

A retrospective comparison of frontal facial dimensions in alveolar-bone-grafted and nongrafted unilateral cleft lip and palate patients

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Patients with repaired CUCLP tend to have persistent facial asymmetries and nasal deformities.¹⁻⁷ Studies comparing craniofacial widths among people with different cleft types⁸⁻⁹ have demonstrated increased interorbital width in isolated cleft palate patients compared with noncleft controls and increases in nasal, intermaxillary, and intergonial widths in bilateral cleft lip and palate patients. Moreover, maxillary alveolar widths in unoperated cleft lip and palate patients tends to be larger than in operated cleft subjects.³ This latter finding provides evidence that habilitative surgeries may serve to

restrict the normal transverse growth of the maxilla.

The technique of alveolar bone grafting has been shown to provide excellent bony support for both the alar base and the erupting dentition near the cleft site.¹⁰⁻¹¹ However, only one study⁷ has evaluated the effect of this surgical technique on facial symmetry. In this study on maxillary symmetry, the effect of three specific treatment protocols were evaluated in 72 consecutively treated children. Two of the protocols employed secondary alveolar bone grafting and the other employed primary alveolar bone grafting. In ad-

Abstract

This retrospective study was undertaken to describe and compare frontal craniofacial dimensions in alveolar-bone-grafted and nongrafted complete unilateral cleft lip and palate (CUCLP) patients and in noncleft subjects with normal occlusions and good facial balance. Clinical data were obtained from the files of the Hospital for Sick Children, Toronto. Patients were eligible for inclusion if they had posteroanterior cephalograms (PA) taken at adulthood and no congenital anomalies other than CUCLP. A total of 86 adult Caucasian CULCP patients were studied, including 58 who had not received grafts, 28 who had received secondary alveolar bone grafts, and, for comparison, 60 noncleft Caucasian adults. The PA cephalometric radiographs were traced, digitized, and measured. Analysis of variance (ANOVA) was used to test for among-groups differences in the means of the ratios, proportions, and angular measures. Tukey-Kramer HSD procedure was used to conduct post-hoc pairwise comparisons following significant ($p \leq 0.05$) F-ratios from ANOVA. Sexual dimorphism was a common finding, with males demonstrating greater facial width. Despite primary surgical repairs, the anterior nasal spine in the nongrafted CUCLP patients was deviated to the noncleft side, and the alar base was depressed on the cleft side. The maxillary incisors close to the cleft site were irregularly inclined, and this irregularity was more severe in the nongrafted CUCLP patients. The long-term effects of secondary alveolar bone grafting on transverse craniofacial growth appears to be minimal and limited to the immediate area of the cleft.

Key Words

Frontal • Cephalometric • Gender • Cleft palate • Alveolar bone grafting

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Table 1
Age distribution in the nongrafted, grafted, and noncleft groups

Group	Cleft				Noncleft	
	Nongrafted N=58		Grafted N=28		N=60	
	Male (N=33)	Female (N=25)	Male (N=15)	Female (N=13)	Male (N=30)	Female (N=30)
Mean	17.8	17.9	18.3	16.9	29.9	23.7
SD	1.8	1.4	2.4	1.7	9.1	3.0

