Gingivosupraperiosteoplasty following Presurgical Maxillary Orthopedics Is Associated with Normal Midface Growth in Complete Unilateral and Bilateral Cleft Patients at Mixed Dentition

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Background: Passive orthodontic appliances and gingivosupraperiosteoplasty are adjuncts that can be used by surgeons at the time of primary cleft lip repair. These treatments, along with the surgical technique of cleft lip and palate repair, may impact midface growth. The objective of this study was to describe the authors' protocol for unilateral and bilateral cleft lip repair and to evaluate midfacial growth in a cohort of patients at mixed dentition who had undergone presurgical passive orthodontic appliance therapy and gingivosupraperiosteoplasty at the time of unilateral and bilateral cleft lip repair.

Methods: Fifteen complete unilateral and 15 complete bilateral cleft lip and palate patients underwent passive orthodontic appliance treatment and primary lip repair with gingivosupraperiosteoplasty. Lateral cephalograms were analyzed by three blinded reviewers. Mean cephalometric measurements at mixed dentition were compared to cephalometric values for noncleft patients, unilateral cleft lip and palate patients who did not undergo gingivoperiosteoplasty or presurgical treatment, and unilateral cleft lip and palate patients who underwent gingivoperiosteoplasty/nasoalveolar molding with independent samples *t* tests.

Results: Mean cephalometric values were within age-specific normal values for sella-nasion–A point, sella-nasion–B point, A point–nasion–B point, and facial axis. Eighty-seven (13/15) percent of unilateral cleft lip and palate patients and 93 percent (14/15) of bilateral cleft lip and palate patients did not exhibit skeletal class III malocclusion. There was no significant difference between cephalometric values for our patients and patients who did not receive gingivosupraperiosteoplasty or presurgical treatment or who underwent the gingivoperiosteoplasty/nasoalveolar molding protocol.

Conclusions: Presurgical passive orthodontic appliances, combined with gingivosupraperiosteoplasty at the time of lip repair, leads to normal maxillary development in most patients at mixed dentition. Assessment of midface growth at skeletal maturity is required. (*Plast. Reconstr. Surg.* 148: 1335, 2021.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

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THERAPEUTIC

Presurgical treatments to align the alveolar segments before definitive cleft lip repair have been used in various formats for centuries. The Millard-Latham technique for aligning the maxillary segments became popular in the 1960s and involved the use of an active presurgical orthopedic device for a rapid closure of the alveolar segments.[1] Criticism of this and other active techniques includes that it results in significant restriction of maxillary

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growth.[2] Following these active methods, passive presurgical orthopedics became increasingly common and were popularized by Pfeifer et al. with the introduction of nasoalveolar molding.[3] Numerous variations of this technique are now widely used in cleft lip repair.[4] Although controversy exists regarding the impact of passive orthopedic devices on midface growth, some groups have shown normal maxillary growth with protocols using these techniques for unilateral cleft lip and palate patients.[5]

Gingivoperiosteoplasty is a controversial technique used by some surgeons that was developed to achieve bony union across the cleft at the time of primary lip repair.[6] The objective of this technique was originally to elevate flaps in the subperiosteal or supraperiosteal plane and close the alveolar defect to generate adequate bone stock in this area for dental eruption, with the possibility of avoiding secondary bone grafting. However, the use of a gingivoperiosteal flap to close this alveolar segment has the potential to disrupt growth, although debate exists about the cause of facial growth disturbance, which some attribute to the degree of undermining or the involvement of active presurgical orthopedic devices.[6,7]

For the past 18 years, our institution has used alveolar molding (passive orthopedic appliances) with progressive changes of maxillary obturating appliances.[8] This technique allows the operator to align the occlusal plane of the segments and narrow the alveolar gap to approximately 2 to 3 mm without collapsing the maxillary segments in the anteroposterior direction.[9] This technique allows closure of the alveolus and anterior palate at the time of primary lip repair. In addition, correction of the slumped alar cartilage is obtained with an attachment to the maxillary plate that gradually elevates the slumped cartilage similar to that described by Grayson and Shetye.[4] This protocol has been used in over 180 patients with complete unilateral and bilateral cleft lips and palates at our institution. The purpose of this article is to present our technique, which differs from Cutting and Grayson's in a number of respects.[10–12] We also present our preliminary treatment results in an ongoing study of facial development in complete unilateral and bilateral cleft lip and palate patients who underwent passive orthodontic appliance and cleft lip closure with gingivosupraperiosteoplasty, a modified version of gingivoperiosteoplasty.

PATIENTS AND METHODS

Patient Recruitment

Fifteen consecutive complete unilateral cleft lip and palate and 15 consecutive complete bilateral cleft lip and palate patients were recruited. All presurgical molding was performed by a single individual, and all surgical treatments were performed by the senior author (S.A.W.).

