－ Original Article －

The effects of timing of secondary alveolar bone graft on craniofacial morphology in patients with unilateral cleft lip and alveolus.

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片側性唇顎裂患者における二次的顎裂部骨移植の時期の違いが顎顔面形態に及ぼす影響について

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Key word：unilateral cleft lip and alveolus, early secondary bone grafting, late secondary bone grafting, cephalometrics

Abstract

Objective: The purpose of this study was to compare the effect of early and late bone grafts in patients with Cleft lip and alveolus only, consequently excluding the influence of palatal closure on craniofacial growth.

Subjects and Methods: The subjects were chosen from the records of the Orthodontic Clinic, Niigata University Medical and Dental Hospital. 30 patients with unilateral cleft lip and alveolus only (without cleft palate) were chosen and divided into 2 groups based on the following selection criteria: Early bone grafting (EBG) at a mean age of 8 years and 3 months. Late bone grafting (LBG) at a mean age of 13 years and 7 months. The majority had orthodontic treatment during the mixed dentition. Lateral cephalograms were traced, and then 22 angular and 27 linear measurements were analyzed.

Results: Mann-Whitney test showed that all angular measurements were not significantly different between the 8 and the 14 years old subjects in the EBG and LBG groups. The difference in the value of A'-PNS between 14 and 8 years showed a significant difference when the groups were compared.

Conclusion: The present study showed decrease in anteroposterior maxillary growth in the EBG group. A possible reason for our finding might be the inhibition of maxillary growth that caused bone grafting operation and the short evaluation period (around 1 year) in the LBG group, while it was longer for the EBG group. Grafted bone is possibly allowed to undergo resorption during remodeling or displacement of the new bone with longer time. As a result, the decrease in the maxillary anteroposterior length exhibited by the distance from A'- PNS was recognized in the EBG group.

抄録

目的：本研究の目的は片側性唇顎裂患者において二次的顎裂部骨移植の時期の違いが顎顔面形態に及ぼす影響を明らかにすることである。

対象：新潟大学医歯学病院矯正歯科診療室において管理されている片側性唇顎裂患者のうち，早期二次的顎裂部骨移植を施行した 17 名（骨移植施行平均年齢８歳３か月，以下早期群と略す），晩期二次的骨移植群骨移植を施行した 13 名（平均年齢 13 歳７か月，以下晩期群と略す）の計 30 名を対象とした。これらの８歳時ならびに 14 歳時の側面頭部 X 線規格写真をトレースし，22 項目の角度計測ならびに 27 項目の距離計測を行ない，両群の８歳時ならびに 14 歳時の値，および８歳時から 14 歳時の変化について両群間で比較した。

結果：８歳時ならびに 14 歳時両時期において，角度計測項目ならびに距離計測項目のすべての計測項目について両群間で有意差は認められなかった。しかしながら，８歳から 14 歳の変化量に関し距離計測項目のうち A'-PNS において，両群間で有意差を認めた。

結論：本研究では上顎骨の前後的な長さに関してその変化量に差を認めた。その理由として１．骨移植術施行時の外科的侵襲による成長抑制，２．晩期群では骨移植後移植骨の置換が完了せず，移植骨の吸収も少ない反面，早期群では骨移植後５年前後経過しており移植骨の置換がおこなわれ，A 点付近の骨吸収が生じること，から，上顎骨の前後的な長さに差が生じたと考えられた。

Introduction

Orofacial clefts are very complicated conditions, with huge psychosocial difficulties to the patients and their families. Interdisciplinary management by oral surgeons, orthodontists, peadodontists, general dentists and speech pathologists is required for these patients.

Because the treatment protocol differs among different centers, many researchers have been trying to assess the effects of the various steps of these different protocols. The subjects' craniofacial morphology is often characterized by a concave facial profile, which is believed to be caused by a lack of the intrinsic growth potential of the nasomaxillary complex and/or the influence of surgical intervention[1,2]. Moreover, the difference in craniofacial growth in cleft patients seems to depend on the extent of the clefting[3,4]. Closure of the cleft in infancy by primary bone grafting or periosteoplasty is generally considered to cause inhibition of subsequent maxillary growth [5,6,7,8].

