Original Research
Pediatric Dentistry

Correlation between cleft width and dental arch symmetry in cleft lip and palate: a longitudinal study

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Declaration of Interests: The authors certify that they have no commercial or associative interest that represents a conflict of interest in connection with the manuscript.

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https://doi.org/10.1590/1807-3107bor-2023.vol37.0021

Submitted: December 14, 2021
Accepted for publication: August 23, 2022
Last revision: September 27, 2022

Abstract: This study aimed to evaluate the influence of cleft width on dental arch symmetry of children with unilateral cleft lip and palate. Forty-one children were subjected to impression preoperatively (T1; mean age = 0.31 ± 0.07 years) and postoperatively (T2; mean age = 6 .73 ± 1.02 years). Eighty-two digitized dental casts were analyzed by stereophotogrammetry software. The cleft palate width was measured in the anterior (P-P′), middle (M-M′), and posterior (U-U′) regions. Also, the following measurements were obtained: anterior intersegment (I-C′) and intrasegment (I-C); total intersegment (I-T′) and intrasegment (I-T); cleft-side (C′-T′) and non-cleft-side (C-T) canine tuberosity. Paired t test and Pearson correlation coefficient were applied ($\alpha = 5\%$). Cleft width had the following means: 10.16 (± 3.46) mm for P-P′, 12.45 (± 3.00) mm for M-M′, and 12.57 (± 2.71) mm for U-U′. In the longitudinal analysis, I-C′ had a significant reduction, while the other measurements significantly increased ($p < 0.001$). Asymmetry was verified in the following analyses at T1: I-C′ *vs.* I-C and I-T′ *vs.* I-T ($p < 0.001$); at T2, only in I-C′ *vs.* I-C ($p < 0.001$). At T1, P-P′ *vs.* I-C′ ($r = 0.722$ and $p < 0.001$), P-P′ *vs.* I-T′ ($r = 0.593$ and $p < 0.001$), M-M′ *vs.* I-C′ ($r = 0.620$ and $p < 0.001$), and M-M′ *vs.* I-T′ ($r = 0.327$ and $p < 0.05$) showed a positive and significant correlation. At T2, there was a correlation between M-M′ and I-C′ ($r = 0.377$ and $p < 0.05$). In conclusion, the anterior and middle cleft widths influenced palatal asymmetry in the first months of life, while middle width influenced residual asymmetry.

Keywords: Cleft Lip; Cleft Palate; Dental Arch; Growth and Development; Pediatric Dentistry.

Introduction

Craniofacial anomalies comprise a diverse group of congenital malformations that affect a significant share of the world population, having become an important public health problem. Cleft lip and palate is the most prevalent malformation in association with syndromes or other congenital anomalies. According to the World Health Organization (WHO), one in every 600 newborn infants in the world has orofacial cleft.[1] In Brazil, a rehabilitation center for craniofacial anomalies has shown similar findings (1:661).[2]

Orofacial cleft affects the lip, lip and palate, or only the palate. Unknown etiological factors play a role during intrauterine life, preventing the fusion between facial processes. The cleft lip and palate rehabilitation protocol begins with primary plastic surgery, either cheiloplasty (lip repair surgery) or palatoplasty (palate repair surgery). Both surgeries are usually performed during the child's first year of life. Reconstructive surgeries are the first stage of the rehabilitation protocol, which involves several professionals such as dentists, speech therapists, nurses, psychologists, and nutritionists, among others.[2-4] Cleft lip and palate treatment protocols are targeted at improving quality of life, esthetics, function, and face and palate symmetry.[5-8]

Residual or persistent asymmetry usually occurs after primary plastic surgeries and requires further therapeutic approaches (secondary plastic surgery or orthopedic treatment) for correction of anatomic and/or functional problems.[5,9-11] Symmetry in individuals with cleft lip and palate has been evaluated in both soft and hard tissues.[12] The analysis of palate symmetry in children is essential before and after surgical repairs.[5] Therefore, it is essential to analyze segments with and without clefts at the very beginning of the rehabilitation protocol to establish correlations between palatal parameters.[12] In individuals with orofacial clefts, three-dimensional imaging technology provides quantitative data with proven accuracy and speed. [5,13]

Palate asymmetry in children with craniofacial anomalies is correlated with factors such as orofacial cleft phenotype classification, treatment protocol, cleft length, and cleft width.[6,11,14,15] However, the literature lacks studies on the influence of cleft width before and after surgical repairs. Moreover, no study so far has explained which cleft width (anterior, middle, or posterior) would play a role in dental arch symmetry in children. Accordingly, this study may provide information to help elucidate the underlying factors in dental arch asymmetry and may establish criteria for other studies. This study aimed to evaluate the influence of cleft width on the dental arch symmetry of children with unilateral cleft lip and palate. The null hypothesis is that palate symmetry is not influenced by cleft width.