Presurgical and Surgical Treatment

All patients underwent passive orthodontic appliance treatment. Presurgical orthopedic treatment was initiated between 1 and 3 weeks after birth. The duration of the treatment was 20 weeks, using passive orthodontic appliances. The nasal component was incorporated after 4 weeks of treatment. Primary lip repair with gingivosupraperiosteoplasty was performed by a single surgeon. [**See Video (online)**, which shows a model describing the surgical technique for gingivosupraperiosteoplasty.] The gingivoperiosteoplasty technique described by Millard was used for all gingivosupraperiosteoplasty procedures, with the modification of a primarily supraperiosteal dissection to avoid damage to the underlying tooth roots, with the dissection converting to subperiosteal away from the tooth roots.[13] Unilateral cleft lip and palate patients underwent rotation advancement repair at approximately 6 months. Bilateral cleft lip and palate patients underwent staged repair with a similar technique at approximately 6 and 9 months of age.

Presurgical Orthopedic Treatment Protocol

The primary objective of our passive orthodontic appliance presurgical treatment protocol is to reduce the severity of the cleft deformity. Other objectives include the following: (1) orienting the segments close enough together to allow for repair of the alveolus with minimal undermining; (2) leveling the segments into the correct occlusal plane, achieving symmetry of the nasal septum and lower lateral cartilage on the affected side; and (3) placing the lip components into a well-balanced, symmetric relationship.

Passive orthodontic appliance treatment should ideally begin within the first 2 weeks of life. This will allow for better jaw movements in the newborn period. Three appliances are made during the treatment. Treatment can begin with pressure points and stretching and separation of the lip muscles, depending on what is required.

Treatment should proceed with a clear idea of what the arch form should be, to avoid a small, collapsed maxilla. In cases in which a segment has to be expanded, the pressure point should be put on the palatal segment to move it, thereby creating free space in the vestibule into which the segment can be moved. In cases in which the greater segment is canted and the occlusal plane must be leveled, a long flange can be made that covers the segment from above and creates a space below, so that the segment can descend. In the case of a wide cleft, it is possible to first reduce it transversely without touching the anterior part. If possible, the segments are closely approximated, but not at the expense of the interarch relationships. Several millimeters of space are left to allow the surgeon room to operate. A 2- to 3-mm gap is recommended; if the segments are in contact, flap closure is difficult. Caution should be taken to avoid overretracting the maxillary alveolar segments, thus creating a class III relationship. This will create a poor prognosis for future facial development.

In unilateral cleft lip and palate patients, the greater segment is generally displaced laterally, and forms the opposite side of the cleft (Fig. 1). The lesser segment is generally further posterior. Before fabricating the device, the cleft space and the anterior and lateral parts should be filled with wax as indicated by the treatment plan. Filling these spaces with wax helps direct the segments into the desired position, taking into consideration the three-dimensional aspects of the maxilla. No retention is placed into the cleft to allow normal physiologic development. For example, if the lesser segment in a unilateral cleft is retruded, the space in front of it should be filled with wax, leaving an empty space so that the lesser segment can grow into the desired position. Several factors should be taken into consideration before fabricating the device, such as what the maxilla will look like when it is in complete physiologic position, and whether any descent of the occlusal plane will be required (Fig. 2).

The passive orthodontic appliance device is made of firm acrylic, initially without the nasal component, and with soft borders, to protect the sensitive oral tissues of the newborn (Fig. 3). The nasal component is added to the passive orthodontic appliance 4 weeks after treatment is instituted when the cleft size is 7 to 5 mm, to avoid excessive elongation of the lateral alar tissue.[14] The acrylic anterior part bearing rubber bands is placed and held to the greater segment, as this segment will be rotated toward the lesser segment in unilateral clefts. If the lesser segment is retruded, the appliance on that side can be made as deep as the gingivobuccal sulcus allows, creating a shield effect in that area, which places pressure on the periosteum to allow downward growth, to create forward traction (shielding philosophy of Frankel), without extending the acrylic to the posterior portion of the tuberosity of the lesser segment. The device should then be rotated toward the posterior portion of the lesser segment.

Appliances for bilateral cleft lip and palate cases also fill the cleft space with wax but leave some retention in the back to maintain the posterior transversal dimension in the anterior part filled space to move the premaxilla medially and posteriorly without ventroflexion (Fig. 4). The appliance should be shorter in the back to bring the premaxilla back without lacerations. The nasal component is incorporated after approximately 4 weeks of therapy with the acrylic plate, once the alveolar gap is reduced (Fig. 5). Following passive orthodontic appliance treatment, the patient is ready for surgical repair at approximately 6 months of age.

The procedure that our institution uses for unilateral clefts is essentially the rotation advancement procedure developed by D. Ralph Millard,

Fig. 1. Unilateral cleft dental models illustrating segment sequence, in which the lesser segment is allowed to grow forward and the greater segment is rotated toward the lesser segment without longitudinal reduction of the maxilla.

