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Geometric morphometric analysis of Palatal shape variability after Early neonatal Cheiloplasty - A Systematic Review

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ABSTRACT

Background: Cleft lip and palate (CLP) is a common congenital craniofacial anomalies that pose significant challenges to functional and aesthetic development. Early neonatal cheiloplasty (ENC) aims to restore lip and nasal anatomy promptly, potentially influencing palatal growth and shape variability.

Objective: This systematic review assesses palatal shape variability in infants undergoing ENC compared to those receiving late operation protocol (LOP) cheiloplasty, using geometric morphometric analysis.

Methods: A systematic search up to April 2025 was conducted across multiple databases following PRISMA guidelines, focusing on studies employing geometric morphometry and principal component analysis to evaluate palatal morphology post-cheiloplasty. The Anatomical Quality Assessment (AQUA) tool was used to evaluate study bias.

Results: Four studies met inclusion criteria, showing that palatal shape variability was greatest pre-surgery, especially in bilateral cleft lip and palate (BCLP) patients. Post-ENC, shape variability decreased significantly, approaching non-cleft controls. Inter-canine width remained relatively stable following ENC, with a mild decrease in LOP groups. ENC did not adversely affect anterior or posterior maxillary growth. Both modified Tennison and Veau techniques yielded comparable morphometric outcomes.

Conclusion: conducted using 2D methods, which have limitations such as the inability to obtain 3D data and the possibility of measurement errors. [12,13] Our review's contribution will be to integrate 2D and 3D techniques, through geometric morphometric analysis and to study the variations in the palatal shape with and without ENC.

1. INTRODUCTION

MATERIALS AND METHODS

Protocol registration

This review was done according to the Cochrane Handbook and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) /statement.[14] The review protocol was registered in the International prospective register of systematic reviews PROSPERO (CRD42024597556).

Eligibility Criteria

The research question of this study was "Is there any difference in palatal shape of infants who underwent ENC when compared to those who underwent LOP?". Based on the population, intervention, comparison, outcome, and study design (PICOS), selection criteria were designed in Table 1.

Category	Inclusion criteria	Exclusion criteria
Participants	Infants with Cleft lip and/or palate planned for cheiloplasty	Infants who do not have cleft of the lip and/or palate
Intervention	Early neonatal cheiloplasty	
Comparison	Late cheiloplasty	
Outcomes	Palatal morphology studied using geometric morphometry and principal component analysis	Study of palatal morphology using 2D analyses and linear measurements
Study design –	. Randomized clinical trials (RCTs), . Prospective controlled clinical trials (CCTs). . Prospective observational studies . Retrospective studies	1. Abstracts 2. Case series/ case reports 3.Narrative reviews . Systematic reviews and meta-analyses. . In-vitro studies

Table 1: Eligibility Criteria

INFORMATION SOURCES, SEARCH STRATEGY, AND STUDY SELECTION

The search process was carried out up to April 2024, using Boolean operators with no language restrictions (Table 2). Searching and assessment of studies were performed independently and in duplicate by two authors (AR and SS), and disagreements were judged by a third author [Table 2].

Database	Search strategy used	No
PubMed Central (NCBI)	1 Neonatal Cheiloplasty 2 Cleft/ AND surgery 3 Palat* 4 #1 OR #2 5 Morphometry OR morphometric 6 #3 AND #5	48 24,936 96,201 24,938 70,531 567

	7 #4 AND #6	83
SCOPUS	Keywords searched: Neonatal AND Cheiloplasty AND palate AND morphometry OR morphometrics	7
Cochrane library	1 „Neonatal Cheiloplasty“ 2 Cleft/ AND surgery 3 „Palate“/exp 4 #1 OR #2 5 „Morphometry“/exp 6 #3 AND #5	2 1119 2807 1119 887 3
EMBASE	1 „Neonatal Cheiloplasty“ 2 Cleft/ AND surgery 3 „Palate“/exp 4 #1 OR #2 5 „Morphometry“/exp 6 #3 AND #5 7 #4 AND #6	8 19,397 29,393 19,400 1,84,164 512 7
Google Scholar	("neonatal cheiloplasty" OR "cleft surgery") AND ("morphometry" OR "geometric morphometry") AND "Palate"	128

Table 2: Search Strategy

2. DATA ITEMS AND COLLECTION

Data extraction sheets were developed, and data were extracted concurrently by the two investigators (SS and AR), as shown in Table 3.