Methodology

Study population

This study was approved by the Institutional Review Board (CAAE: 48123315.4.0000.5441). No consent form was necessary because the study was conducted with dental casts, which were part of the institute's routine.

Inclusion criteria were children with unilateral cleft lip and palate.A single surgeon operated all participants. Cheiloplasty was performed at 3 months of life, while palatoplasty at 12 months of life.[3] Dental casts were analyzed in the periods: preoperatively (T1) – one day before cheiloplasty; and postoperatively (T2) – almost 6 years after cheiloplasty and palatoplasty. These time periods were chosen taking into consideration the institutional protocol, as follows:[3] around 3 months of life – the child was evaluated and operated by the plastic surgeon; 6 years after the primary surgeries – the child was reevaluated to verify whether secondary plastic surgery was necessary (new cheiloplasty and/or new palatoplasty).[3] Children with other congenital anomalies, supernumerary teeth, and poor-quality dental casts were excluded from the study.

Microsoft Excel 2019 (Microsoft Corporation, Albuquerque, USA) was used to calculate the sample size. The following values were obtained from a pilot study: standard deviation of 2.33 mm for the anterior intersegment distance (I-C'), with level of significance of 5%, test power of 80%, and minimum detectable difference of 1.5 mm. Thus, the minimum sample size was 39 participants.

Digital anthropometric analysis

The dental casts were digitized using a 3D laser scanner (3Shape´s R700™ Scanner, Copenhagen, Denmark), while the anthropometric analyses were quantified by stereophotogrammetry software (Mirror imaging software, Canfield Scientific Inc., Fairfield, USA).[16-18]

Anatomic landmarks and linear parameters were used in the dental arch evaluations according to previous studies with children.[8,9,16,19,20] The following parameters were measured: P-P' – Anterior cleft width (straight line between the most anterior points of the alveolar bone crests); M-M′ – Middle cleft width (straight line between the points located in the medial region of the palatal segments adjacent to the cleft); U-U′ – Posterior cleft width (straight line between the most posterior points of the palatal segments adjacent to the cleft); I-C′ – Anterior intersegment distance (between the interincisive point and the primary canine cusp in the smaller bone segment); I-C – Anterior intrasegment distance (between the interincisive point and the primary canine cusp in the greater bone segment); I-T′ – Total intersegment distance (between the interincisive point and the tuberosity of the smaller bone segment); I-T – Total intrasegment distance (between the interincisive point and the tuberosity of the greater bone segment); C′-T′ – Cleft-side canine tuberosity distance (between the primary canine cusp and the tuberosity of the smaller bone segment); and C-T – Non-cleft-side canine tuberosity distance (between the primary canine cusp and the tuberosity of the greater bone segment). All the parameters were quantified in mm (Figure 1).

Statistical analysis

The reproducibility of the method was evaluated by the intraclass coefficient, in which one-third of the sample was analyzed twice after a two-week interval.[16,17] After the Shapiro-Wilk test, the paired t test was used for longitudinal analysis and symmetry measurements. The influence of cleft width on palate symmetry was assessed by the Pearson correlation matrix. All statistical tests were performed using GraphPad Prism (Prism 5 for Windows – Version 5.0 – GraphPad software., Inc., San Diego, USA) with $\alpha = 5\%$.

Results

Group of participants

Eighty-two digitized dental models were selected from 41 children. The mean age was 0.31 (± 0.07) years at T1 and 6.73 (± 1.02) years at T2. Cleft width yielded the following means: 10.16 (± 3.46) mm for P-P′, 12.45 (± 3.00) mm for M-M′, and 12.57 (± 2.71) mm for U-U′.

Reproducibility and longitudinal assessment

The high correlation between the repeated measures (r = 0.97) indicate that the measurements were sufficiently reproducible. The longitudinal analysis of the palatal parameters show that only I-C′ had a significant reduction, while the other