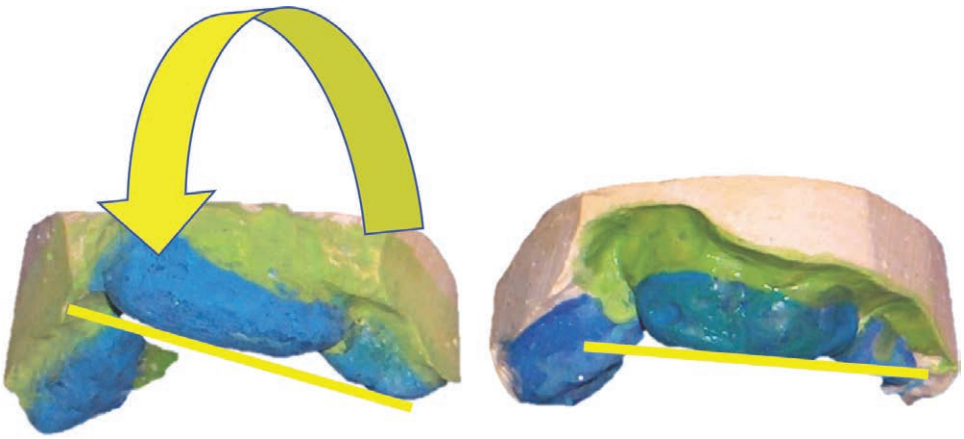

Fig. 2. Dental model illustrating alignment of the occlusal plane. The occlusal plane should be aligned before the size of the cleft is reduced.

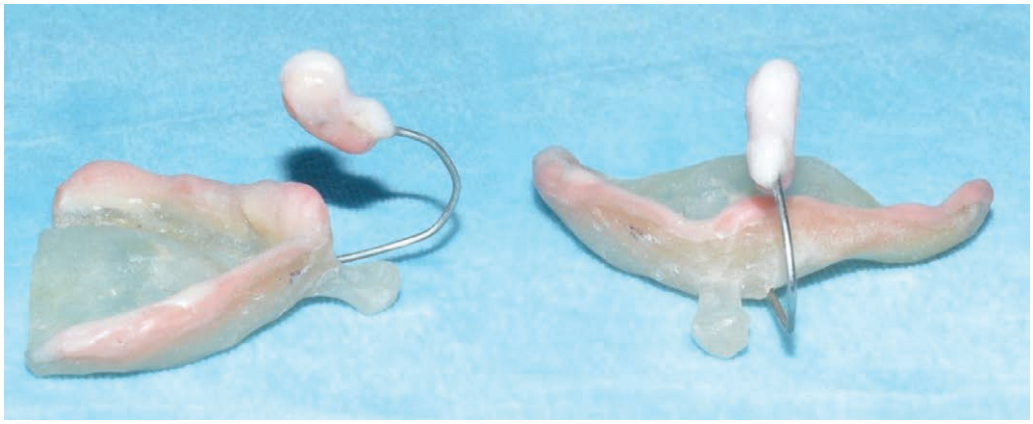

Fig. 3. Passive orthodontic unilateral appliance used during treatment of unilateral cleft lip and palate patients.

Jr., M.D. The only difference is that the incision on the superior portion of the advancement flap is not taken around the alar base, nor is the white roll flap considered necessary. A "supraperiosteal" alveoloplasty, or gingivosupraperiosteoplasty, is used to close the alveolar cleft and 10 to 12 mm of the anterior palate using a vomer flap, and a McComb nasal correction is performed. The dissection on the alveolar segment is supraperiosteal to avoid damaging deciduous teeth that are ready for eruption and converts to a subperiosteal dissection once away from underlying tooth roots.

Fig. 4. Bilateral cleft dental models illustrating the movement of the segments and premaxilla in bilateral cleft lip and palate patients. The premaxilla should be moved medially and posteriorly without ventroflexion to be aligned with the posterior segments.

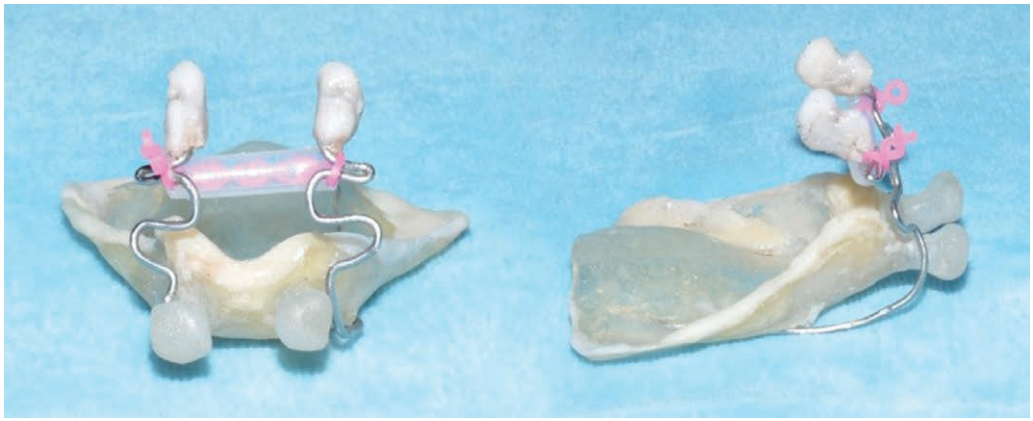

Fig. 5. Passive orthodontic bilateral appliance used during treatment of bilateral cleft lip and palate patients. Different adjustments are made in accordance with the treatment plan.