Since Boyne and Sands [9,10] introduced a technique for bone grafting prior to the eruption of the canine, many hospitals have adopted this method. Ideally, secondary bone grafting should be performed at the early transitional dentition stage, after the eruption of the permanent incisors, but before the eruption of the permanent maxillary canines[9,11,12,13]. Specifically, bone grafting should be undergone before the eruption of the canine in the cleft region, when the root of the canine is one-fourth to two-thirds formed[14]. Bone grafting shouldn't be considered in isolation, but as a part of a more comprehensive orthodontic treatment, as it will allow a smooth eruption of the lateral incisor and/or canine and will guarantee a well aligned maxillary arch without restoring to bridgework. In addition, oronasal fistulae are closed, and the maxillary segment is stabilized[11,12]. At this point, the procedure is able to create an osseous environment that permits the spontaneous eruption or orthodontic adjustment of the canine tooth. The chances of obtaining a normal interdental septum in the former site of a cleft are considerably higher when the grafting is done prior to canine eruption[12]. On the other hand, bone graft placed after the eruption of permanent dentition has more chances of resorption[15].

As sagittal and transverse growth of the maxilla has largely finished by 8 to 9 years of age[12], the chances of interfering with maxillary growth are minimal after this age; however, vertical growth of the alveolus continues after that age. The beneficial effects of bone grafting before eruption of the canine is that, as the canine erupts, it induces deposition of bone on the alveolar crest and adds to the vertical height of the maxilla[14].

As for the effect of secondary alveolar bone grafting on craniofacial growth (especially maxillary growth), patients with complete unilateral cleft lip and palate (UCLP) have been investigated by many reports[16,17,18,19], and no influence from secondary alveolar bone grafting during mixed dentition have been reported.

However, Enemark et al[20]. have stated that secondary bone grafting has no effect on sagittal growth of the maxilla, whereas the anterior facial height was reduced. The overall conclusion of the study showed that better results would be achieved with secondary bone grating if it were performed before eruption of the canine.

Ross[21] in a comparative study of three centers stated that the vertical growth of the maxilla decreased due to secondary alveolar bone graft in the late mixed dentition. Brattstrom et al[7]. compared the treatment outcomes in 3 different centers, and concluded that regimens that included primary bone grafting to the alveolus had resulted in inhibited anterior maxillary growth, and those that included secondary bone grafting had yielded better maxillary development but had not been as good as regimens that omitted bone grafting altogether.

Objectives

Previous studies have investigated the lateral and frontal craniofacial morphology of patients with various orofacial clefts but very few, if ever, considered the craniofacial morphology in patients with cleft lip and alveolar process only, most probably due to the rarity of the condition. However, palatal closure has an unmistakable effect on the maxillary growth.

The aim of this study was to compare lateral craniofacial morphology in patients with unilateral cleft lip and alveolus (without cleft palate) who had undergone secondary bone graft at a mean age of 8 years and 3 months, and those patients who had undergone it at a mean age of 13 years and 7 months. Then, we investigated whether secondary alveolar bone grafting per se had any effect on the craniofacial morphology or not.

Subjects and Methods

Subjects:

The subjects were chosen from the records of the Orthodontic Clinic, Niigata University Medical and Dental Hospital. Thirty patients with complete unilateral cleft lip and alveolar process only (without cleft palate) were selected. All the subjects had alveolar bone grafts at one point.

The subjects were divided into the following two groups according to the age at which the bone graft was done:

1. Early bone grafting group (EBG) consisted of 17 patients, (7 females and 10 males): Secondary alveolar bone grafting at a mean age of 8 years, 3 months, range from 7 years and 5 months to 9 years and 7 months.
2. Late bone grafting group (LBG) comprised 13 patients (7 females and 6 males): the inclusion criteria for this group was secondary alveolar bone graft after 12 years old. Secondary alveolar bone grafting at a mean age of 13 years and 7 months, range from 12 years and 10 months to 13 years and 10 months.

We compared the two groups in terms of amount of overjet before the first phase orthodontic treatment, as well as types of that treatment, in order to exclude any major differences between the two groups, which could affect the results. We investigated the overjet on the non-affected side before the first phase orthodontic treatment, 1.41 2.78 mm, 1.55 2.24 mm of overjet were for the EBG and LBG groups respectively. Comparison between the two groups using the unpaired Student t-test showed no significant difference.

Both groups had almost the same first phase orthodontic treatment, which usually starts around 7-9 years old, and continues for approximately one year. (Table 1).