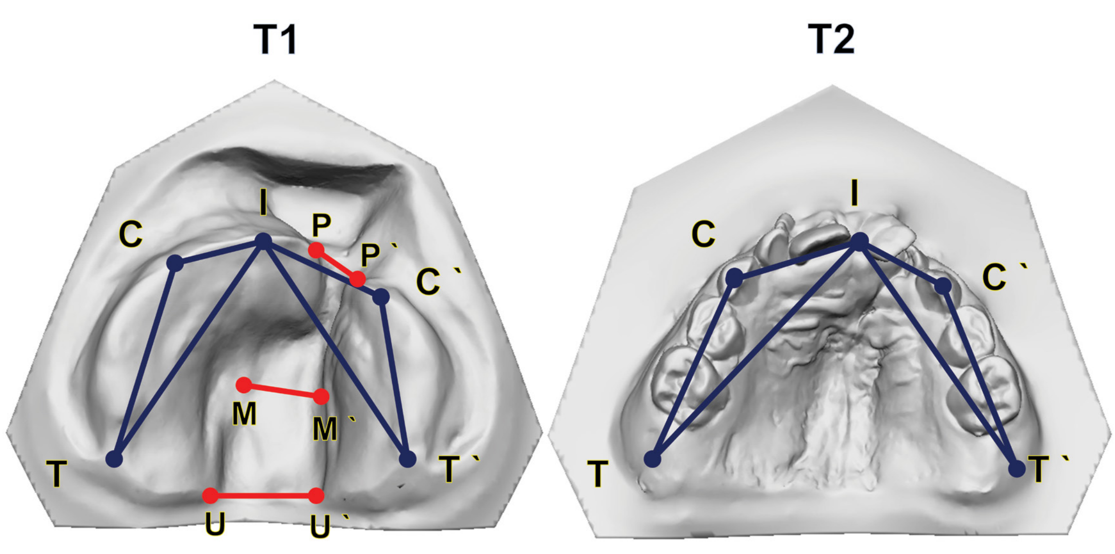

Figure 1. Dental arches at T1 and T2 showing the anatomic landmarks, cleft width, and linear parameters for the palate.

measurements significantly increased in the evaluated period (Table 1).

Symmetry and correlations

At T1, asymmetry was verified in the following analyses: I-C′ *vs.* I-C and I-T′ *vs.* I-T; while at T2, only in I-C′ *vs.* I-C (Table 2).

At T1, P-P′, M-M′, and U-U′ showed a significant correlation. Anterior width (P-P′) was significantly correlated with I-C′, I-T′, and C′-T′, while middle width (M-M′) was correlated with I-C′ and I-T′. Posterior width (U-U′) showed a significant negative correlation with I-T and C-T. At T2, only M-M′ *vs.* I-C′ showed a significant positive correlation (Figure 2).

Discussion

The craniofacial growth of anatomical structures (teeth, skeleton, and muscles) does not always occur naturally and symmetrically. Considering orofacial clefts, although asymmetries are frequent, large deviations may result in important anatomical and functional changes that require orthodontic, surgical, and prosthetic treatments.[12] Thus, the early assessment of palate symmetry in children with oral clefts can provide information and consequently prevent further serious problems.

This is the first study to evaluate the symmetry of dental arches in children with unilateral cleft lip and palate before and after primary plastic surgeries performed by a single plastic surgeon and to correlate the results with anterior, middle, and posterior cleft widths. Numerous parameters can influence the symmetry of dental arches.[5,11,14,15] However, this study focused on the understanding of cleft width, considering the lack of width classifications.

Previous studies have quantified asymmetry using digitized dental models of the maxillary dental arch only.[21] The use of palatine raphe has been considered the axis of symmetry by some authors, but it has not been confirmed whether this anatomical region is the center of the palate.[21] Thus, in the case of participants with unilateral cleft lip and palate, the lack of palatine raphe did not allow the analysis of symmetry on this median axis. The choice of the interincisive point as the axis of symmetry was applied in this study similarly to other anthropometric studies.[16,17,19]

Table 1. Mean growth differences and relative growth percentage in the evaluated period (paired t test).

Parameters	Mean difference (mm)	SD	Relative growth (%)	p-value*
I-C′	6.77	1.0	- 34.52	< 0.001
I-C	- 3.35	0.08	26.21	< 0.001
I-T′	- 3.92	3.13	11.27	< 0.001
I-T	- 9.03	2.04	31.17	< 0.001
C′-T′	- 9.52	2.32	48.34	< 0.001
C-T	- 9.27	1.26	47.95	< 0.001

*Statistically significant difference. Mean difference: T1 – T2. SD: Standard deviation. mm: millimeters.

Table 2. Analysis of palate symmetry in the evaluated period (paired t test).

Parameters	T1			T2		
	Mean difference			Mean difference		
	(mm)	SD	p-value	(mm)	SD	p-value
I-C′ *vs.* I-C	6.82	1.42	< 0.001*	-3.29	0.28	< 0.001*
I-T′ *vs.* I-T	5.76	0.55	< 0.001*	0.65	0.53	0.312
C′-T′ *vs.* C-T	0.33	0.32	0.427	0.57	0.74	0.154

*Statistically significant difference. Mean difference: T1 – T2. SD: Standard deviation. mm: millimeters.