Sl No	Study	Sample Characteristics	Groups	Type of Cleft	Type of cheiloplasty	Time of evaluation	Software for Morphometric analysis and number of landmarks	Results

1	Hoffmannova E et al. 2016	33 patients 3.8±2.7 days	SG: Neonatal cheiloplasty LOP (Later operation protocol) group: cheiloplasty at 6 months of age Control group of	Complete Unilateral Cleft lip and palate (cUCLP)	Modified Tennison technique	T0: before cheiloplasty T1: Before palatoplasty 10 months after lip surgery	11 landmarks Mophome3cs software	Variation in maxillary form was greatest in SG at T0. The maxillary segments 10 months after neonatal cheiloplasty in SG
			non-cleft patients					shared almost the same growth tendency as noncleft controls.
2	Hoffmannova E et al. 2018	56 patients 3 days ± 1 day	cUCLP: complete UCLP group UCLP + b: UCLP with either a soft or combined tissue bridge LOP (Later operation protocol) group: cheiloplasty at 6 months of age Control group of non-cleft patients	cUCLP, UCLP + b	Modified Tennison technique	T0: before cheiloplasty T1: Before palatoplasty 10 months after lip surgery	11 landmarks Mophome3cs software	Variation in maxillary form was greatest in SG at T0. Shape variability in c UCLP approached that of UCLP+b at T1.

3	Jaklova L et al 2020	26 patients 5±5days	cBCLP: complete BCLP group BCLP + b: BCLP with either a soft or combined tissue bridge LOP (Later operation protocol) group: cheiloplast y at 6 months of age Control group of non-cleft patients	cBCLP BCLP + b	Modified Veau technique	T0: before cheiloplast y T1: Before palatoplast y 12±6 months after lip surgery	12 landmarks Mophome3cs software	Shape variability was most pronounce d in newborns (T0) within both cleft groups, and was especially severe in the cBCLP group. While a notable decrease in variability was noted in cBCLP patients, BCLP+B patients appeared to undergo favorable growth of the maxilla and palate.
4	Jaklova et al. 2021	68 newborns 14 days of birth	Study group: 51 UCLP and 17 BCLP No comparativ e groups	UCLP and BCLP	Modified Tennison (UCLP) or Veau (BCLP) technique.	T0: Before cheiloplast y (mean age of UCLP 4 ± 3 days, BCLP 6 ± 5 days) T1: before palatoplast y (mean age of UCLP 10 ±	Morphome3c s software	The palate of both cleft types increased overall in the period between cheiloplast y and palatoplast y in the anterior

						2 months, BCLP 12 ± 3 months).		and posterior directions of the maxillary segments. In the BCLP neonates, significant changes occurred mainly in the areas of the most intensive growth: on the premaxilla and the posterior and partly the anterior ends of the maxillary segments.

Table 3: Data extraction sheets

3. RISK OF BIAS AND QUALITY ASSESSMENT

The anatomical quality assessment (AQUA) tool[15] was used for risk of bias and quality assessment **(Table 4)**. Quality assessment was done independently by two investigators. Studies were assessed under 5 domains which were (i) Objective(s) and subject characteristics, (ii) Study design, (iii) Methodology characterisation, (iv) Descriptive anatomy and (v) Reporting of results. Each domain has a set of signalling questions to help assess and judge the ROB pertaining to it. The signalling questions were answered as "Yes", "No", or "Unclear". The question was rated as "Unclear" when the reported data was insufficient. The ROB for each domain was judged as "Low" and "High". If all the signalling questions for a domain were answered as "Yes," then the ROB for that domain was judged as "Low." If a signalling question had a "No" or "Unclear" rating, the respective domain was judged as having high ROB.