For each group, lateral cephalograms were chosen

Table 1. Distribution of first phase orthodontic treatment

Orthodontic treatment	EBG	LBG
Incisors alignment	9	6
Maxillary arch expansion	1	0
Maxillary arch expansion & Incisor Alignment	2	2
No orthodontic treatment	5	5

cases

as follows:

EBG: before the bone graft operation at a mean age of 8 years and 3 months (just a few days before the operation), ranging from 7 years and 5 months to 9 years and 7 months., and after the bone graft at a mean age of 14 years and 4 months, ranging from 13 years 10 months to 14 years 11 months.

LBG: before the bone graft operation at a mean age of 8 years and 4 months, ranging from 7 years and 10 months to 9 years and 5 months, and after the bone graft at a mean age of 14 years and 7 months, ranging from 14 years to 14 years and 11 months.

Methods

The lateral cephalograms were taken in the Department of Radiology, Niigata University Medical and Dental Hospital, with vertically adjustable holders. All the cephalograms were obtained from subjects in intercuspal position. The lateral cephalograms of all the subjects were traced and measured by hand on 0.003mm matte acetate paper (Yunipa, Kimoto, Tokyo, Japan) by the first author at the Division of Orthodontics, Niigata University Graduate School of Medical and Dental Sciences, Japan.

Measurements

Angular and linear measurements were shown in Figures 1and 2.

Data analysis:

Data were tabulated and analyzed using Macintosh software program StatView 4.5, applying Mann-Whitney test for comparison both groups before and after the bone graft, and to compare the differences in the angular and linear measurements between the early and the late bone graft groups. A p-value of less than 0.05 was considered to be significant.

Methodological errors:

6 cephalograms were chosen randomly, retraced and remeasured after one month. Then, the results were compared using paired Student's t-test. No significant error was recognized.

Results

The results of Mann-Whitney test comparing the means of the angular and linear measurements at 8 and 14 years of the EBG group and the LBG group showed no significant differences (Table 2, 3).

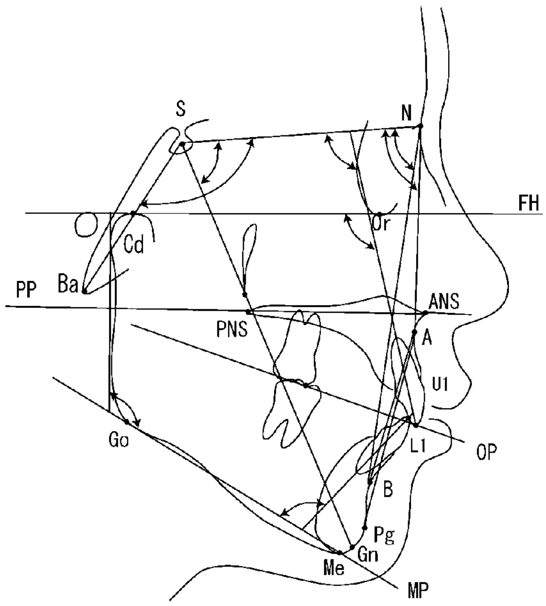

Figure1. Angular measurements

Figure1 Legend:

N: Nasio. S: Sella. Cd: Conylon. Ba: Basion. Go: Gonion. Me: Menton. Gn: Gnathion. Po: Pogonion. B: B point. L1: incisal edge of lower incisor. U1: incisal edge of upper incisor. A: A point.ANS: anterior nasal spine. PNS: posterior nasal spine. Or: orbital. FH: Frankfort plane. PP: palatal plane. OP: occlusal plane. MP: Mandibular plane.

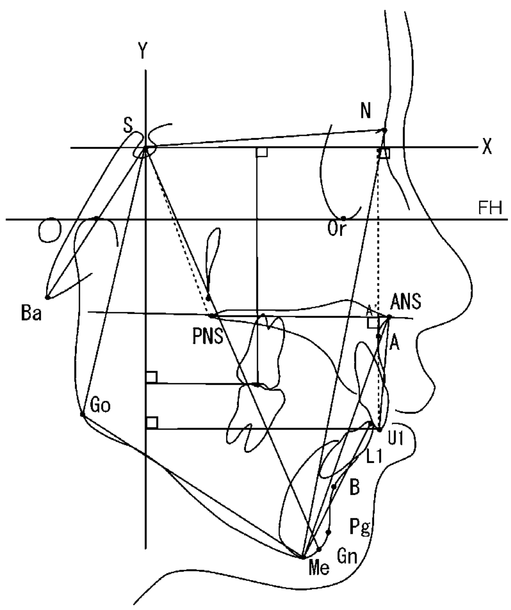

Figure2. Linear measurements

Figure2 legend:

N: Nasio. S: Sella. Ba: Basion. Go: Gonion. Me: Menton.