P-P′	0	0	0.123	0.002	0.036	-0.161	-0.056	-0.178	1.0
*** 0.580	**M-M′**	0	* 0.377	0.114	0.197	0.071	0.067	0.005	
* 0.376	*** 0.578	**U-U′**	0.256	0.049	0.095	0.094	-0.037	-0.057	
*** 0.722	*** 0.620	0.252	**I-C′**	* 0.392	*** 0.600	** 0.441	0.266	** 0.441	
-0.276	-0.186	-0.191	-0.264	**I-C**	** 0.475	** 0.485	* 0.369	** 0.443	0
*** 0.593	* 0.327	0.030	*** 0.617	-0.001	**I-T′**	*** 0.661	*** 0.858	*** 0.803	
-0.159	-0.299	*** -0.502	-0.222	*** 0.628	0.296	**I-T**	*** 0.612	*** 0.729	
** -0.415	-0.288	-0.179	*** -0.635	** 0.400	0.031	** 0.410	**C′-T′**	*** 0.815	
0.012	-0.099	** -0.440	-0.081	0.038	* 0.375	*** 0.716	0.286	**C-T**	-1.0

Note: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Figure 2. Pearson correlation matrix. The lower left-hand corner displays the coefficients at T1. The upper right-hand corner displays the coefficients at T2. The correlation matrix shows Pearson's correlation values, which measure the degree of linear relationship between each measured parameter. The right column shows the color legend according to the coefficients, ranging from -1 (brown color) to +1 (dark-green color). Coefficients closer to -1 indicate inversely proportional parameters, while those closer to +1 indicate directly proportional parameters. Coefficients with a value of zero (white color) indicate a weak correlation.

The data in the present study corroborate the intrinsic difference in the development of cleft lip and palate. The limitation of anterior linear growth on the cleft side was significant and concurs with the findings of previous studies.[8,16,17,19] Cheiloplasty can limit anterior palate development, but not in the posterior region, because of the continuous pressure exerted by the healing tissue on the dental arch.[5,8,16,20] The unilateral growth of the dental arch suggests that both cleft width and treatment protocol influenced palate formation.

One of the most relevant findings was obtained with the longitudinal analysis of palate symmetry. Considering the analyses between palatal segments, the findings prior to the reparative surgeries (T1) were already expected because the cleft itself plays a role in palate asymmetry. The presence of the cleft can increase parameters I-C′ and I-T′. These findings are in line with those of other authors who have demonstrated the difference in palate symmetry before cheiloplasty.[5,15,22]

The analyses indicate improvement of palate symmetry between I-T′ and I-T, at T2, due to the growth of the posterior region of the palate.[16] These data were consistent with the increase in parameters C′-T′ and C-T and were congruous with those of other authors.[8,23] The asymmetry in the anterior palate region was also observed in the analysis I-C′ *vs.* I-C at T2, that is, the role of cleft width in asymmetry at T1 persisted at T2. We emphasize that palatoplasty was unable to correct this asymmetry. A narrow palate commonly leads to superimposition of the smaller and greater segments (collapsed palate), resulting in an asymmetric dental arch.[5,10,22] Clinically, crossbite is the result of an asymmetric and collapsed palate.[10,22]

This study emphasized the influence of the width of cleft palate on palate development. The aim was to understand which width would have the greatest influence on dental arch symmetry in each period. At T1, the strong positive correlations between P-P′ and M-M′ *vs.* I-C′ and I-T′ indicate that the anterior (P-P′) and middle (M-M′) widths influenced palate symmetry. At T2, the significant positive correlation between M-M′ width and I-C′ shows asymmetry of the anterior region of the palate. Thus, the data show that width influenced symmetry, and the null hypothesis was then rejected.

Cleft width influences surgical repair and, consequently, the symmetry of craniofacial development. Cheiloplasty and palatoplasty performed on a wide cleft would require large mucoperiosteal flaps. The consequence would be a thicker amount of scar tissue.[18,24] Usually, anthropometric comparisons between cleft widths (anterior, middle, and posterior) have demonstrated that middle and posterior widths are greater than the anterior width.[18,25] Another study has suggested that the cleft middle width may be associated with the development and maxillary growth in individuals with unilateral cleft lip and palate.[26] The present study suggests that middle width influenced palate symmetry before and after surgical repairs.

Considering that palate width is a negative predictor of palate development,[5,11,15,23,27] we emphasize the importance of further evaluation of cleft palate width. The proposal of a cleft width classification would contribute to determining the influence of cleft width on palate growth and treatment protocols. These analyses could help improve palate development according to the inherent features of each child.

The limitations of the present study include the lack of a sample group with different orofacial cleft phenotypes and comparisons with participants who underwent orthopedic treatments such as a nasoalveolar molding and/or Hotz plate technique before cheiloplasty. Therefore, further studies are still needed to verify these variables.

Conclusion

Palate asymmetry in the first months of life was influenced by anterior and middle cleft widths, while residual asymmetry in the anterior region after reparative surgeries was correlated with the middle cleft width.

Acknowledgements

The authors would like to acknowledge the financial support from the São Paulo Research Foundation (Fapesp grant # 2017/02706-9).

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