Table 4: QUALITY ASSESSMENT AND RISK OF BIAS; AQUA TOOL

SL.NO	STUDY	RISK OF BIAS (AQUA TOOL)		RISK OF BIAS
Domain 1: OBJECTIVE(S) AND SUBJECT CHARACTERISTICS				
1	**Hoffmannova E et al. 2016**	Was (Were) the objective(s) of the study clearly defined?	Y	Low
		Was (Were) the chosen subject sample(s) and sample size appropriate for the objective(s) of the study?	Y	
		Are the baseline and demographic characteristics of the subjects (age, sex, ethnicity, healthy or diseased, etc.) appropriate and clearly defined?	Y	
		Could the method of subject selection have in any way	Y	

		introduced bias into the study?		
Domain 2: STUDY DESIGN				
		Does the study design appropriately address the research question(s)?	Y	Low
		Were the materials used in the study appropriate for the given objective(s) of the study?	Y	
		Were the methods used in the study appropriate for the given objective(s) of the study?	Y	
		Was the study design, including methods/techniques applied in the study, widely accepted or standard in the literature? If "no", are the novel features of the study design clearly described?	Y	
		Could the study design have in any way introduced bias into the study?	Y	
Domain 3: METHODOLOGY CHARACTERIZATION				
		Are the methods/techniques applied in the study described in enough detail for them to be reproduced?	Y	Unclear
		Was the specialty and the experience of the individual(s) performing each part of the study (such as cadaveric dissection or image assessment) clearly stated?	N	
		Are all the materials and methods used in the study clearly described, includ- ing details of manufacturers, suppliers etc.?	Y	
		Were appropriate measures taken to reduce inter- and intra-observer variability?	N	
		Do the images presented in the study indicate an accurate reflection of the methods/techniques (imaging, cadaveric, intraoperative, etc.) applied in the study?	Y	
		Could the characterization of methods have in any way introduced bias into the study?	Y	
Domain 4: DESCRIPTIVE ANATOMY				
		Were the anatomical definition(s) (normal anatomy, variations, classifications, etc.) clearly and accurately described?	Y	Low
		Were the outcomes and parameters assessed in the study (variation, length, diameter, etc.) appropriate and clearly defined?	Y	

		Were the figures (images, illustrations, diagrams, etc.) presented in the study clear and understandable?	Y	
		Were any ambiguous anatomical observations (i.e., those likely to be classified as "others") clearly described/depicted?	N	
		Could the description of anatomy have in any way introduced bias into the study?	N	
Domain 5: REPORTING OF RESULTS				
		Was the statistical analysis appropriate?	Y	Low
		Are the reported results as presented in the study clear and comprehensible, and are the reported values consistent throughout the manuscript?	Y	
		Do the reported numbers or results always correspond to the number of sub jects in the study? If not, do the authors clearly explain the reason(s) for subject exclusion?	Y	
		Are all potential confounders reported in the study, and subsequently measured and evaluated, if appropriate?	Y	
		Could the reporting of results have in any way introduced bias into the study?	N	
SL.NO	**STUDY**	**RISK OF BIAS (AQUA TOOL)**		**RISK OF BIAS**
Domain 1: OBJECTIVE(S) AND SUBJECT CHARACTERISTICS				
2	**Hoffmannova E et al. 2018**	Was (Were) the objective(s) of the study clearly defined?	Y	
		Was (Were) the chosen subject sample(s) and sample size appropriate for the objective(s) of the study?	Y	
		Are the baseline and demographic characteristics of the subjects (age, sex, ethnicity, healthy or diseased, etc.) appropriate and clearly defined?	Y	
		Could the method of subject selection have in any way introduced bias into the study?	Y	
Domain 2: STUDY DESIGN				
		Does the study design appropriately address the research question(s)?	Y	Low
		Were the materials used in the study appropriate for the given objective(s) of the study?	Y	
		Were the methods used in the study appropriate for the	Y	