Gn: Gnathion. Po: Pogonion. B: B point. L1: incisal edge of lower incisor. U1: incisal edge of upper incisor.

A: A point. A': constructed by extending a perpendicular line from point A to the palatal plane. ANS: anterior nasal spine. PNS: posterior nasal spine. Or: orbital. Y: Y axis. X: X axis.

Table 2. Comparison of the mean of angular measurments between the early and late bone grafting groups.

Variables	8 years				p	14 years				p
	EBG		LBG			EBG		LBG		
	mean	SD	mean	SD		mean	SD	mean	SD	
SNA	83.0	5.9	83.5	2.6	NS	81.0	5.7	83.2	3.1	NS
SNB	76.6	3.3	75.9	2.8	NS	77.9	3.7	78.5	2.1	NS
ANB	3.7	3.6	4.7	3.0	NS	3.1	3.5	4.6	2.9	NS
NAPog	163.1	7.8	165.7	4.3	NS	173.6	8.0	172.8	5.7	NS
Y axis	63.7	3.0	64.6	2.2	NS	64.6	4.9	64.3	2.8	NS
NSGn	71.5	3.4	71.3	2.8	NS	72.4	4.8	71.1	3.5	NS
NSBa	131.5	4.3	132.8	3.6	NS	130.1	3.4	132.5	4.3	NS
GZN	90.2	3.9	90.5	4.3	NS	92.3	4.6	90.9	4.4	NS
Gonial	127.7	4.8	125.0	6.3	NS	125.8	4.8	122.8	8.1	NS
FH-SN	7.7	2.9	7.0	2.1	NS	7.6	2.8	6.8	2.1	NS
PP-SN	7.9	4.6	7.6	2.3	NS	7.3	2.9	8.5	2.5	NS
OP-SN	20.9	5.6	17.9	7.2	NS	16.9	4.9	15.5	6.9	NS
MP-SN	37.1	5.4	35.0	6.9	NS	37.3	5.4	33.7	6.9	NS
PP-FH	1.9	0.7	1.3	0.9	NS	2.7	1.8	2.5	1.5	NS
OP-FH	12.3	3.4	11.8	4.2	NS	9.3	4.9	9.0	5.0	NS
MP-FH	28.9	6.2	28.7	4.5	NS	29.7	4.4	26.9	5.5	NS
U1-FH affected side	99.0	8.9	104.0	8.4	NS	109.6	7.8	104.5	10.6	NS
U1-FH non-affected side	100.7	9.3	99.0	7.1	NS	111.6	6.9	109.5	10.5	NS
U1-SN affected side	90.6	8.8	94.3	6.7	NS	101.9	9.2	97.7	9.9	NS
U1-SN non-affected side	92.8	9.7	91.9	7.1	NS	105.3	6.5	100.4	9.4	NS
L1- MP	99.5	6.8	96.8	7.7	NS	98.5	8.8	96.9	6.6	NS
Inter incisal	130.9	11.0	135.9	11.6	NS	120.3	11.0	130.1	5.7	NS

SD: Standard Deviation *: $p<0.05$, NS: Not significant

Table 3. Comparison of the mean of linear measurments between the early and late bone grafting groups.

