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3D morphometric evaluation of the dental arches in children with cleft lip and palate submitted to different surgical techniques

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Abstract

Objectives This study aimed to compare dimensional alterations of dental arches in children with unilateral complete cleft lip and palate before and after different techniques of primary plastic surgeries.

Materials and methods The sample was divided into two groups: group 1—cheiloplasty by Millard's technique and one-stage palatoplasty by von Langenbeck's technique; group 2—cheiloplasty by Millard's technique and two-stage palatoplasty: anterior palatoplasty by Hans Pichler's technique and posterior palatoplasty by Sommerlad's technique. Dental arches were evaluated before (T1), after the first phase (T2), and 1 year after the second phase (T3) of primary surgeries. Linear measurements and palatal area were assessed. To analyze the method's error, interclass correlation coefficient was applied. ANOVA (followed by Tukey test), dependent, and independent t-test were used ($p < 0.05$).

Results At T1, the intertuberosity distance was statistically greater in G2 ($p = 0.004$). At T2, the anterior length of the dental arch was statistically greater in G2 ($p = 0.025$), while the area of the smaller palatal segment ($p = 0.001$), cleft area ($p = 0.014$), and total area ($p = 0.002$) were statistically smaller in G2. At T3, the intertuberosity distance was statistically greater in G2 ($p = 0.017$).

Conclusion This study suggests that cheiloplasty and one-stage palatoplasty resulted in smaller growth of maxilla than cheiloplasty and two-stage palatoplasty in the linear measurements (T-T' and I-CC') and total area of the dental arches. Clinical relevance.

Surgical protocols need to be evaluated to verify their effects aiming at improving the clinical practice of the interdisciplinary team, determining new parameters for the rehabilitation of individuals with cleft lip and palate.

Keywords Cleft lip · Cleft palate · Dental models · Growth and development

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Introduction

Starting at the first months of life, children with cleft lip and palate undergo an extensive and complex rehabilitative treatment accomplished by the primary plastic surgeries—cleft lip and palate repair [1]. Paradoxically, surgical approaches cause sagittal and transversal alterations in the growth and development of the maxilla and influence the relation of dental arches [1–4]. Post-surgical tissue healing limits the capacity of tissue distension and negatively influences on the face's skeletal growth, mainly in individuals with large cleft lip and palate [1].

For primary cleft lip repair, Millard's technique proved to be revolutionary for lip closure, as it consists of designing incisions that allow the flap to rotate [5]. Among the techniques for primary palate repair, von Langenbeck's technique, described in 1861, is the most common one [6]. In this technique, relaxing incisions are made on both sides (from retromolar to the canine region) that provide displacement of the mucoperiosteal flaps, facilitating the union of these flaps at the level of the septum, keeping them fixed only by the palatine vascular bundle. The anterior part of the palate was repaired using a mucoperiosteal flap (non-cleft side) and pedicle flap (cleft side). The suture is performed on the nasal floor, muscle tissue, and oral mucosa [6, 7]. The recent literature [8] compares some palate repair techniques (Furlow Z-plasty, von Langenbeck, and two-stage palatoplasty) showing that rates of wound dehiscence 1 week and fistula formation 3 months after the surgery did not significantly differ among the three techniques. A systematic review presented inconclusive evidence of the effects of one- and two-stage palatoplasty on maxillofacial growth. In addition, the authors confirm the need for randomized clinical studies aimed at long-term results [9]. An important contribution was made by Hans Pichler in 1926, for the closure of the hard palate using a vomer flap [10, 11]. To improve velopharyngeal competence, Kriens (1969) [12] proposed the anatomical repositioning of soft palate elevator muscle, which is inserted in the posterior margin of the hard palate with longitudinally directed fibers, to restore the intravelar muscle complex, providing mobility of the soft palate and the improvement of velopharyngeal competence [13]. Sommerlad's technique, also called radical intravelar veloplasty, has been showing excellent results in speech, with a reduction in velopharyngeal insufficiency [14]. Studies have evaluated protocols in which palate repair is performed in two stages and reported that hard and soft palate repair, before 2 years of age, can lead to a restriction of maxillary growth at an earlier age [4]. In protocols that primary palate repair is performed in two stages, growth inhibition is postponed until the hard palate is closed [4]. However, primary palate repair in a late period impairs speech development [15]. The ideal age for one-stage primary (hard and soft palate repair) is still controversial, and some centers have recommended it between 12 and 18 months, to avoid growth disorders [16]. Therefore, the literature still lacks consensus on the type of primary surgery, the technique, and the surgical time that would cause lesser damage to the maxillary growth of individuals with cleft lip and palate [3, 9, 17, 18]. This study aimed to compare dimensional alterations of dental arches in children with unilateral complete cleft lip and palate before and after different techniques of primary plastic surgeries. This study hypothesized that there was no difference regarding the techniques of primary plastic surgeries: cheiloplasty and one- or two-stage palatoplasty.