		given objective(s) of the study?		
		Was the study design, including methods/techniques applied in the study, widely accepted or standard in the literature? If "no", are the novel features of the study design clearly described?	Y	
		Could the study design have in any way introduced bias into the study?	N	
Domain 3: METHODOLOGY CHARACTERIZATION				
		Are the methods/techniques applied in the study described in enough detail for them to be reproduced?	Y	Unclear
		Was the specialty and the experience of the individual(s) performing each part of the study (such as cadaveric dissection or image assessment) clearly stated?	N	
		Are all the materials and methods used in the study clearly described, includ- ing details of manufacturers, suppliers etc.?	Y	
		Were appropriate measures taken to reduce inter- and intra-observer variability?	N	
		Do the images presented in the study indicate an accurate reflection of the methods/techniques (imaging, cadaveric, intraoperative, etc.) applied in the study?	Y	
		Could the characterization of methods have in any way introduced bias into the study?	Y	
Domain 4: DESCRIPTIVE ANATOMY				
		Were the anatomical definition(s) (normal anatomy, variations, classifications, etc.) clearly and accurately described?	Y	Low
		Were the outcomes and parameters assessed in the study (variation, length, diameter, etc.) appropriate and clearly defined?	Y	
		Were the figures (images, illustrations, diagrams, etc.) presented in the study clear and understandable?	Y	
		Were any ambiguous anatomical observations (i.e., those likely to be classified N as "others") clearly described/depicted?	Y	
		Could the description of anatomy have in any way introduced bias into the study?	N	

Domain 5: REPORTING OF RESULTS				
		Was the statistical analysis appropriate?	Y	Low
		Are the reported results as presented in the study clear and comprehensible, and are the reported values consistent throughout the manuscript?	Y	
		Do the reported numbers or results always correspond to the number of sub jects in the study? If not, do the authors clearly explain the reason(s) for subject exclusion?	Y	
		Are all potential confounders reported in the study, and subsequently measured and evaluated, if appropriate?	Y	
		Could the reporting of results have in any way introduced bias into the study?	N	
SL.NO	**STUDY**	**RISK OF BIAS (AQUA TOOL)**		**RISK OF BIAS**
Domain 1: OBJECTIVE(S) AND SUBJECT CHARACTERISTICS				
3	**Jaklova L et al. 2020**	Was (Were) the objective(s) of the study clearly defined?	Y	Low
		Was (Were) the chosen subject sample(s) and sample size appropriate for the objective(s) of the study?	Y	
		Are the baseline and demographic characteristics of the subjects (age, sex, ethnicity, healthy or diseased, etc.) appropriate and clearly defined?	Y	
		Could the method of subject selection have in any way introduced bias into the study?	Y	
Domain 2: STUDY DESIGN				
		Does the study design appropriately address the research question(s)?	Y	Low
		Were the materials used in the study appropriate for the given objective(s) of the study?	Y	
		Were the methods used in the study appropriate for the given objective(s) of the study?	Y	
		Was the study design, including methods/techniques applied in the study, widely accepted or standard in the literature? If “no”, are the novel features of the study design clearly described?	Y	
		Could the study design have in any way introduced bias into the study?	N	
Domain 3: METHODOLOGY CHARACTERIZATION				

		Are the methods/techniques applied in the study described in enough detail for them to be reproduced?	Y	Unclear
		Was the specialty and the experience of the individual(s) performing each part of the study (such as cadaveric dissection or image assessment) clearly stated?	N	
		Are all the materials and methods used in the study clearly described, includ- ing details of manufacturers, suppliers etc.?	Y	
		Were appropriate measures taken to reduce inter- and intra-observer variability?	N	
		Do the images presented in the study indicate an accurate reflection of the methods/techniques (imaging, cadaveric, intraoperative, etc.) applied in the study?	Y	
		Could the characterization of methods have in any way introduced bias into the study?	Y	
Domain 4: DESCRIPTIVE ANATOMY				
		Were the anatomical definition(s) (normal anatomy, variations, classifications, etc.) clearly and accurately described?	Y	Low
		Were the outcomes and parameters assessed in the study (variation, length, diameter, etc.) appropriate and clearly defined?	Y	
		Were the figures (images, illustrations, diagrams, etc.) presented in the study clear and understandable?	Y	
		Were any ambiguous anatomical observations (i.e., those likely to be classified as “others”) clearly described/depicted?	Y	
		Could the description of anatomy have in any way introduced bias into the study?	N	
Domain 5: REPORTING OF RESULTS				
		Was the statistical analysis appropriate?	Y	Low
		Are the reported results as presented in the study clear and comprehensible, and are the reported values consistent throughout the manuscript?	Y	
		Do the reported numbers or results always correspond to the number of sub jects in the study? If not, do the authors clearly explain the reason(s) for subject exclusion?	Y	