Variables	8 years				p	14 years				p
	EBG		LBG			EBG		LBG		
	mean	SD	mean	SD		mean	SD	mean	SD	
S-N	65.2	4.2	65.0	1.9	NS	70.4	5.2	69.6	2.8	NS
S-Ba	43.4	3.1	44.2	1.9	NS	49.4	4.3	50.7	5.2	NS
N-Ba	99.4	5.7	100.4	2.6	NS	109.6	6.8	110.3	3.5	NS
N-PP	48.4	4.3	48.0	3.3	NS	54.9	4.7	56.3	4.0	NS
S-PP	40.6	3.0	40.8	2.7	NS	47.1	3.4	46.8	3.3	NS
A'-PNS	48.0	4.4	47.8	2.1	NS	49.3	4.4	51.3	2.9	NS
S-PNS	44.4	2.6	44.8	2.5	NS	50.3	3.0	49.9	3.2	NS
S-Gn	112.8	4.9	113.3	4.1	NS	130.3	7.6	131.8	5.7	NS
N-Me	110.1	6.2	111.6	4.7	NS	128.1	9.2	127.0	6.2	NS
S-Go	69.1	5.2	72.4	5.5	NS	81.7	5.9	84.2	6.7	NS
Me-Go	60.1	4.7	61.0	4.0	NS	69.3	5.3	71.2	3.6	NS
U1-X affected side	64.4	6.4	66.7	5.7	NS	77.4	5.7	76.7	5.5	NS
U1-X non-affected side	67.0	5.6	69.3	4.1	NS	77.6	6.1	77.7	5.7	NS
U6 fossa-X	55.8	5.6	58.0	3.7	NS	70.3	5.6	70.2	4.9	NS
U1-Y affected side	66.4	8.1	66.0	4.2	NS	71.6	8.0	70.1	4.6	NS
U1-Y non-affected side	64.0	7.4	62.5	4.5	NS	72.5	9.2	70.2	5.4	NS
U6 fossa-Y	29.5	5.2	28.7	2.9	NS	38.0	6.5	36.9	4.3	NS
L1-Me	35.1	2.4	36.0	3.7	NS	41.8	3.8	43.9	2.4	NS
U1-ANS affected side	26.2	2.7	27.0	2.2	NS	31.9	2.7	31.1	2.0	NS
U1-ANS non-affected side	27.7	2.5	28.0	1.8	NS	31.0	2.5	30.5	2.3	NS
N-ANS	48.7	4.4	49.2	2.9	NS	54.4	4.6	65.3	4.1	NS
ANS-Me	65.7	3.8	66.0	3.4	NS	75.5	5.7	73.3	4.9	NS

SD: Standard deviation. *: $p<0.05$, NS: Not significant

Table 4. Comparison of the differences of angular measurments between the early and late bone grafting groups.

Variables	EBG		LBG		p-value
	mean	SD	mean	SD	
SNA	−2.0	2.1	−0.3	2.5	NS
SNB	1.3	1.9	2.6	1.4	NS
ANB	−3.3	3.2	−3.0	2.3	NS
NAPog	10.5	6.7	9.1	2.7	NS
NSBa	−1.4	2.7	−0.3	3.4	NS
Y axis	0.9	2.7	−0.3	1.2	NS
NSGn	0.9	3.0	−0.6	2.0	NS
GZN	2.1	3.4	0.5	2.6	NS
Gonial	−1.9	3.9	−2.1	3.3	NS
FH-SN	−0.1	1.3	−0.4	1.3	NS
MP-SN	1.0	4.8	−2.1	3.3	NS
PP-SN	−0.8	3.9	0.6	2.3	NS
OP-SN	−3.1	6.2	−4.9	4.2	NS
MP-FH	1.6	6.1	−1.7	2.1	NS
PP-FH	−0.2	1.6	1.0	2.3	NS
OP-FH	−2.0	2.5	−4.3	3.1	NS
U1-FH affected side	7.9	5.8	4.1	5.9	NS
U1-FH non-affected side	11.9	9.9	10.4	8.1	NS
U1-SN affected side	8.9	8.1	7.0	8.5	NS
U1-SN non-affected side	12.4	9.2	8.5	4.2	NS
L1- MP	−1.0	6.3	0.0	7.1	NS
Inter incisal	−10.6	8.6	−5.8	10.3	NS

SD: Standard Deviation *: $p<0.05$, NS: Not significant

Table 5. Comparison of the differences of linear measurments between the early and late bone grafting groups.

Variables	EBG		LBG		p-value
	mean	SD	mean	SD	
S-N	5.2	1.7	4.6	1.8	NS
S-Ba	6.0	2.4	6.5	5.2	NS
N-Ba	10.2	3.6	9.9	3.5	NS
N-PP	6.5	1.8	8.1	3.1	NS
S-PP	6.4	2.4	6.0	2.7	NS
A'-PNS	1.2	2.0	3.6	2.1	*
S-PNS	5.9	1.7	5.5	1.9	NS
S-Gn	17.5	5.2	18.5	3.9	NS
N-Me	17.1	5.4	15.4	3.4	NS
S-Go	12.6	3.6	11.8	6.1	NS
Me-Go	9.0	5.1	10.2	3.3	NS
U1-X affected side	13.0	4.4	10.0	6.6	NS
U1-X non-affected side	10.6	2.5	8.5	4.3	NS
U6 fossa-X	14.5	3.5	12.2	4.1	NS
U1-Y affected side	5.2	4.2	4.1	2.7	NS
U1-Y non-affected side	8.5	4.4	7.6	3.0	NS
U6 fossa-Y	8.5	2.7	8.2	2.2	NS
L1-Me	6.7	2.2	7.4	2.9	NS
U1-ANS affected side	5.7	2.5	4.1	2.2	NS
U1-ANS non-affected side	3.3	1.3	2.5	1.5	NS
N-ANS	5.7	2.6	7.3	2.8	NS
ANS-Me	9.9	4.1	9.0	2.6	NS