Material and methods

Sample selection

This study was submitted and approved by the Institutional Review Board under protocol number CAAE 79,124,317.8.3001.5441. The children were selected in the routine treatment of the Pediatric Dentistry Clinic of Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo (HRAC, USP), from 2010 until 2019. Inclusion criteria comprised children with unilateral complete cleft lip and palate, both genders, operated by the same surgeon, without previous surgery, and with complete documentation before surgery and 1 year after the primary surgeries. The exclusion criteria were syndrome or associated malformation and patients who had undergone any primary surgeries.

The sample size was calculated so that the number of children met the minimum number to conduct the study. Thus, we consider the study of Carrara et al. [19], with a standard deviation of 2.32 mm in the total length of the palate. The minimum number of children in each group was 27, with a level of significance of 5%, test power of 80%, and minimum difference to be detected of 1.8 mm.

The sample was divided into two groups according to the surgical technique:

- Group 1 (G1)—28 children were submitted to cheiloplasty for cleft lip repair at 3 months of age by Millard's technique and one-stage palatoplasty (hard and soft palate primary repair) at 12 months of age by von Langenbeck's technique (Fig. 1A).
- Group 2 (G2)—28 children submitted to cleft lip repair by Millard's technique and simultaneously by Hans Pichler's technique to repair the hard palate at 3 months of age (two-stage palatoplasty); the soft palate repair was

Fig. 1 A Group 1—cheiloplasty by Millard's technique at 3 months of age and total palatoplasty by von Langenbeck technique at 12 months of age (cheiloplasty and one-stage palatoplasty). B Group 2—cheiloplasty by Millard's technique together with anterior palatoplasty by Hans Pichler's technique at 3 months of age and posterior palatoplasty by Sommerlad's technique at 12 months of age (cheiloplasty and two-stage palatoplasty)
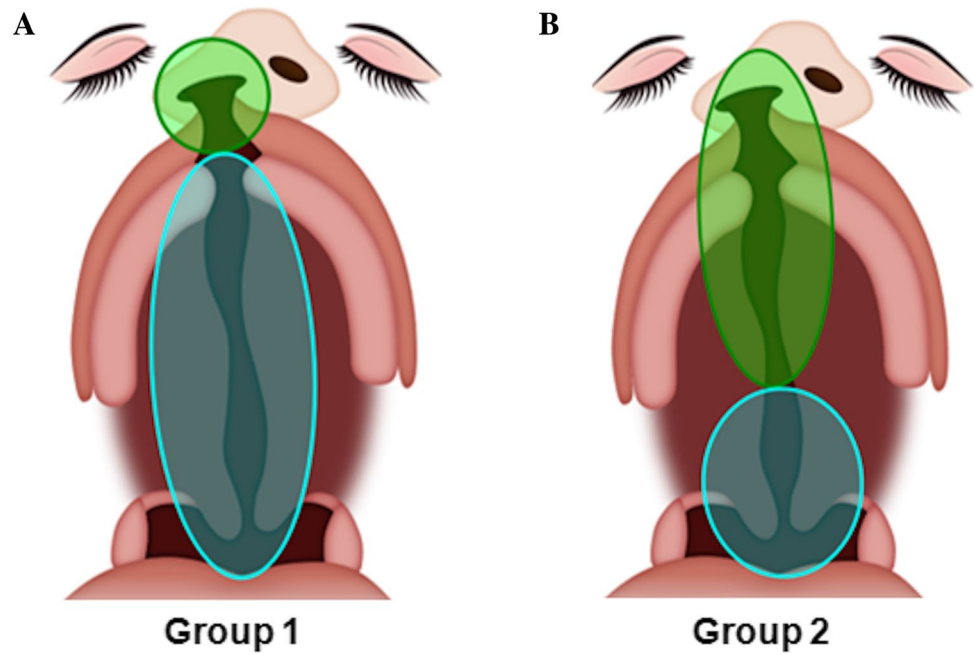
performed at 12 months of age to close the posterior palate by Sommerlad's technique (Fig. 1B).