Nostril stents are maintained in place for the first postoperative week. A staged approach is used for bilateral cleft lip repair following the principles used for the unilateral cleft lip deformity. The bilateral cleft is treated as two unilateral clefts, and is repaired with staged rotation advancements.[13,14] Although a synchronous approach is the most widely used approach for bilateral repairs, current techniques result in a tight upper lip, short midlip height, a retroclined premaxillary segment, and a higher than usual need for surgical maxillary advancement.[15,16] Staged repairs provide a lax upper lip that will not restrict maxillary growth.[11,12]

Cephalometric Analysis

Cephalometric analysis was performed to evaluate maxillary and mandibular growth and facial growth relative to the facial axis. Lateral cephalometric digital radiographs of 15 unilateral and 15 bilateral cleft lip and palate patients at mixed dentition before orthodontic treatment (6 to 9 years of age) were traced by three independent blinded reviewers using Vistadent software (Vistadent OC 1.1). Cephalometric evaluation using Steiner, Harvold, and Ricketts analysis was performed to obtain mean values for sella-nasion–A point (growth of maxilla), sella-nasion–B point, (growth of mandible), A point–nasion–B point (maxillomandibular relation), and the facial axis angle (direction of growth of the mandible). Mean cephalometric values were compared to normative values.[17,18] Intraclass correlation coefficients were calculated to assess interrater agreement for each cephalometric variable. Independent samples *t* tests were used to statistically evaluate differences between cephalometric values for our patients and normative cephalometric values, in addition to sella-nasion–A point, sella-nasion–B point, and A point–nasion–B point for unilateral cleft lip and palate patients reported in the Eurocleft study, which did not use gingivoperiosteoplasty or presurgical treatment, and from the New York University Nasoalveolar Molding Center, which used a gingivoperiosteoplasty/nasoalveolar molding protocol.[19,20] Statistical calculations were performed using IBM SPSS Version 26.0 (IBM Corp., Armonk, N.Y.).

RESULTS

Thirty patients (15 with complete unilateral cleft lip and palate and 15 with complete bilateral cleft lip and palate) underwent passive orthodontic appliance treatment and cleft lip closure with gingivosupraperiosteoplasty. All patients were classified as severe (≥8 mm cleft size).[21] Fourteen patients (47 percent) were female and 16 (53 percent) were male (Table 1). Patient age ranged from 6 to 12 years at mixed

Table 1. Overview of Demographics and Cleft Characteristics

Parameter	Unilateral (%)	Bilateral (%)
Sex		
Female	47	47
Male	53	53
Cleft classification		
Severe	100	100
Age of initiation of POA		
Within 2 wk (nasal component later)	100	100
Occlusal status at mixed dentition		
Class I	73	40
Class II	13	53
Class III	13	7
Need for secondary bone grafting		
Underwent secondary bone grafting	60	87

POA, passive orthodontic appliances.

Table 2. Overview of Mean Age at Surgery

	No. of Patients	Mean (mo)	SD (mo)
Mean age at cleft lip repair			
Unilateral	15	6.01	0.79
Bilateral (stage I)	15	7.18	2.51
Bilateral (stage II)	30	11.04	3.93

dentition. Mean age at the time of initial cleft repair for all patients was 6 ± 2 months (range, 4 to 14 months) (Table 2). Figures 6 through 8 illustrate examples of the senior author's technique and results at mixed dentition in complete unilateral and bilateral cleft lip and palate patients. Two unilateral and one bilateral cleft lip and palate patients exhibited skeletal class III malocclusion (Table 3). Eighty-seven percent of unilateral cleft lip and palate patients and 93 percent of bilateral cleft lip and palate patients had class I or class II skeletal occlusion at mixed dentition. Sixty percent of unilateral cleft lip and palate and 87 percent of bilateral cleft lip and palate cases required secondary alveolar bone grafting. Tables 4 and 5 present the preliminary treatment results in terms of cephalometric parameters.