SD: Standard Deviation. *: $p<0.05$, NS: Not significant

While the outcomes of Mann-Whitney test comparing the mean differences of the angular measurements exhibited no significant difference (Table 4), those comparing the mean differences in the linear measurements showed a significant difference in the value of A'-PNS due to the decrease of A'-PNS value in the EBG group compared to the LBG group. (Table 5).

Discussion

Secondary bone grafting of the alveolar cleft during the period of mixed dentition in conjunction with the orthodontic treatment has become the standard care for patients with cleft lip and palate. Most cleft palate centers and craniofacial centers support the usage of secondary alveolar bone grafting because of the detrimental effects of primary alveolar grafting on growth[11,16] .

The available evidence on non cleft subjects would indicate that growth in width and length of the anterior maxilla has almost ceased by 8 years of age[22,23) , and should thus not be subject to interference by surgery performed after this age. Primary bone grafting also has a more severe impact on vertical growth than on sagittal growth of the maxilla [21] . It has been a consensus that reconstructive surgery of clefts can inhibit maxillary growth[1] . Semb [16] has stated that major controversies under discussion involve optimal timing of surgery and optimal technique for minimizing these disturbances in growth. When children with clefts are to be exposed to additional surgical procedure such as secondary bone grafting, the theoretical chances for its further interference with growth must be considered.

Abyholm et al.[11] stated that bone grafting generally might interfere with growth, and this kind of operations should be postponed until the greater part of the growth potential of the involved growth site was exhausted. If the aim of bone grafting is restricted to ensure permanent stabilization of the maxillary segment, the operation will be able to be delayed until maxillary growth has ceased. However, when the scope of objectives of the bone grafting is to be widened to include uneventful eruption of permanent lateral incisors and subsequent orthodontic closure of the gap and canines, bone grafting should be performed ahead of the approximate age of eruption of these teeth.

These conflicting interests call for a compromise. According to the current knowledge of growth patterns of anterior maxilla, the grafting of cancellous bone to the cleft area at the age of 7-8 years old is unlikely to interfere significantly with subsequent maxillary growth. This represents the lower age limit. On the other hand, the best results were obtained when bone grafting had been performed prior to the eruption of the canine on the cleft side, which has huge time range depending on sexual, ethnic and individual variations. However, in most cases the canines on the affected side erupt around 13-14 years old, which then is the upper age limit for bone grafting. The upper limit is not absolute, since good results were achieved in many patients subjected to bone grafting at an older age.

In addition to the downward and forward translation of the maxilla that characterizes midfacial growth, accretion of bone on the occlusal aspects of the alveolar process makes a substantial contribution to the increase in height of the upper face. It is therefore essential that grafted bone should be able to accommodate the eruption of teeth through the transplanted area and also participate in subsequent growth. Semb[16] has stated that the clinical experience indicates that the vertical development of the alveolus continues undisturbed following the insertion of a bone graft. This phenomenon was recognized in the present study as well.

Friede[24] has stated that vomero-premaxillary suture appears to play an important role in early postnatal growth of the midface in children with unilateral cleft lip and palate, but there does not seem to be information in the literature to indicate how long growth of this suture remains important in maxillary development. Although extreme care is usually taken to avoid the vomero-premaxillary suture during bone grafting, its varying position may make it vulnerable to accidental injury when flaps are raised.

Nevertheless, Semb [16] suggested that postponement of grafting until the ages of 8 or 9 years minimized any such risk. The present findings also indicate that no disturbance of the vertical development of the maxilla was observed.

Daskalogiannakis[17] concluded that mixed dentition bone grafting did no adverse effects on subsequent vertical and anteroposterior maxillary growth in complete unilateral cleft lip and palate patients during the first several years following the procedure. This previous findings was mostly consistent with the present results.