The evaluation was performed through 3D digitized images of the dental casts of each child by two previously calibrated and trained examiners. The dental casts were obtained at the following phases:

- T1: Before primary surgeries.
- T2: After the accomplishment of cleft lip repair or first period of primary surgeries:

    - G1—after Millard's technique
    - G2—after Millard's/Hans Pichler's technique

- T3: 1 year after the accomplishment of the primary surgeries.

The dental casts were obtained from the files of the institution. The casts were digitized with a scanner (Scanner 3D, 3Shape's R700™ Scanner, Copenhagen, Denmark) coupled to a computer. After the scanning, the measurements were performed with the software of the stereophotogrammetry system (Mirror imaging software, Canfield Scientific Inc., Fairfield, NJ, USA) [14–17]. The measurements were executed on the 3D images. The points and lines to obtain the linear measurements and the dental arch area followed previous literature [9, 13–15, 18, 19]. The following linear measurements were assessed in mm (Fig. 2A):

- Intercanine distance (C–C'): the transversal line between the eruption points of the primary canines;
- Intertuberosity distance (T-T'): the transversal line between the left and right tuberosity;

Fig. 2 A Anatomic points and linear measurements: C–C' (intercanine distance), I-CC' (anterior length of the dental arch), T-T' (intertuberosity distance), I-TT' (total length of the palate), P-P' (anterior cleft width), U-U' (posterior cleft width). B Dental arch areas: gPPlate (area of the greater palatal segment), Clf (cleft area), and sPPlate (area of the smaller palatal segment)
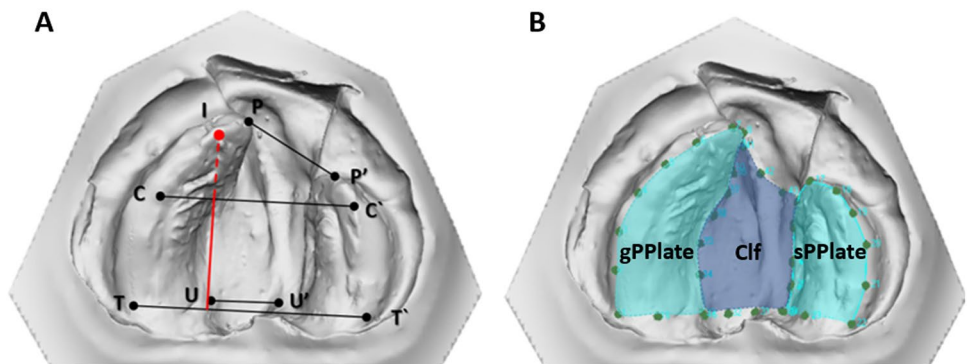
- Anterior length of the dental arch (I-CC'): straight line passing through the interincisive point (I) and perpendicular to the intercanine distance (C–C');
- The total length of the palate (I-TT'): straight line passing through the interincisive point (I) and perpendicular to the Intertuberosity distance (I-TT');
- Anterior cleft width (P-P');
- Posterior cleft width (U-U').

The area was measured in mm². The total area was the sum of the greater and smaller cleft segments area and cleft area, which was marked by points on the alveolar edge crest, contouring all the palatal shelf, ending at the most posterior point of the tuber. The cleft area was anteriorly marked by a point on the alveolar edge crest of both segments and posteriorly by points on tuber [13, 20, 21]. If teeth were present, the points changed to gingival margins towards the palatal margin of teeth (Fig. 2B).

- Area of the greater palatal segment (gPPlate);
- Area of the smaller palatal segment (sPPlate);
- Cleft area (Clf);
- Total area.