		Are all potential confounders reported in the study, and subsequently measured and evaluated, if appropriate?	Y	
		Could the reporting of results have in any way introduced bias into the study?	N	
SL.NO	**STUDY**	**RISK OF BIAS (AQUA TOOL)**		**RISK OF BIAS**
Domain 1: OBJECTIVE(S) AND SUBJECT CHARACTERISTICS				
4	**Jaklova L et al. 2021**	Was (Were) the objective(s) of the study clearly defined?	Y	Low
		Was (Were) the chosen subject sample(s) and sample size appropriate for the objective(s) of the study?	Y	
		Are the baseline and demographic characteristics of the subjects (age, sex, ethnicity, healthy or diseased, etc.) appropriate and clearly defined?	Y	
		Could the method of subject selection have in any way introduced bias into the study?	Y	
Domain 2: STUDY DESIGN				
		Does the study design appropriately address the research question(s)?	Y	Low
		Were the materials used in the study appropriate for the given objective(s) of the study?	Y	
		Were the methods used in the study appropriate for the given objective(s) of the study?	Y	
		Was the study design, including methods/techniques applied in the study, widely accepted or standard in the literature? If “no”, are the novel features of the study design clearly described?	Y	
		Could the study design have in any way introduced bias into the study?	N	
Domain 3: METHODOLOGY CHARACTERIZATION				
		Are the methods/techniques applied in the study described in enough detail for them to be reproduced?	Y	Unclear
		Was the specialty and the experience of the individual(s) performing each part of the study (such as cadaveric dissection or image assessment) clearly	N	
		stated?		
		Are all the materials and methods used in the study clearly described, includ- ing details of manufacturers, suppliers etc.?	Y	

		Were appropriate measures taken to reduce inter- and intra-observer variability?	N	
		Do the images presented in the study indicate an accurate reflection of the methods/techniques (imaging, cadaveric, intraoperative, etc.) applied in the study?	Y	
		Could the characterization of methods have in any way introduced bias into the study?	Y	
Domain 4: DESCRIPTIVE ANATOMY				
		Were the anatomical definition(s) (normal anatomy, variations, classifications, etc.) clearly and accurately described?	Y	Low
		Were the outcomes and parameters assessed in the study (variation, length, diameter, etc.) appropriate and clearly defined?	Y	
		Were the figures (images, illustrations, diagrams, etc.) presented in the study clear and understandable?	Y	
		Were any ambiguous anatomical observations (i.e., those likely to be classified as "others") clearly described/depicted?	Y	
		Could the description of anatomy have in any way introduced bias into the study?	N	
Domain 5: REPORTING OF RESULTS				
		Was the statistical analysis appropriate?	Y	Low
		Are the reported results as presented in the study clear and comprehensible, and are the reported values consistent throughout the manuscript?	Y	
		Do the reported numbers or results always correspond to the number of sub jects in the study? If not, do the authors clearly explain the reason(s) for subject exclusion?	Y	
		Are all potential confounders reported in the study, and subsequently measured and evaluated, if appropriate?	Y	
		Could the reporting of results have in any way introduced bias into the study?	N	

4. RESULTS

Study Selection

The PRISMA flow diagram gives an overview of the selection process (Figure 1). The search strategy yielded a total of 100 studies. Four studies [16–19] were finally included in this systematic analysis after two-stage selection criteria which included title and abstract reading followed by full text reading. Twelve studies were excluded which included case reports, non-comparative studies and due to lack of consideration of palatal characteristics. No randomised clinical trials were

found on this topic.