Levitt et al.[18] in their well matched study revealed the absence of any clear significant difference in craniofacial growth between the grafted and non grafted groups, nonetheless there was a decreased growth in ANS-FH when the presurgical and postsurgical slopes in the grafted group were compared. This would be suggestive of the potential for some vertical growth deficiencies following secondary alveolar bone grafting. However, even this small difference was not found in this study.

The final influence of secondary bone grafting on maxillary growth cannot be determined until growth has ceased. As our observation period was relatively short, these results must be considered as preliminary. The reason for such short observation period is that most patients started the second phase orthodontic treatment afterwards, which affects the measurements dramatically and deem them unreliable.

A very confounding variable in studies such as this is the possible influence of the orthodontic treatment that is often carried out at the same time as the study. Nonetheless, it is possible that the presence of a bone graft could influence the response of the anterior maxilla to orthodontic pressure and indirectly affects the skeletal landmarks used differently between the two groups.

Enemark et al.[20] compared mixed groups of cleft lip and alveolus only, unilateral cleft lip and palate, and bilateral clefts, and then stated that the maxillary growth demonstrated a significant growth in the early grafted group and contributed to the early commencement of orthodontic treatment. On the other hand, vertical growth of the maxilla was affected anteriorly in the two relatively early grafted groups, which might be resulting from the extensive mobilization of the palatal mucosa performed during surgery, which is done to enable the flaps to be sutured without tension and dehiscence. A reliable comparison with the results of this study is very hard to be done, due to the mixed nature of the subjects employed in Enemark et al.'s study.

A possible reason for our finding might be the short evaluation period (around 1 year) in the LBG group, while it was longer for the EBG group. Grafted bone is possibly allowed to undergo resorption during remodeling or displacement of the new bone with longer time. As a result, the decrease in the maxillary anteroposterior length exhibited by the distance from A'- PNS was recognized in the EBG group.

Ross[21] stated that an older group grafted at 11 to13 years had the same vertical deficiency seen in the group grafted in earlier age, and then concluded that it was possible to think that only if bone grafting was postponed until 15 years old or later the vertical growth affects would be avoided. However, nothing of this was noted in our results, mainly due to the differences in our samples.

Another controversial issue is the experiences and skills of the relating surgeon, which will eventually determine the amount of surgical intervention to the patient. This is, obviously, a very sensitive area and the judgment is totally subjective.

This study included 30 patients with cleft lip and alveolus, with very restricted inclusion criteria, representing an attempt to further clarify the pure effect of secondary alveolar bone grafting on maxillary basal skeletal growth and development without the confounding effect of palatal scaring resulting from closure.

The shortcomings of the few previous studies into this topic are typical of research in this area. Namely, the inability to control for sampling bias when using retrospective data, and to draw conclusions regarding maxillary growth exists. Although an ideal experimental design would involve the use of a randomized prospective clinical trial, such data do not exist in the cleft field at the time being. The possibility of it being available in the near future seems unlikely. The benefits of the secondary alveolar bone grafting are numerous and so readily apparent in clinical practice that withholding this treatment from randomly selected subjects was considered inappropriate and highly unethical.

As our results showed, there is slight decrease in the length of maxilla in EBG group. However, since both groups had more or less a protrusive profile (mean ANB for the EBG group was 6.4 and for the LBG group was 7.6 at 8 years old) even with the inhibition of anteroposterior maxillary growth arising from grafting, sever orthodontic problems did not arise. Nevertheless, there is no evidence that bone grafting alter to any clinically significant extent the individual's pattern of facial growth that has been established up to that point. It is encouraging that the huge benefits to be derived from secondary alveolar bone grafting possibly outweigh the long-term undesirable negative effects, if any.

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References

1) Slaughter, W.B., Pruzansky, S.: The rationale for velar closure as a primary procedure in the repair of cleft palate defects. Plast. Reconstr. Surg, 13: 341-57,1954.

2) Ross, R. The Clinical implications of facial growth in cleft lip and palate. Cleft Palate Cranio. J.,7: 37-47,1970.

3) Krogman, W.B., Meier, J., Canter, H., Ross, P., Mazaheri, M.: Mehta, S., Craniofacial serial dimensions related to age, sex, cleft type from six months of age to two years. Growth, 39: 195-208,1975.

4) Jain, R.B., Krogman, W.M.: Cleft type and sex differences in craniofacial growth in clefting from one month to ten years. Cleft Palate J, 20: 238-45, 1981.