Statistical analysis

All statistical analyses were performed in *Statistica* software (*Statistica for Windows, 13.3*), with a significance level of 5%. The normality test was Shapiro–Wilk. The paired interclass correlation coefficient (ICC) [22] analyzed the intra and interexaminer error in 1/3 of the sample, 15 days after the first measurement [23]. Repeated measurement ANOVA,

followed by Tukey test and dependent t-test, evaluated the intragroup comparisons. Independent t-test assessed the intergroup comparisons.

Results

Sample characterization regarding gender and age

The mean age (in years) of the sample was 0.317 at T1, 1.120 at T2, and 2.104 at T3. Twenty-two girls and 34 boys participated in the study.

Analysis of intraexaminer and interexaminer reproducibility

A methodological error was evaluated by two examiners E1 and E2. Interexaminer results were E1 − 0.983 and E2 − 0.905. Intraexaminer results were 0.760 (1ª measurement) and 0.782 (2ª measurement). Those coefficients imply suitable reliability [24].

Group 1—dimensional alterations

In G1, intercanine distance (C–C'), anterior length of the dental arch (I-CC'), anterior and posterior cleft width (P-P' and U-U'), and cleft area (Clf) decreased significantly at T2. T-T' distance, gPPlate, and sPPlate increased at T2. The total length of the palate (I-TT') increased significantly from T1 to T3, and the total area decreased (Table 1).

Table 1 Analysis of the linear dimensions of the maxillary arches (mm) and area (mm²) of G1 at T1, T2, and T3 (ANOVA followed by Tukey test and dependent t-test)

Variables	T1		T2		T3		p
	Mean	SD	Mean	SD	Mean	SD	
C–C'	27.40[A]	2.84	25.94[B]	2.73	25.54[B]	2.72	**0.000***
I-CC'	7.21[A]	1.74	5.50[B]	1.49	5.47[B]	1.53	**0.000***
T-T'	34.57[A]	2.74	35.78[B]	3.46	35.79[B]	4.11	**0.045***
I-TT'	25.81[A]	2.71	26.34[AB]	2.53	27.23[B]	2.34	**0.042***
P-P'	10.43[A]	2.95	1.96[B]	3.57	——	——	**0.000***
U-U'	12.37[A]	1.93	11.06[B]	2.63	——	——	**0.019***
gPPlate	508.31[A]	67.94	557.55[B]	73.41	——	——	**0.009***
sPPlate	343.34[A]	45.60	382.80[B]	60.12	——	——	**0.006***
Clf	319.71[A]	100.26	268.98[B]	77.55	——	——	**0.020***
Total area	1163.39[A]	147.45	1209.34[A]	161.92	1010.52[B]	143.74	**0.000***

*Statistically significant difference

Different uppercase letters in row mean statistically significant difference

Variables: C–C' (intercanine distance), I-CC' (anterior length of the dental arch), T-T' (intertuberosity distance), I-TT' (total length of palate), P-P' (anterior cleft width), U-U' (posterior cleft width), gPPlate (area of the greater palatal segment), sPPlate (area of the smaller palatal segment), Clf (cleft area), Total area (the sum of the area of greater and smaller palatal segments, and cleft area)

Table 2 Analysis of the linear dimensions of the maxillary arches (mm) and area (mm^2) of Group 2 at T1, T2, and T3 (ANOVA followed by Tukey test and dependent t-test)

Variables	T1		T2		T3		p
	Mean	SD	Mean	SD	Mean	SD	
C–C'	28.08[A]	3.22	26.79[AB]	2.40	26.77[B]	2.16	**0.02***
I-CC'	7.11[A]	1.33	6.32[AB]	1.18	5.78[B]	1.32	**0.000***
T-T'	36.42[A]	2.05	36.77[AB]	2.35	37.64[B]	2.21	**0.03***
I-TT'	24.77[A]	3.56	25.21[A]	3.10	27.18[B]	1.90	**0.002***
P-P'	10.53	3.84	——	——	——	——	——
U-U'	13.40[A]	3.24	11.74	2.91	——	——	**0.03***
gPPlate	477.34[A]	90.87	522.41[A]	167.26	——	——	0.236
sPPlate	342.34[A]	72.25	330.75[A]	62.91	——	——	0.52
Clf	271.05[A]	88.23	208.75[B]	90.51	——	——	**0.007***
Total area	1090.74[A]	179.48	1061.91[A]	194.14	1055.83[A]	162.90	0.666