There was good interrater reliability for all cephalometric parameters for unilateral cleft lip and palate (intraclass correlation coefficient = 0.908 for sella-nasion–A point, 0.077 for sella-nasion–B point, 0.872 for A point–nasion–B point, and 0.828 for facial axis) and bilateral cleft lip and palate (intraclass correlation coefficient = 0.943 for sella-nasion–A point, 0.940 for sella-nasion–B point, 0.949 for A point–nasion–B point, and 0.915 for facial axis) patients. Mean cephalometric values for unilateral and bilateral cleft lip and palate patients were within 1 SD of age-specific normal values for sella-nasion–A point (80.0 ± 3.7 degrees), sella-nasion–B point (74.0 ± 3.4 degrees), A point–nasion–B point (4.0 ± 1.4 degrees), and the facial axis (90.0 ± 3.5 degrees) (Fig. 9), except for A point–nasion–B point for bilateral cleft lip and palate patients, which was within 2 SD of age-specific normal values. Mean cephalometric values for unilateral cleft lip and palate patients were 79.0 ± 5.1 degrees for sella-nasion–A point, 75.8 ± 4.2 degrees for sella-nasion–B point, 3.0 ± 1.5 degrees for A point–nasion–B point, and 88.9 ± 2.8 degrees for facial axis. Mean cephalometric values for bilateral cleft lip and palate patients were 78.7 ± 4.9 degrees for sella-nasion–A point, 73.0 ± 3.2 degrees for sella-nasion–B point, 5.8 ± 3.0 degrees for A point–nasion–B point, and 87.9 ± 2.9 degrees for facial axis. There was no significant difference for sella-nasion–A point, sella-nasion–B point, and facial axis between unilateral and bilateral cleft lip and palate patients and patients without clefts at mixed dentition. The mean A point–nasion–B point for bilateral cleft lip and palate patients was significantly greater than normative

Fig. 6. Presentation of the patient in case 1 with complete unilateral cleft lip and palate. All patients with complete unilateral cleft lip and palate started presurgical treatment between 1 and 3 weeks of age, with a total period of 20 weeks. The first operation was performed at 6 months of age involving closure of the cleft lip, gingivosupraperiosteoplasty, and cleft nasal correction. The closure of the cleft palate was performed at 18 months. Newborn 6 weeks old, frontal (*above*, *left*) and profile (*above*, *center*) views. After presurgical treatment, frontal (*above*, *right*) and profile (*below*, *left*) views. Long-term follow-up, frontal (*below*, *center*) and profile (*below*, *right*) views.

Fig. 7. Presentation of the patient in case 2 with complete bilateral cleft lip and palate. All patients with complete bilateral cleft lip and palate started presurgical treatment between 1 and 3 weeks of age, with total period of 20 weeks. A protocol for synchronous repair was used in two patients, where the surgery was performed at 6 months of age involving closure of the cleft lip, gingivosupraperiosteoplasty, and cleft nasal correction. The remaining bilateral cleft lip and palate patients followed a protocol for staged repair, where they had the first stage of the surgical repair performed at 6 months of age, and the second stage at 9 months of age. The closure of the cleft palate was performed at 18 months. Newborn 6 weeks old, frontal (*above*, *left*) and profile (*above*, *center*) views. After presurgical treatment, frontal (*above, right*) and profile (*below, left*) views. Long-term follow-up, frontal (*below, center*) and profile (*below, right*) views.

cephalometric data for A point–nasion–B point at mixed dentition, and significantly less for unilateral cleft lip and palate patients ($p < 0.05$). No significant difference was found between sella-nasion–A point, sella-nasion–B point, and A point–nasion–B point values for our patients and patients from the Eurocleft study with unilateral cleft lip and palate who underwent no gingivoperiosteoplasty or presurgical treatment. There was also no significant difference between sella-nasion–A point, sella-nasion–B point, and A point–nasion–B point values for our patients and patients from the New York University Nasoalveolar Molding Center who underwent both gingivoperiosteoplasty and nasoalveolar molding ($p < 0.05$).

DISCUSSION

Passive orthodontic appliances allow the maxillary segments, muscles, and soft tissues to be placed into a more physiologic position. By establishing better facial symmetry and balance, passive orthodontic appliances simplify surgical repair, reduce scarring, and may have less impact on future facial growth. Passive orthodontic appliances also allow for gingivosupraperiosteoplasty to be performed, as alignment and approximation of the alveolar segments is required to narrow the alveolar cleft and limit dissection.[22] These techniques are technically challenging and have a variable success rate across institutions. Controversy remains regarding the timing and the use of orthopedic appliances and the role of gingivoperiosteoplasty/gingivosupraperiosteoplasty in the repair of alveolar clefts.

Our results demonstrate that presurgical treatment and alignment of the alveolar cleft and the anterior palate do not interfere with maxillary growth or cause a class III malocclusion at mixed dentition. There was no significant difference for sella-nasion–A point, sella-nasion–B point, and facial axis between unilateral and bilateral cleft lip and palate patients who underwent treatment with passive orthodontic appliances and cleft lip closure with gingivosupraperiosteoplasty compared to normative cephalometric values, indicating that there was no deficiency in midface growth in patients treated with our protocol. The mean A point–nasion–B point value for bilateral cleft lip and palate was significantly greater than the value normally found in bilateral cleft lip and palate patients at mixed dentition, indicating that there was less maxillary hypoplasia and thus less possibility of maxillary collapse during future facial growth ($p < 0.05$). None of the patients had an abnormal facial axis, indicating that patients are more