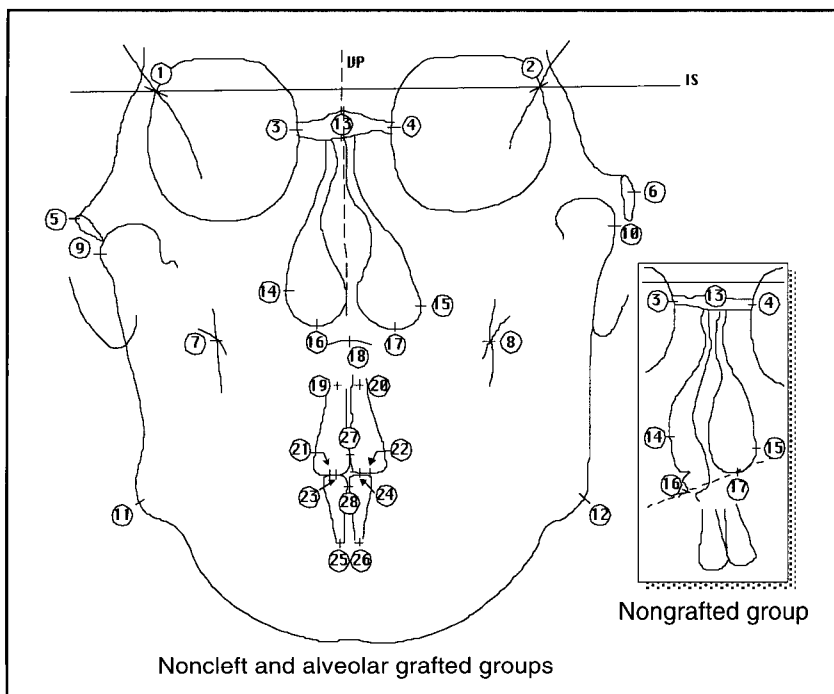


Figure 1

Figure 1

P-A cephalometric planes and landmarks. IS—line joining points 1 & 2; VP—line perpendicular to IS and through point 13; 1, 2—intersection of right and left orbital margins with greater wing of sphenoid; 3, 4—right and left most convex points on the orbits measured parallel to VP; 5, 6—right and left lateral-most points on the zygomatic process of the temporal bone measured parallel to VP; 7, 8—right and left intersection of maxillary alveolar process with the extension of the zygomatic arch; 9, 10—right and left lateral-most points on the mandibular condyles measured parallel to VP; 11, 12—right and left most convex points on the angle of the mandible; 13—midpoint of right and left orbits measured midway between points 3 and 4, and parallel to IS; 14, 15—right and left lateral-most points on the lateral alar curvature measured parallel to VP; 16, 17—right and left inferior-most points on the alar base measured parallel to IS in the grafted and noncleft groups, 16—the most inferior point on the cleft alar rim measured parallel to IS in nongrafted group; 18—anterior nasal spine; 19, 20—right and left apices of maxillary central incisors; 21, 22—right and left midpoints of maxillary central incisor crowns; 23, 24—right and left midpoints of mandibular central incisor crowns; 25, 26—right and left apices of mandibular central incisors; 27—midpoint of maxillary central incisors; 28—midpoint of mandibular central incisors.

dition to among-groups differences in symmetry of the nasal septum, the main findings were that the group with primary alveolar grafting had decreased palatal width and more symmetrical dentoalveolar development. Although this study attempted to evaluate specific treatment effects on frontal craniofacial symmetry, it is clear that further craniofacial growth could alter these initial conditions. For example, subsequent craniofacial growth could lead to an exacerbation of the minor facial asymmetries that were evident at a young age. The purpose of the present study was to test for differences in craniofacial width and symmetry at adulthood among grafted and nongrafted CUCLP patients and noncleft controls.

Materials and methods

The CUCLP data were obtained from the files of the Hospital for Sick Children, Toronto, Ontario, Canada. The inclusion criteria for the cleft sample were cephalometric records at late adolescence or early adulthood (15 years or older for females and 16 years or older for males) and no congenital anomalies other than CUCLP. Based on these criteria, a total of 86 CUCLP patients were included in the study: 28 (13 female, 15 male) who had received secondary alveolar bone grafting, and 58 (25 female, 33 male) who did not have bone grafts (Table 1). Although inclusion was independent of race, all the patients were Caucasian.

To determine the extent of facial asymmetry in the cleft patients, posteroanterior (PA) cephalograms from a group of noncleft Caucasians (30 male and 30 female) were analyzed for comparison. These subjects were from McNamara's sample^{12,13} of untreated subjects of European American ancestry who were judged to have normal occlusions. McNamara obtained a normal occlusion sample by clinical examination, from which a subsample was selected for facial balance. On the basis of an untraced lateral headfilm, three orthodontists unanimously agreed that each of the subjects had a well-balanced face. The subjects also had no history of orthodontic treatment, facial or orthognathic surgery, or extensive restorative dentistry. Detailed descriptions of the hard and soft tissue measures as viewed in the lateral headfilm are provided by McNamara and Ellis¹² and McNamara, Brust, and Riolo.¹³

From the final sample of subjects with normal occlusions and well-balanced faces, 30 male and 30 female subjects were randomly selected for use in the current investigation. In all, six groups

were assembled: CUCLP nongrafted males, CUCLP nongrafted females, CUCLP grafted males, CUCLP grafted females, noncleft males, and noncleft females.