*Statistically significant difference

Different uppercase letters in row mean statistically significant difference

Table 3 Intergroup analysis (group 1 × group 2) of linear dimensions of maxillary arches (mm) and area (mm2) at T1 (independent t-test)

T1	G1	G2	p
	Mean (SD)	Mean (SD)	
C–C'	27.40(2.84)	28.08(3.22)	0.458
I-CC'	7.21(1.74)	7.11(1.33)	0.721
T-T'	**34.57(2.74)**	**36.42(2.05)**	**0.004***
I-TT'	25.81(2.71)	24.77(3.56)	0.132
P-P'	10.43(2.95)	10.53(3.84)	0.909
U-U'	12.37(1.93)	13.40(3.24)	0.216
gPPlate	508.31(67.94)	477.34(90.87)	0.164
sPPlate	343.34(45.60)	342.34(72.25)	0.961
Clf	319.71(100.26)	271.05(88.23)	0.051
Total area	1163.39(147.45)	1090.74(179.48)	0.071

*Statistically significant difference

Table 4 Intergroup analysis (group 1 × group 2) of linear dimensions of maxillary arches (mm) and area (mm2) at T2 (independent t-test)

T2	G1	G2	p
	Mean (SD)	Mean (SD)	
C–C'	25.94(2.73)	26.79(2.40)	0.133
I-CC'	5.50(1.49)	6.32(1.18)	**0.025***
T-T'	35.78(3.46)	36.77(2.35)	0.134
I-TT'	26.34(2.53)	25.21(3.10)	0.139
P-P'	1.96(3.57)	——	-
U-U'	11.06(2.63)	11.74(2.91)	0.171
gPPlate	557.55(73.41)	522.41(167.26)	0.273
sPPlate	382.80(60.12)	330.75(62.91)	**0.001***
Clf	268.98(77.55)	208.75(90.51)	**0.014***
Total area	1209.34(161.92)	1061.91(194.14)	**0.002***

*Statistically significant difference

Group 2—dimensional alterations

In G2, C–C' and I-CC' distance decreased significantly from T1 to T3. Posterior cleft width (U-U') and cleft area (Clf) presented a smaller average at T2. At T3, intertuberosity distance (TT') and the total length of the palate (I-TT') showed higher values compared to T1 (Table 2).

Intergroup (G1 × G2)—dimensional alterations

At T1, T-T' distance was statistically greater in G2 than in G1 (Table 3). At T2, I-CC' was statistically greater in G2, while sPPlate, Clf, and total area were statistically smaller in G2 (Table 4). At T3, T-T' distance was statistically greater in G2 than in G1 (Table 5).

The intergroup comparison of the linear alterations of the measurements of the maxillary arches from T2 to T1 (Δ = T2-T1) revealed a statistically smaller area sPPlate for

Table 5 Intergroup analysis (group 1 × group 2) of linear dimensions of maxillary arches (mm) and area (mm2) at T3 (independent t-test)

T3	G1	G2	p
	Mean (SD)	Mean (SD)	
C–C'	25.54(2.72)	26.77(2.16)	0.060
I-CC'	5.47(1.53)	5.78(1.32)	0.424
T-T'	35.79(4.11)	37.64(2.21)	**0.017***
I-TT'	27.23(2.34)	27.18(1.90)	0.945
P-P'	——	——	-
U-U'	——	——	-
gPPlate	——	——	-
sPPlate	——	——	-
Clf	——	——	-
Total area	1010.52(143.74)	1055.83(162.90)	0.248

Table 6 Intergroup analysis (G1×G2) of the linear dimensions of the maxillary arches (mm) and area (mm²) from T2 to T1 (Δ=T2-T1), T3 to T2 (Δ=T3-T2) and T3 to T1 (Δ=T3-T1) (independent t-test)