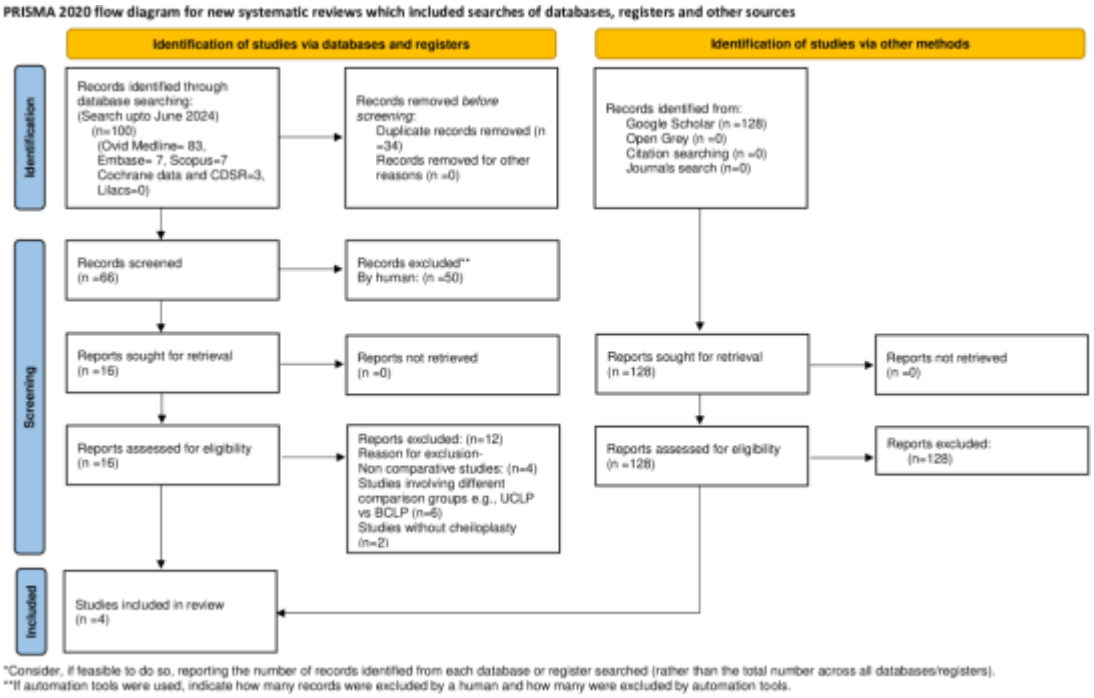

Figure 1: PRISMA flow diagram of the study

5. RISK OF BIAS ASSESSMENT IN INCLUDED STUDIES (TABLE 4)

No article was excluded after the AQUA tool application. All the included studies were adjudged to have a low risk of bias.

1. STUDY CHARACTERISTICS

A summary of the characteristics of all studies is displayed in Table 3. All the selected studies were published between 2016-2021. Hoffmanova et al.[17] compared the palatal morphology in patients with complete unilateral cleft lip and palate (cUCLP) who underwent the Modified Tennison technique of ENC with those who underwent lip repair at 6 months of age. In addition, they also included a control group of non-cleft patients. They extended their study in 2018[16] and included patients with UCLP with either a soft or combined tissue bridge (UCLP+b) as the 4th group. Jaklova et al.[18] compared the palatal vault shape in infants who underwent ENC by modified Veau technique. A total of 4 groups were included which included complete Bilateral Cleft Lip and Palate (cBCLP), BCLP with soft tissue bridge (BCLP+b), LOP and a control group of non-cleft subjects. They conducted another similar study in 2021[19] wherein they assessed palatal morphology in UCLP and BCLP patients with no comparison between the two groups.