For nongrafted CUCLP patients, all surgeries had been completed by a single surgeon according to a fixed protocol: lip repair with the LeMesurier procedure at 3 to 6 months, and hard and soft palate repair using the pushback procedure at 18 months. Surgeries for the grafted CUCLP patients were also performed by a single surgeon who used a protocol similar to that employed for the nongrafted patients; however, these patients also received secondary alveolar bone grafting. Secondary alveolar bone grafting is a standard procedure that involves grafting the alveolar cleft when the root of the tooth adjacent to the cleft site, generally the canine, is approximately two-thirds formed or prior to its eruption into the maxillary arch. All patients in both the grafted and nongrafted groups had similar orthodontic treatment in the mixed and permanent dentition.

The PA cephalometric radiographs were traced and selected hard tissue landmarks were digitized (Figure 1). In all instances, the radiographs were turned prior to digitization so that the cleft was on the right side of the tracing. Because all the cleft patients were treated at a single center, all cephalograms were obtained from a single cephalostat. The cephalograms for the noncleft patients were also obtained from a single, albeit different, machine. Thus, to correct for possible systematic magnification differences between the cleft and noncleft groups and to control for variations in head inclination among films, ratios of right and left horizontal and right and left vertical linear measures were used to evaluate symmetry in the various groups (Tables 2). Intra-examiner reliability scores were generated by separate replications of the tracings and digitization for 15 randomly selected cephalograms. The error of the method was determined according to Dahlberg's formula $\Sigma d^2/2N$,¹⁴ where d is the difference between the two digitizations and $N = 15$.

Statistical analysis

Standard descriptive statistics (means and standard deviations) were calculated for the cephalometric measures in each of the six groups of subjects. Two-way ANOVA with gender (male and female), treatment (no treatment and noncleft, grafting and cleft, no grafting and cleft), and gender by treatment interaction factors was used to test for among-groups differences in the means of the various measures. The Tukey-

Table 2
Cephalometric measures

Dimension	Characteristic
Tansverse linear (mm)	
3 to 4	Orbital
5 to 6	Zygomatic
7 to 8	Maxillary
9 to 10	Lateral condylar
11 to 12	Gonial
14 to 15	Lateral nasal
16 to 17	Apical nasal
Vertical ratio (measured perpendicular to IS, a plane through points 1 and 2)	
5-IS/6-IS	Zygomatic height
7-IS/8-IS	Maxillary height
9-IS/10-IS	Lateral condylar height
11-IS/12-IS	Gonial height
14-IS/15-IS	Lateral nasal height
16-IS/17-IS	Apical nasal height
Horizontal ratio (measured perpendicular to VP, a plane perpendicular to IS and through point 13)	
3-VP/4-VP	Mesial orbital width
5-VP/6-VP	Zygomatic width
7-VP/8-VP	Maxillary width
9-VP/10-VP	Lateral condylar width
11-VP/12-VP	Gonial angle width
14-VP/15-VP	Lateral nasal width
16-VP/17-VP	Apical width
Angular (°) (measured on the cleft side with respect to IS)	
19-21 to IS	Cleft-side incisor
20-22 to IS	Noncleft-side incisor
13-18 to IS	Anterior nasal spine
16-17 to IS	Nasal base

Kramer HSD procedure was used to conduct post-hoc pairwise comparisons following ($p \leq 0.05$) significant F-ratios from ANOVA.

Results

Table 3 summarizes means and standard deviations for the linear measurements of width, symmetry ratios, and angles. Table 4 summarizes the significant ANOVA pairwise comparisons for symmetry ratios and angular measurements. For the linear width measurements, because of possible systematic differences in cephalometric magnification between the cleft and noncleft groups, only grafted versus nongrafted comparisons that were not affected by magnification differences are reported. The cephalometric tracing and digitization error ranged from 0.27 mm to 1.83 mm for the width measurements and 0.74° to 2.17° for the angular measurements.