5) Friede H, Johanson B.: A follow-up study of cleft children treated with primary bone grafting. 1. Orthodontic aspects. Scand J Plats Reconstruct Surg, 8: 88-103,1981.

6) Witsenburg, B.: The reconstruction of anterior residual bone defects in patients with cleft lip, alveolus and palate. A review. J. Maxillofac. Surg, 13: 197-208,1985.

7) Brattstrom, V., McWilliam, J., Larson, O., Semb, G.: Craniofacial development in children with clefts of the lip, alveolus, and palate treated according to four different regimes. I. Maxillary development. Scan. J. Plast. Reconstr. Surg, 25: 259-67. 1991.

8) Molsted, K., Dahl, E., Skovgaard, L.T., Asher-McDade, C., Brattstrom, V., McCance, A., Prahl-Andersen, B., Semb, G., Shaw, G.: A multicentre comparison of treatment regimens for unilateral cleft lip and palate using a multiple regression model. Scand. J. Plast. Reconstr. Surg. Hand Surg. 27: 277-84,1993.

9) Boyne, P.J., Sands, N.R.: Secondary bone grafting of residual alveolar and palatal clefts. J.Oral Surg.,30:87-92,1972.

10) Boyne, P, Sands N. Combined orthodontic-surgical management of residual palate-alveolar cleft defects. Am.J.Orthod, 70: 20-37,1976.

11) Abyholm, F.G., Bergland, O., Semb, G.: Secondary bone grafting of alveolar. Scan. J.Plast. Reconstr. Surg., 15: 127-40,1981.

12) Bergland, O., Semb, G., and Abyholm, F.: Elimination of residual alveolar clefts by secondary bone grafting and subsequent orthodontic treatment. Cleft Palate J. 23:175-205,1986.

13) Bergland, O., Semb, G., Borchgrevinck, H.: Esland, G. Secondary bones grafting and orthodontic treatment in patients with bilateral complete clefts of lip and palate. Ann. Plast. Surg.1986; 17: 460-74.

14) Kortebein, M. J., Nelson, C., and Sadove, A. M. : Retrospective analysis of 135 secondary alveolar cleft grafts using iliac or calvarial bone. J. Oral Maxillofac. Surg. 49: 493-498, 1991.

15) Dempf R, Textron T, Kramer FJ, Hausa man JE. : Alveolar bone grafting in patients with complete clefts: a comparative study between secondary and tertiary bone grafting. Cleft Palate Crania J. 39: 18-25,2002.

16) Serb, G.: Effect of alveolar bone grafting on maxillary growth in unilateral cleft lip and palate patients. Cleft palate J. 25: 288-95, 1998.

17) Daskalogiannakis, J., Ross, R.B. Effect of alveolar bone grafting in the mixed dentition on maxillary growth in complete. unilateral cleft lip and palate patients. Cleft Palate-Craniofacial J. 34: 455-58,1997.

18) Levitt, T., Ross, E.L. JR., Trotman, C.: Maxillary Growth in Patients with clefts following Secondary alveolar Bone Grafting. Cleft Palate-Craniofacial J. 36: 398-406,1999.

19) Chang, H.P., Chuang, M.C., Yang, Y.H., Liu, P.H., Chang, C.H., Cheng, C.F., Lai, J.P.: Maxillofacial growth in children with unilateral cleft lip and

palate following secondary alveolar bone grafting: An Interim Evaluation. Plast. Reconstructive surgery. 115: 687-95,2005.

20) Enermark, H., Sindet-Pedersen, S., Bundgaard M., Long term results after secondary bone grafting of alveolar clefts. J Oral. Maxillofac. Surg. 45: 913-18,1987.

21) Ross, R.B. : Treatment variables affecting facial growth in complete unilateral cleft lip and palate. Part 3: Alveolus repair and bone grafting. Cleft Palate J. 24: 33-44,1987.

22) Björk A, Skieller V. : Growth in width of the maxilla studied by the implant method. Scand J Plast Reconstr Surg. 8: 26-33,1974.

23) Björk A, Skieller V. : Growth of the maxilla in three dimensions as revealed radiographically by the implant method. Br J Orthod. 4:53-56,1977.

24) Friede H.: The vomero-premaxillary suture--a neglected growth site in mid-facial development of unilateral cleft lip and palate patients. Cleft Palate J. 15: 398-404,1978.