Variables	G1		G2		p
	Mean	SD	Mean	SD	
Δ = T2-T1					
C–C'	− 1.46	2.47	− 1.29	3.46	0.831
I-CC'	− 1.70	2.20	− 0.79	1.91	0.104
T-T'	1.21	2.71	0.35	2.40	0.215
I-TT'	0.53	3.14	0.44	4.41	0.931
U-U'	− 1.31	2.74	− 1.65	4.05	0.714
gPPlate	49.24	93.90	45.06	196.94	0.919
sPPlate	39.46	70.48	− 11.59	95.04	**0.026***
Clf	− 50.73	109.42	− 62.29	113.28	0.699
Total area	37.96	185.50	− 28.83	256.11	0.268
Δ = T3-T2					
C–C'	− 0.41	1.64	− 0.03	1.74	0.403
I-CC'	− 0.04	1.35	− 0.54	1.30	0.162
T-T'	0.01	2.24	0.86	2.18	0.154
I-TT'	0.89	2.21	1.97	2.44	0.088
Total area	− 198.8	188.1	− 6.08	179.21	**0.000***
Δ = T3-T1					
C–C'	− 1.87	2.69	− 1.31	3.08	0.476
I-CC'	− 1.74	2.06	− 1.33	2.01	0.460
T-T'	1.22	3.59	1.21	2.78	0.995
I-TT'	1.41	3.32	2.41	3.77	0.300
Total area	− 160.85	161.93	− 34.91	213.12	**0.016***

*Statistically significant difference

G2. The intergroup comparison of the linear alterations of the measurements of the maxillary arches from T3 to T2 (Δ=T3-T2) and from T3 to T1 (Δ=T3-T1) exhibited a total area statistically greater in G2 (Table 6).

Discussion

In the present study, two surgical protocols were evaluated to rehabilitate children with unilateral complete cleft lip and palate, using stereophotogrammetry in digitized casts. In Group 1 (G1), the maxillary dimensions of the anterior dental arch (C–C' and I-CC') and cleft dimensions (P-P', U-U' and cleft area) decreased after primary cleft lip repair (T2), indicating that the maxillary segments transversally approximated. The reduced dimensions of the anterior maxilla indicated the early detrimental effect of the surgery, and the immediate post-operatory period is critical for maxillary retrusion [4, 25]. Instead, the intertuberosity distance (T-T') has significantly increased during the study period. Other studies corroborate the results of this present study that the primary cleft lip repair (cheiloplasty) did not interfere in the

intertuberosity growth [4, 20, 23, 25–29]. Moreover, studies suggested primary cleft lip repair inhibits the maxillary growth in cleft lip and palate individuals [28, 30, 31]. The total dental arch length (I-TT') increased significantly from T1 to T3, as observed in the previous studies [20, 23, 26, 27, 29]. The area of the greater palatal segment (gPPlate) and the area of the smaller palatal segment (sPPlate) increased significantly in T2. In contrast, the total area decreased, which means that the primary surgeries had a retrusive force in palatine segments. Following with the present study, Carrara et al. [19] showed a total area reduction after primaries surgeries.

In Group 2, C–C' and I-CC' decreased significantly from T1 to T3. The rationale behind this result is that primary surgeries affect the transversal and anterior portion of the maxillary segments, as in G1. T-T' and I-TT' increased significantly from T1 to T3. Mikoya et al. [3] compared the dental arches of children operated at one or two stages and observed that the transversal relation was better in the latter protocol. On the other hand, Xu et al. [32] concluded that the sagittal maxillary length might be affected by either one- or two-step primary repair of the palate. Posterior cleft width (U-U), sPPlate, and cleft area were reduced from T1 to T2. P-P' measurements were performed at T1 because at the first phase of hard palate primary repair enabled the closure of the anterior palate with soft tissue.

Comparing the maxillary dimensions between groups (group 1×group 2), at T1, T-T' distance was statistically greater in G2 than in G1. At T2, I-CC' length was statistically greater in G2, while the sPPlate area, Clf area, and the total area were statistically smaller in G2. At T3, T-T' distance was statistically greater in G2 than in G1, suggesting that two-stage palatoplasty enabled a greater growth of the palate. It is important to emphasize that the difficulty in comparing the results with those in the literature can be explained because of different methodologies, treatment protocols, and following-up periods. Few studies evaluated the effects of surgical procedures, considering different surgical techniques and periods [18, 19].