Linear measurements (Table 4)

In terms of facial width, there were no significant differences between the grafted and

Table 3
Means and standard deviations for group measurements

Variable	Nongrafted				Grafted				Noncleft			
	Female		Male		Female		Male		Female		Male	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Transverse linear (mm)												
Orbital	26.93	2.56	27.27	2.59	25.78	2.37	27.62	2.45	24.96	2.60	27.80	3.04
Zygomatic	129.60	4.08	135.93	5.44	130.26	4.93	135.82	3.82	130.42	5.03	141.86	4.80
Maxillary	63.04	3.97	64.51	3.53	61.87	3.50	65.57	3.77	61.91	2.97	66.34	3.42
Condylar	117.30	5.34	122.84	5.49	116.32	4.41	120.04	7.52	118.17	4.40	127.98	5.46
Gonial	98.60	5.61	102.26	5.67	97.18	5.74	102.49	4.90	96.59	5.48	106.11	6.86
Lateral nasal	29.53	3.55	29.38	3.56	29.41	2.40	29.55	4.36	28.89	2.79	30.89	2.89
Apical nasal	14.28	3.64	14.96	3.38	15.65	2.80	15.25	5.05	14.93	3.49	13.93	4.21
Vertical ratio (symmetry)												
Zygomatic	1.03	0.25	0.99	0.09	1.04	0.09	1.05	0.11	0.95	0.11	0.99	0.12
Maxillary	1.00	0.04	0.99	0.04	0.99	0.04	0.99	0.03	1.00	0.04	1.00	0.05
Condylar	0.96	0.10	0.99	0.09	1.01	0.09	1.01	0.11	1.00	0.08	1.01	0.08
Gonial	1.01	0.05	1.00	0.03	0.99	0.04	1.00	0.05	0.99	0.04	1.01	0.03
Lateral nasal	1.01	0.08	1.03	0.10	1.04	0.10	1.03	0.13	1.00	0.05	0.98	0.08
Apical nasal	1.02	0.05	1.04	0.07	1.07	0.07	1.03	0.05	1.00	0.02	1.00	0.01
Transverse ratio (symmetry)												
Orbital	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Zygomatic	0.99	0.04	1.01	0.05	0.99	0.05	0.99	0.06	1.02	0.04	1.02	0.05
Maxillary	0.99	0.10	1.02	0.12	1.02	0.14	0.97	0.12	1.01	0.09	1.01	0.11
Condylar	0.99	0.06	1.02	0.07	1.01	0.05	0.99	0.14	1.03	0.07	1.03	0.07
Gonial	1.00	0.10	1.04	0.10	1.04	0.16	1.01	0.18	1.02	0.11	1.02	0.13
Lateral nasal	1.07	0.22	1.09	0.23	1.01	0.21	1.05	0.23	1.05	0.18	0.97	0.17
Angular (°)												
Cleft incisor	78.46	6.44	82.56	6.17	82.75	8.08	85.10	6.65	87.91	1.92	88.65	3.08
Noncleft incisor	86.79	6.50	91.51	6.73	89.26	5.47	88.39	5.39	90.58	2.63	91.73	3.19
Ant. nasal spine	92.25	2.89	91.27	2.71	91.73	2.56	92.01	3.44	89.73	1.70	90.10	2.03
Nasal base	3.46	11.46	7.69	14.39	14.35	13.95	9.76	17.33	0.12	4.24	0.74	3.47

nongrafted cleft groups. Interorbital, interzygomatic, intermaxillary, intercondylar, and intergonial widths were all significantly greater in males than in females, by 1.67 mm, 7.77 mm, 3.20 mm, 6.35 mm, and 6.16 mm, respectively.

Ratios

For the various ratios, values approaching unity imply cleft side/noncleft side symmetry within a treatment group. There were no significant differences between the grafted and nongrafted groups in any of the transverse ratios. With regard to the vertical ratios, the right/left apical nasal height ratio was less symmetrical in both cleft groups than in the noncleft group, thereby indicating a relatively depressed alar base on the cleft side in both nongrafted and grafted patients.