2. QUALITATIVE ANALYSIS

Using a combination of three-dimensional (3-D) geometric morphometric methods and classical morphometry, Hoffmanova et al. (2016) compared the maxillary morphology before and 10 months after neonatal cheiloplasty in patients of Czech origin. “Coherent point drift dense correspondence analysis (CPD-DCA)” was used to study the palatal vault morphology. Geometric morphometry revealed greater variation in maxillary form in the neonatal group. The size variation represented by Principal Component analysis (PC1) showed 51.1% variability against only 15.3% in the shape (PC2).

There was maxillary growth in all directions and reduction in cleft width. The same authors conducted a prospective study to compare maxillary arch in UCLP patients who underwent ENC (surgery at 3 days) and compared it with non-cleft controls and patients who underwent Late Operation Protocol (LOP) (surgery at 3-6 months of age). By using PCA of the corresponding shape variables, the shape variability of the upper dental arch in patients with cUCLP and UCLP+b was examined. Shape variability in cUCLP group was maximum at age 0 which approached the shape parameters in the patients with UCLP+b. The shape variability was found to decrease after 10 months of age. A similar study was conducted by Jaklova et al. on patients with BCLP and the data was compared to that of patients with BCLP+b. Metric analysis,

multivariate statistics, superprojection techniques, and coherent point drift-dense correspondence analysis were among the analyses used for studying shape variability. While palatal variability in neonatal cBCLP was higher, it decreased over 12 months and approximated that of BCLP + B. The premaxilla and the anterior and partially posterior ends of the maxillary segments were the main locations of the regions with the most noticeable palatal growth. Favourable growth changes appeared in BCLP+b group compared to the other group. The same authors compared the data obtained from BCLP patients to that from UCLP patients. PCA found that maximum shape variability was found in individuals with BCLP at T0 compared to UCLP. This variability decreased over time but still remained higher than UCLP patients. Infants with BCLP or UCLP did not have restricted anterior or posterior palatal growth, according to morphometric evaluation. Even though the inter canine and anterior widths diminished during the first year of life, the reduction in cleft was instead brought on by intense anterior growth in conjunction with the formative effects of cheiloplasty rather than the narrowing of dentoalveolar arches.

6. DISCUSSION

In this systematic review, strict selection criteria were used to include articles related to geometric morphometric analysis of palatal shape variability in patients with UCLP or BCLP defects undergoing ENC. This systematic review also set out to assess the growth of the upper dental arch in patients with cleft defects, ascertain whether cheiloplasty had an adverse effect on this growth, and examine the effects of the type and severity of the cleft on this growth.

Risk of Bias assessment using the AQUA tool revealed low risk of bias as the surgical protocol was standardised in all the included studies and were carried out at appropriate age groups.

All the included studies evaluated shape variability through scatter plots of the 2 components of the principal component analysis (PCA)[20]. PC1, which stood for premaxillary retraction, premaxillary centralisation, and maxillary segment growth, described alterations in growth. PC2 was used to represent all other cleft type differences including alveolar cleft width. PC1 exhibited higher differences in the BCLP group compared to the UCLP group irrespective of the time period. PC2 demonstrated greater cleft widths at T0 than at T1 as is expected post-surgical lip repair and its effect on the cleft maxillary arch.

The palatal shape variability was greatest at T0 (before cheiloplasty) in all the groups especially in patients with BCLP. This supports the well-known fact that shape variability is greatest in non-operated cleft patients compared to non-cleft controls (Bugaighis et al., 2010[21]; Bejdova et al., 2012[22]; Ruskova et al.,2014[23]; Hoffmannova et al., 2016, 2018[16,17]). The reason for this discrepancy is that each CLCP patient has a unique palate morphology. Shape variability is also higher in BCLP cases when compared to UCLP. The premaxilla lacks a stable shape because it is only joined to the maxilla by soft tissues rather than bone in BCLP patients while only the cleft side of the maxilla is affected in UCLP patients. This is also reflected in facial shape variability as reported by Singh et al (2007)[24].

