft palate patients, they were the initial consonants /f, s, p, p^h, ts, ts^h/. Some patients produced errors other than the errors we targeted, such as tonal errors, diphthong

errors and substitution of final consonants. These errors were out of the scope of this research and would not be investigated further.

Since most of the patients taken part in this research showed no articulation errors in both pre- and post- surgery period, so if any patients made articulation errors in one of the assessments (pre-surgery, 4 months, 1 year and 2 year post-surgery), they would be identified and studied individually. A total of seven patients were identified, of which five had undergone osteotomy and two had undergone distraction.

Different patterns of articulation changes were seen among the five patients undergone osteotomy. One patient (subject 4) had his articulation errors persisted. Before surgery, his articulation errors consisted of both substitution and omission of phonemes. They were gliding of fricative and affricates (/s, ts, ts^h/ → [l]), labiolization of fricative (/f/ → [w]), omission of fricatives and affricates (/f, s, ts, ts^h/ → [R‘), and omission of plosive (/p/ → [R‘) After surgery, the type of errors he made remained the same except he didn’t show omission of plosives. The number of substitution errors decreased slightly from 65 pre-surgically to 56 post-surgically while that of omission errors increased slightly from 16 pre-surgically to 24 post-surgically. The total number of errors persisted. This was consistent with previous studies (Maegawa et al., 1988; Dalston et al., 1984) that no deterioration in articulation was observed after osteotomy to displace the maxilla to a more forwarded

position.

One patient (subject 14) improved slightly after the maxillary advancement. The patient got seven distortion errors (weak fricative /f/) pre-surgically. After surgery, all her distortion errors resolved and this improvement remained till 2 years postoperatively. This was consistent with previous studies (Janulewicz et al., 2004; Kummer et al., 1989) that a reduction in the number of errors was observed following surgical advancement by osteotomy. The improved articulation was due to the improved maxillar-mandibular relationships which favor the production of alveolar phonemes.

Two patients got their articulation performance slightly worsen postoperatively. Both of them had no articulation errors pre-surgically but nasal emission errors developed after undergone the surgery. After surgery, one patient (subject 5) had nasal emission occurred during the production of plosive (/p/), six errors were made in total four months postoperatively. The other patient (subject 9) also had nasal emission occurred during the production of plosives (/p/, and /p^h/) four months after surgery, then no nasal emission was observed during the production of /p/ and /p^h/ one year postoperatively. However, nasal emission was found during the production of affricate (/ts/) and this problem persisted till two years after surgery. The nasal emission was consistent with the velopharyngeal functioning of this patient

after surgery. The nasendoscopy findings showed that the patient has worsened velopharyngeal closure (90% dropped to 75%) post-operatively, leading to the nasal emission found. Deterioration in articulation after osteotomy has been previously reported. The findings matched with the studies conducted by Ruscello et al. (1986). The deterioration could be the result of failing to adjust to the structural relationships between the oral structures.

One patient had no articulation error before surgery. However, a number of distortion errors (lateralization of fricative /s/ and affricate/ts, ts^h/) noted four months postoperatively. Twenty five lateralization errors were reported. All the errors resolved when reviewed one year after surgery. It was suggested that the patient could not adapt well to the new articulatory structures, therefore errors observed shortly after undergone the surgery. Upon adaptation to the new structural relationships, all the errors resolved automatically.

For the two patients underwent distraction, both of their number and type of errors persisted postoperatively. One patient (subject 23) showed lateralization of fricative /s/ before and after surgery. The number of errors increased from 18 preoperatively to 20 four months postoperatively. The other patient (subject 26) showed velopharyngeal friction during the production of fricatives /s, f/ before surgery. The type and the number of errors he made remained unchanged after

surgery.

The relapse data was not reported for patients undergoing distraction; this is due to the incomplete maxillary advancement during the time of articulation assessments. Relapse would happen only after the forward movement of maxilla is completed, therefore only those of osteotomy were reported, of which immediate advancement could be achieved. However, there was no significant relationship between the observed error patterns changed over time and the amount of relapse reported. This is consistent that no literature has reported the significant relapse that could affect articulation.

In this study, most patients have normal articulation pre- and post-surgically (20 out of 27). Among the limited number of patients (seven) who showed articulation errors, different error patterns were shown. This indicated that individuals react differently to the structural changes after surgery. No significant difference between the two surgeries (osteotomy and distraction) on the articulation performance was found post-operatively. However, since articulation consist only a small part of the whole project, cleft patients with maxillary hypoplasia wishes to have maxillary advancement may need to be aware of possible consequences of velopharyngeal incompetence brought by the two surgeries. This was reported by our team members in other literature.

Limitation and further research

The results of this study may have been affected by the relative small number of subjects and the pre-operative articulation performance of the subjects which most of them had no articulation errors. Cautions should be taken when interpreting the degree of the errors as only minority of patients had errors while majority were normal. Further research on comparison between the two surgery groups across time could include more subjects, both having normal and abnormal articulation pre-surgically. This helps to investigate possible (improvement or deterioration) change after surgery.

Conclusion and clinical implication

The results of this study showed no significant difference of articulation changes in patients undergoing traditional osteotomy versus distraction pre-surgically and post-surgically. This may be affected by the relative large number of patients having normal articulation in both groups pre-surgically. However, when consider between traditional osteotomy versus distraction osteogenesis, cleft patients with maxillary hypoplasia should take into account factors other than articulation which maybe affected after the maxillary advancement, they are the possible changes in velopharyngeal function and possible relapse that may occur.

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