Angles

For the anterior nasal spine angle, perfect symmetry is implied by a value of 90° (Figure 1) for

the anterior nasal spine relative to a line, IS, joining the intersection of the right and left orbital margins with the lesser wing of sphenoid (line joining points 13 to 18, see Table 2). In the cleft patients, this angle was measured on the cleft side, and it generally exceeded 90°, indicating a significant tilt of the anterior nasal spine toward the noncleft side. Thus, there was a significant difference in comparison with the noncleft control; however, there was no significant difference between the grafted and nongrafted groups. The slope of the nasal floor (line joining points 15 to 16, see Table 2) was indicated by the nasal base angle. This angle was also measured on the cleft side and was taken relative to line IS. The nasal base angle was greater in the grafted cleft group compared with the noncleft group, with the nasal base more inferior on the cleft side. Although this angle was significantly greater in the grafted than the nongrafted cleft group, the difference is probably of little significance because the

nongrafted patients had no alveolar bone grafting and, therefore, little or no bone in the apical nasal and cleft region. Finally, the mean values for the cleft and noncleft maxillary incisal angles (lines joining points 19 to 21 and 20 to 22, respectively, measured on the cleft side relative to line IS, see Table 2) were always less than 90°. The maxillary central incisors tended to be angled toward the cleft side (Table 3). The maxillary incisor angle on the cleft side showed a significant difference between males and females (Table 4), with incisors more upright in males. Grafted cleft patients had a more upright maxillary central incisor on the cleft side than did the nongrafted patients.

Discussion

Constriction related to surgical repair of the lip and palate would be expected to have a more profound effect on the maxilla. In this study, there was no difference in maxillary width among cleft groups. This finding is not surprising, given that maxillary arch expansion would be one of the orthodontic treatment objectives that would tend to make arch width dimensions similar in both cleft groups. Molsted and co-workers⁷ measured maxillary casts and found a constriction of the palate in primary alveolar bone grafted children compared with children who had secondary bone grafts; however, these patients had received no orthodontic treatment at the time measurements were made. In our study, measurements of maxillary alveolar casts were not available to supplement the cephalometric data; however, the available evidence from this and previous studies supports a maxillary arch constriction in patients who have received bone grafts prior to orthodontic treatment.

Normally, anterior nasal spine is positioned in the midline of the face, approximately perpendicular to the intersphenoidal plane, and this was the finding in the noncleft group. However, in repaired unilateral cleft lip and palate patients, the superior region of the nasal septum typically deviates toward the cleft side then curves back toward the noncleft side, with the anterior nasal spine most often located on the noncleft side of the facial midline.^{4,15} In our study, there was a deviation of the anterior nasal spine toward the noncleft side; however, there was no difference between the grafted and nongrafted groups. In a recent cross-sectional study of the nasomaxillary complex in cleft lip and palate patients, Kyrkandies et al.⁶ found a similar anterior nasal spine deviation that peaks during the

Table 4
Significant ($p \leq 0.05$) pairwise ANOVA group comparisons for the ratio and angular measurements

Group Contrast	Apical nasal height ratio	Nasal base angle	Measure		
			Anterior nasal spine angle	Cleft incisor angle	Noncleft incisor angle
Male vs female	ns	ns	ns	2.40	ns
Noncleft vs grafted	-0.05	-11.62	-1.99	4.35	ns
Noncleft vs nongrafted	-0.03	-5.14	-1.84	7.77	ns
Grafted vs nongrafted	ns	6.48	ns	3.42	ns

ns = nonsignificant

pubertal growth spurt. The finding of a depressed alar base in both the grafted and nongrafted CUCLP groups is in keeping with the absence of alveolar bony support of the alar base region at birth. In spite of bone grafting, the alar base region never attains a morphology similar to that of noncleft individuals.

As expected, the maxillary central incisor adjacent to the cleft site in CUCLP patients demonstrated marked irregularity, with the long axis of this tooth inclined toward the cleft region. The inclination of the cleft-side maxillary central incisor was less pronounced in grafted patients, thereby providing support for the use of secondary alveolar bone grafting because this technique allows orthodontic alignment of the incisor roots and a more normal esthetic dental result. Finally, the absence of associated mandibular asymmetries suggests that the mandible is unaffected by the asymmetries present in the maxilla.

Summary

Based on posterior-anterior cephalometric radiographs, the long-term effects on craniofacial growth of alveolar bone grafting appears to be minimal and limited to the immediate area of the cleft.

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