Morphometric analysis of the UCLP palate revealed a reduction in shape variability by 10 months post ENC. The shape variability and growth tendency approached that of healthy non-cleft control at the end of 10 months. This may be attributed to the fact that the anterior cleft width decreased as a result of anterior growth and the formative influence of the repaired lip, which in turn reduced the upper jaw defect.

The degree of the cleft has been shown in numerous studies to be a crucial factor that may influence the results of surgery and growth. Alveolar cleft width, which is larger in cUCLP patients than in UCLP + b patients, was found to decrease more in cUCLP patients during development than in UCLP + b patients[25].

Among the cleft types, the UCLP+b group and the BCLP+b group demonstrated favourable growth and minimum shape variability compared to the more severe counterparts. This is in agreement to the study by Smahel Z et al.[26] which stated that both an osseous and a soft tissue bridge exert a favorable effect on the shortening and retrusion of the maxilla and thus also on the maxillo-mandibular relations and on facial configuration in cleft patients.

Various growth changes were observed in the maxillary arches following ENC. An increase in inter- tuberosity width was evident in all cleft groups following ENC and such changes were not evident following LOP. However, these changes have been determined to be due to normal physiological growth of the infants and not due to the lip repair[27]. Numerous studies have reported a significant effect of cleft severity on the negative relationship between palatal length and cleft size. The findings of our review were consistent with these studies and confirmed that palatal length showed decrease after ENC and LOP. This is thought to be due to retraction and centralisation of arches in cleft patients following lip repair. According to some studies, the palatal length does not change between cheiloplasty and palatoplasty in cleft patients. This inconsistency may be due to different surgical techniques used in these studies. Further research is required to determine the effect of surgical technique on change in palatal length in cleft subjects.

Inter-canine width remained near constant upto 10 months following ENC while it showed a mild decrease following LOP. This also implies that cheiloplasty in no way inhibits or decreases the normal maxillary posterior growth in cleft patients. Numerous studies provide strong support for the reduced growth trend observed in patients who underwent LOP[28]. This also strengthens the evidence that the reduction in alveolar cleft width is not due to constrictive effect of surgical lip repair. Further research in this direction is required if the lip pressure on the maxillary arches is sufficient enough to bring about

any restrictive changes.

The technique of lip repair did not seem to affect the shape variability in any manner as might be expected. Jaklova et al (2020)[18] in their study included patients who has undergone ENC by modified Veau‟s technique. There was no dentoalveolar arch constriction or palate length reduction. Alveolar cleft widths decreased as a result of anterior maxillary segment growth and the reconstructed lip‟s formative influence. Premaxillary size was linked to the severity of the cleft, which in turn was correlated with this reduction. These findings were similar in the other studies wherein the lip repair was done by the modified Tennison‟s technique.

A thorough morphometric analysis of the BCLP palate provided evidence in favour of the theory that ENC does not impede palatal growth in any way. Previous studies assessing palatal growth in neonates following LOP reported similar outcomes[29]. Those with BCLP+b were expected to grow more favourably, and more extended anterior expansion of maxillary segments was observed in them[16,17,30]. This was associated with the occlusive effect of the reconstructed lip during cheiloplasty[27,31,32], which caused the diameter of the alveolar cleft to decrease. Throughout the first year of life, the premaxilla becomes more retrusive and centralised as a result of the favourable forming effects of ENC[33].

3. CONCLUSION

Palatal shape variability after neonatal cheiloplasty is a multifaceted issue that can impact surgical outcomes, functional development, and aesthetic results. Continuous monitoring and individualized follow-up care are crucial for managing these variations and ensuring optimal outcomes for patients. Our review concluded that shape variability was maximum in BCLP patients at the pre-surgical level. Lip repair brought about a reduction in shape variability at post-surgery. There was a decrease in inter- canine width, significant only in BCLP patients. ENC did not adversely affect anterior or posterior growth in cleft patients. ENC could be an equivalent or even better alternative to LOP in cleft lip repair. However, more randomised trials are required to form a better conclusion regarding the efficacy and effect of these two surgical procedures on the morphology of the palate in cleft patients.

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