Fig. 8. Mixed dentition in bilateral cleft lip and palate patient. Usually, bilateral cleft lip and palate patients have midface underdevelopment after repair. After undergoing gingivosupraperiosteoplasty in combination with passive orthodontic appliances, this patient had good midface growth and class II occlusion following bilateral cleft lip and palate repair.

likely to have normal mandibular growth and less likely to develop class III malocclusion. A large facial axis indicates that patients are below class III and are likely to end up with class III malocclusion after future mandibular growth. The mean unilateral cleft lip and palate A

Table 3. Demographics and Cleft Characteristics

Patient	Sex	Age at Cleft Lip Repair (mo)	Anterior Cleft Size (mm)	Posterior Cleft Size (mm)	Cleft Severity	Secondary Bone Grafting	Anterior Fistula	Skeletal Occlusal Status at Mixed Dentition (Class)
Unilateral								
1	F	6.41	12	13	Severe	Yes	No	I
2	F	6.15	9	12	Severe	Yes	No	II
3	M	5.03	8	12	Severe	No	No	I
4	F	5.79	13	16	Severe	Yes	No	I
5	F	7.89	10	13	Severe	No	No	III
6	M	7.20	9	11	Severe	Yes	No	I
7	M	5.62	8	10	Severe	Yes	No	II
8	M	5.59	8	9	Severe	Yes	No	I
9	F	5.49	11	12	Severe	Yes	Yes	I
10	M	6.38	10	16	Severe	Yes	No	I
11	F	5.87	10	15	Severe	Yes	Yes	I
12	M	4.97	12	18	Severe	No	No	I
13	F	6.03	18	22	Severe	No	No	I
14	M	5.10	13	18	Severe	No	Yes	III
15	M	5.93	17	20	Severe	No	No	I
Bilateral								
16	F	6.05*	12	11	Severe	Yes	Yes	II
17	M	6.64*	15	9	Severe	Yes	Yes	II
18	M	6.94*	7	16	Severe	No	No	II
19	M	6.64*	15	3	Severe	Yes	No	I
20	F	5.03*	14	16	Severe	No	Yes	II
21	M	6.18*	10	3	Severe	Yes	Yes	II
22	F	9.17*	11	12	Severe	Yes	Yes	I
23	M	6.67*	16	15	Severe	Yes	Yes	I
24	M	7.30*	12	11	Severe	Yes	No	II
25	M	14.14*	9	15	Severe	Yes	No	II
26	F	4.40*	17	17	Severe	Yes	No	II
27	F	10.10*	15	15	Severe	Yes	No	I
28	F	4.43*	15	17	Severe	Yes	Yes	I
29	F	5.77*	17	18	Severe	Yes	No	I
30	M	7.00*	18	17	Severe	Yes	Yes	III

F, female; M, male.
*First stage of bilateral cleft lip repair.

Table 4. Results of Cephalometric Analyses of Unilateral Cases*

Patient	SNA (deg)	SNB (deg)	ANB (deg)	Facial Axis (deg)
1	80.5 ± 1.1	77.2 ± 1.1	3.2 ± 0.2	88.7 ± 1.2
2	82.9 ± 1.2	78.1 ± 1.0	4.8 ± 0.5	90.9 ± 1.9
3	75.3 ± 3.2	73.9 ± 3.6	1.4 ± 0.5	92.8 ± 3.4
4	74.1 ± 1.1	71 ± 1	3.1 ± 1.1	87.5 ± 1.4
5	70.9 ± 1.8	71.5 ± 0.5	−0.5 ± 1.3	89.1 ± 2.0
6	74.8 ± 0.5	71.4 ± 1.5	3.5 ± 1.3	88 ± 1
7	75.4 ± 0.4	71.1 ± 0.2	4.3 ± 0.2	82.5 ± 1.3
8	81.5 ± 0.7	80.1 ± 1.0	1.4 ± 1.0	91.6 ± 2.6
9	76.3 ± 2.0	73.2 ± 2.1	3.1 ± 0.1	86.9 ± 2.8
10	91.3 ± 6.4	88.4 ± 5.6	2.9 ± 0.8	94.3 ± 2.5
11	79.9 ± 1.0	75.7 ± 0.9	4.2 ± 0.2	88.6 ± 0.6
12	81.0 ± 1.2	75.8 ± 0.0	5.2 ± 1.1	88.2 ± 2.3
13	84.8 ± 3.7	80.1 ± 2.2	3.7 ± 0.9	89.0 ± 0.1
14	77.1 ± 2.1	75.6 ± 1.5	1.5 ± 0.7	87.3 ± 1.2
15	79.9 ± 4.7	76.4 ± 3.0	3.4 ± 2.0	87.9 ± 2.7
Total	79.0 ± 5.1	75.8 ± 4.2	3.0 ± 1.5	88.9 ± 2.8