In the intergroup analysis, from T2 to T1 (Δ = T2-T1), the sPPlate measurement was smaller in G2. From T3 to T1(Δ = T3-T1) and from T3 to T2 (Δ = T3-T2), the total area measurement was significantly smaller in G1. It showed that the one-stage palatoplasty affected maxillary growth negatively. These results are in agreement with previous studies [33–35]. In the present study, the results showed that G2 had less maxillary retrusion than G1. It can be explained due to the fact that anterior hard palate surgery limited the movement of maxillary segments after repair. G1 had a greater restriction of cleft area than G2, whereas the maxillary segments had no surgical repair on the anterior hard palate that could serve as a limiting factor, and the palatal segments had no barrier

to stop the restriction made by lip repair. The hypothesis was rejected because the cheiloplasty and one-stage palatoplasty revealed greater restriction than cheiloplasty and two-stage palatoplasty (T-T' and I-CC') and total area measurements.

There is a deficiency in sagittal and transverse growth of the palate in individuals with unilateral complete cleft lip and palate. Sagittal deficiency is related not only to early palatoplasty but also to surgical reconstruction of the lip. The scar tension of the lip can restrict the growth of the anterior maxillary. Thus, the presence of anterior crossbite is a frequent finding in these patients during childhood [36]. Some recent studies report that there is no difference in sagittal development between patients undergoing one- and two-stage palatoplasty [37, 38]. The absence of medial palatal suture and palatoplasty potentiate the deficiency in the transverse growth of the dental arches. Posterior crossbites are also frequently seen in these patients. Palate expansion is commonly performed with Hyrax or Haas type expanders during orthodontic interventions. This procedure contributes to the correction of the transverse palatal deficiency. In permanent dentition, natural compensation of mandibular premolars and molars is common due to maxillary atresia with an excessive inclination of the crowns to the lingual side [36]. Currently, orthodontists confirm that both transversal and sagittal deficiencies are commonly found [38, 39].

Some methodological difficulties can be highlighted in the present study, as the timing of surgeries. There is a protocol at all centers, but not always the exact protocol as surgery or timing could be achieved. Items of unusual timing can be listed: the sickness of children, problems in parents' work, transportation, dental decay, and missing appointments. Other factors presented are difficulties to have a standard sample: several surgeons, different repair techniques, cleft size, and missing a non-cleft group. The same surgeon can choose different techniques for different children with the same cleft. Therefore, all those elements listed above bring obstacles for having a large standard sample. The literature reports that other facts may affect the maxillary dimension, such as genetic facial pattern [29], cleft severity [29, 40], hypoplasia inherent to the palatal tissue [29, 41, 43], the cleft presence itself [43], surgeon's ability [19, [44], and the differences in the treatment protocols [45].

The actual institutional protocol indicates orthodontic treatment in the mixed dentition, so the children with oral clefts will undergo orthodontic treatment after nine years of age [36]. As soon as possible, our dentists' team will start a project with active preoperative infant orthopedics. Soon, we will have more results from a different treatment protocol. Moreover, in the present study, the purpose was to evaluate the growth and development of maxilla. In future investigations, it will be relevant to study the speech problems of all patients.

Based on the analyses of the results of this present study, surgical protocols need to be evaluated to verify their effects. Targeting at improving the clinical practice of the interdisciplinary team, determining new parameters for the rehabilitation of individuals with cleft lip and palate, and confirming the outcomes during extensive following-up periods. Altogether, it would improve the quality of cleft lip and palate individuals' rehabilitation.

Conclusion

Palatal growth was influenced at the first year of life after surgery. This study suggests that cheiloplasty and one-stage palatoplasty resulted in smaller growth of maxilla than cheiloplasty and two-stage palatoplasty in the linear measurements (T-T' and I-CC') and the total area of the dental arches.

Declarations

Ethical approval All procedures performed in studies were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical Approval number—CAAE: 79124317.8.3001.5441. Process number: 3.009.626.

Patient consent Not required.

Conflict of interest The authors declare no competing interests.

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