SNA, sella-nasion–A point; SNB, sella-nasion–B point; ANB, A point–nasion–B point.
*Values are mean ± SD.

point–nasion–B point was significantly less ($p < 0.05$) than the normative value; however, it was not less than 2 degrees, indicating there was no class III skeletal tendency. No significant difference was found between sella-nasion–A point, sella-nasion–B point, and A point–nasion–B point values for our patients and patients with unilateral cleft lip and palate who underwent no gingivoperiosteoplasty/gingivosupraperiosteoplasty or presurgical treatment and patients who followed a gingivoperiosteoplasty and nasoalveolar molding protocol, indicating that our protocol does not have a deleterious impact on midface growth compared to protocols that do not use these techniques, and to similar protocols from institutions that have reported no deleterious effects on midface growth.[19,20,23]

Table 5. Results of Cephalometric Analyses of Bilateral Cases*

Patient	SNA (deg)	SNB (deg)	ANB (deg)	Facial Axis (deg)
16	77.0 ± 4.5	70.8 ± 1.6	8.0 ± 0.9	86.8 ± 1.1
17	84.4 ± 1.5	79.1 ± 0.3	5.4 ± 1.3	92.1 ± 0.1
18	79.5 ± 1.6	73.6 ± 0.9	5.9 ± 0.7	85.8 ± 2.0
19	73.4 ± 2.3	70.9 ± 2.0	2.5 ± 0.4	88.7 ± 1.1
20	83.4 ± 1.7	74.6 ± 0.7	8.8 ± 1.3	91.8 ± 1.1
21	85.9 ± 1.5	77.6 ± 0.8	8.4 ± 1.2	92.1 ± 1.0
22	73.6 ± 0.4	71.2 ± 0.4	2.3 ± 0.2	85.7 ± 1.2
23	75.8 ± 1.2	75.2 ± 1.3	0.8 ± 0.3	86.5 ± 1.2
24	83.6 ± 0.8	73.9 ± 1.4	10.6 ± 0.7	89.4 ± 0.5
25	79.7 ± 1.3	70.6 ± 1.3	8.9 ± 0.2	87.4 ± 2.0
26	83.0 ± 2.4	73.2 ± 0.6	7.5 ± 2.8	87.6 ± 1.4
27	79.0 ± 1.4	74.3 ± 0.3	4.1 ± 2.1	89.6 ± 0.5
28	75.9 ± 1.1	74.3 ± 3.2	3.7 ± 0.9	87.0 ± 2.0
29	78.4 ± 0.5	70.4 ± 0.5	7.9 ± 0.5	86.7 ± 1.5
30	68.1 ± 1.5	66.0 ± 1.1	2.2 ± 1.4	81.3 ± 3.2
Total	78.7 ± 4.9	73.0 ± 3.2	5.8 ± 3.0	87.9 ± 2.9

SNA, sella-nasion–A point; SNB, sella-nasion–B point; ANB, A point–nasion–B point.
*Values are mean ± SD.

The results of our ongoing analysis of facial growth should be interpreted in relation to their context. Many other factors in cleft lip and palate patients can influence their midfacial development, including size of the maxilla (patients with very wide clefts have maxillary deficiency), presurgical treatment, healing response of individual patients, skill of the surgeon, scar tissue formation, and the underlying skeletal pattern of each patient.[24] To further establish the outcomes of passive orthodontic appliances combined with gingivosupraperiosteoplasty at the time of cleft lip repair, ongoing evaluation of midface growth in relation to skeletal maturity is required.

The goal of passive orthodontic appliance treatment is to establish the most physiologically balanced maxilla within the limitations of the patient's skeletal deficiency. Use of passive orthodontic appliances allows for the alveolar segments to not only be brought together, but also to be oriented in their correct, symmetrical arch form. An additional benefit is the establishment of the correct occlusal planes. In reducing the alveolar gap, alignment of the lip segments is improved, reducing the nasal base width and introducing laxity of the alar rim.[4] Passive orthodontic appliances also allow for elongation of the columella, mitigating the need for future procedures to elongate the columella, such as Abbe flaps.

Gingivoperiosteoplasty originally relied on the osteogenic potential of periosteum to generate osseous continuity across the alveolar cleft and promote bony continuity and stabilization of the maxillary arch.[25] This may be accomplished subperiosteally or supraperiosteally.[26–29] It should be noted that our institution performs gingivosupraperiosteoplasty, a partially supraperiosteal gingivoperiosteoplasty, rather than a true subperiosteal gingivoperiosteoplasty, thus avoiding damaging tooth roots and having little impact on maxillary growth.[30] The use of gingivosupraperiosteoplasty mitigates potential adverse effects on facial growth from extensive subperiosteal dissection at the flap donor site and produces more favorable dentoalveolar development. We presume that a subsequent bone graft will be needed, which is not difficult when the soft tissue is closed. Our objective is to avoid anterior fistulas and improve the success

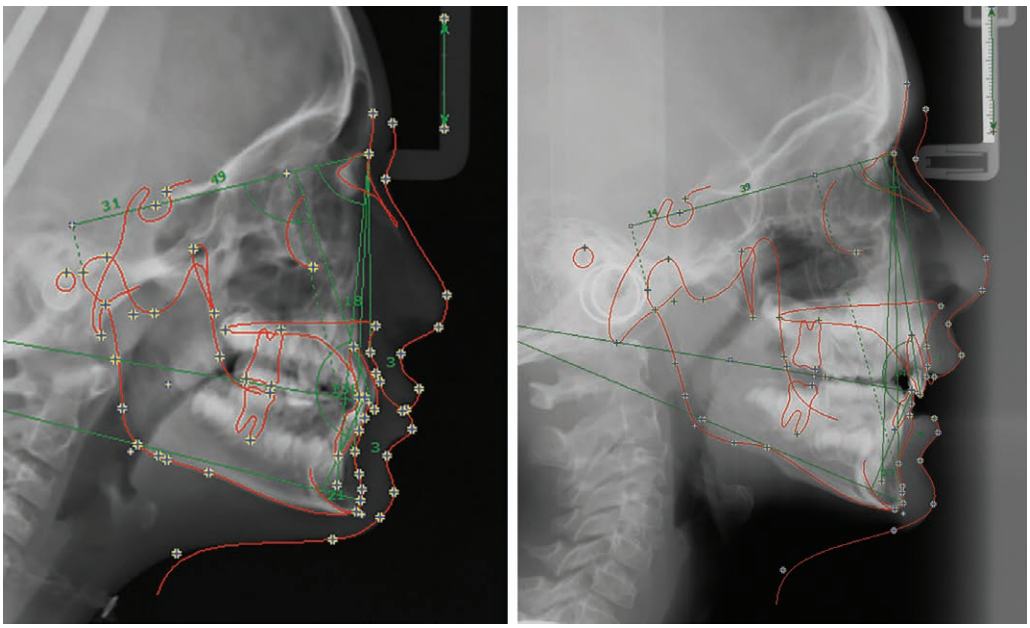

Fig. 9. Cephalometric films and tracings using Steiner, Harvold, and Ricketts analysis of the unilateral cleft lip and palate case (*left*) and bilateral cleft lip and palate case (*right*) at 7 years of age.

of alveolar bone grafting, reducing the need for additional bone grafting procedures.

Previous evidence of the deleterious effects of primary gingivoperiosteoplasty on facial growth has caused some to abandon the procedure.[31,32] Others, however, have attributed the facial growth deficiency to wide periosteal undermining in the Skoog procedure and the effects of the Latham device in the Millard procedure.[2,23] Only the group from New York University has been able to show preliminary results indicating no deleterious effects on facial growth.[23] Wang et al. reported that primary gingivoperiosteoplasty can achieve high success rates; however, no measurements of facial growth were presented and thus no conclusions about the effects of secondary alveolar bone grafting versus primary gingivoperiosteoplasty in this cohort can be made.[33] However, this remains a point of concern, as the authors stated that they stopped performing primary gingivoperiosteoplasty in 2003 because of the deleterious effects on facial growth described in the literature. Longitudinal studies of facially mature patients are required to fully appreciate the long-term implications.

This retrospective study evaluated the influence of our treatment protocol including passive orthodontic appliances and gingivosupraperiosteoplasty on facial growth and occlusion in patients with complete unilateral and bilateral cleft lip and palate. Our protocol also included staged repair for bilateral cleft lip and palate patients, which also may have implications for facial growth. All components of the protocol matter; however, the long-term effects of staged bilateral cleft lip repairs on facial growth will be published in a forthcoming study. Unilateral cleft lip and palate patients did not have this component of the protocol, but instead had only gingivoperiosteoplasty and passive orthodontic appliances, and had good midface growth outcomes. The focus of this study is the gingivosupraperiosteoplasty/passive orthodontic appliance elements of our protocol, as it is a response to literature that calls for more long-term growth studies.[2] The results of our long-term follow-up and analysis of facial growth demonstrate that presurgical passive orthodontic appliances, combined with gingivosupraperiosteoplasty at the time of cleft lip repair, leads to normal maxillary development in most cases in unilateral and bilateral cleft lip and palate patients at mixed dentition.

Although some argue against the use of passive orthodontic appliances and gingivoperiosteoplasty/gingivosupraperiosteoplasty, suggesting that these types of procedures have deleterious effects on facial growth, we feel that the normal maxillary growth that we can obtain using presurgical passive orthodontic appliances combined with gingivosupraperiosteoplasty justifies continuing their use, especially when considering the potential advantages the use of passive orthodontic appliances and gingivosupraperiosteoplasty can afford. Advantages include allowing for closure of the

alveolus and anterior palate, avoiding anterior fistulas, and improving the success of secondary alveolar bone grafting.

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PATIENT CONSENT

Parents or guardians provided written consent for use of patients' images.

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