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Review

Influence of vomer flap on craniofacial growth in patients with cleft lip and palate: A systematic review

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ABSTRACT

The aim of this review was to evaluate the impact of the vomer flap on craniofacial growth in patients with cleft lip and palate. The review was conducted according to the PRISMA checklist and is registered in the International Prospective Register of Systematic Reviews (PROSPERO — CRD42018095714). Two investigators performed the research using the PubMed/MEDLINE, Embase, and Web of Science databases for studies published until November 2018. The focused question was 'Does the vomer flap have a lesser impact on craniofacial growth in patients with cleft lip and palate?'. A total of 13 articles was selected for this review, comparing the vomer flap technique with other flap surgery techniques. The outcomes analyzed were: facial development (primary outcome); and the growth of the maxilla and mandible, occlusion, occurrence of fistula, and speech development (secondary outcomes). It was concluded that there is no difference in impact between vomer flap and the other flap surgery techniques on craniofacial development.

1. Introduction

The main objective of surgical treatment in patients with cleft lip and palate is the anatomical closure of the defect in order to prevent impairment of speech development and feeding, while ensuring that there is no significant restriction of maxillary growth, which in turn may be influenced by the choice of surgical protocol (Rohrich et al., 2000; Shaw et al., 1992; Silva Filho et al., 2001, Agrawal, 2009). Therefore, several protocols have been proposed for the treatment of patients with cleft lip and palate in an attempt to minimize the influence of surgery on craniofacial growth. The protocols vary according to the techniques employed, period of intervention, treatment sequence for lip, hard, and soft palate correction, and presurgical orthodontic and orthopedic interventions (Silva Filho et al., 2001; Kulewicz and Dudkiewicz, 2010).

It has been hypothesized that the scars caused by palatoplasty procedures contribute to maxillary growth disturbances. Therefore, some studies have proposed techniques to reduce scarring in the palate (Fudalej et al., 2012). In addition, some authors have reported that surgical time might also be an influencing factor limiting maxillary growth (Graber, 1949; Bardach et al., 1984; Friede and Enemark, 2001).

The vomer flap surgical technique for closure of the hard palate has been used since 1926, and has undergone subsequent modifications (Liao et al., 2014; de Jong and Breugem, 2014). The advantages of this type of flap are ease of execution, minimal trauma to tissues, and reduced surgical time. Additionally, the flap is located in a region of good vascularization, and provides effective nasal coverage in most types of fissure, thereby proving to be useful in the majority of patients with cleft lip and palate (Kobus, 1984; Agrawal and Panda, 2006).

The treatment of patients with cleft lip and palate is complex, and although there are a large number of surgical procedures in use, there is no consensus regarding the most effective technique. This may be attributed to the numerous criteria that need to be considered and evaluated in formulating the ideal treatment method (Rohrich et al., 2000; Agrawal, 2009; Kulewicz and Dudkiewicz, 2010). Therefore, this systematic review was carried out to establish whether the vomer flap has a lesser impact on craniofacial growth in patients with cleft lip and palate.

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2. Materials and methods

2.1. Registry protocol

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Moher et al., 2010). Furthermore, the methods used in this systematic review were registered in the International Prospective Register of Systematic Reviews (PROSPERO — CRD42018095714).

2.2. Eligibility criteria

The study focused on addressing the following question: 'Does the vomer flap have a lesser impact on craniofacial growth in patients with cleft lip and palate?'. The PICO tool was used to identify the components of clinical evidence, which are as follows:

1. Population — non-syndromic patients with cleft lip and palate.
2. Intervention — patients who underwent vomer flap for correction of cleft in the hard palate.
3. Comparison — patients who underwent other surgical techniques for correction of cleft in the hard palate.
4. Outcome — craniofacial growth (primary outcome); speech development and occurrence of fistula (secondary outcomes).

Randomized controlled trials (RCTs) and prospective and retrospective studies were included in this review (retrospective studies were included because of the limited number of RCTs on the subject). In vitro studies, animal studies, case series, case reports, and systematic reviews were excluded.

2.3. Information sources and search

Two independent authors (LM, CAAL) conducted an electronic search of the PubMed/MEDLINE, Embase, and Web of Science databases for articles published until March 2018. The keywords used were: ((“cleft lip"[MeSH Terms] OR (“cleft"[All Fields] AND “lip"[All Fields]) OR “cleft lip"[All Fields]) AND (“palate"[MeSH Terms] OR “palate"[All Fields]) AND (“vomer"[MeSH Terms] OR “vomer"[All Fields]) AND (“surgical flaps"[MeSH Terms] OR (“surgical"[All Fields] AND “flaps"[All Fields]) OR “surgical flaps"[All Fields] OR “flap"[All Fields])) OR ((“cleft palate"[MeSH Terms] OR (“cleft"[All Fields] AND “palate"[All Fields]) OR “cleft palate"[All Fields]) AND (“vomer"[MeSH Terms] OR “vomer"[All Fields]) AND (“surgical flaps"[MeSH Terms] OR (“surgical"[All Fields] AND “flaps"[All Fields]) OR “surgical flaps"[All Fields] OR “flap"[All Fields])).

2.4. Data collection process

One author (LM) collected relevant information from the articles and a second author (CAAL) reviewed all the information collected. Careful analyses were carried out in cases of author disagreement, which were resolved through discussion with a third author (JMLG) until a consensus was reached.

2.5. Risk of bias

Two investigators (LM and JMLG) assessed the methodological quality of the studies using the Newcastle-Ottawa scale (NOS) for cohort studies, which is based on three major components: selection, comparability, and outcome. According to the NOS, a maximum of nine stars can be given to a study, and represents the highest quality. A score of five or fewer stars indicates a high risk of bias, while a score of six or more stars indicates a low risk of bias. In one study, by Ganesh et al. (2015), which was a randomized controlled trial (RCT), the Cochrane scale was used to assess the risk of bias.

2.6. Additional analyses

The kappa statistic (κ) was used to determine inter-reader agreement during the article selection process in the database search.

3. Results

3.1. Study selection

The database search retrieved 243 articles: 85 from PubMed/MEDLINE, 71 from Web of Science, and 87 from Embase. After the removal of duplicates, 89 studies remained. After reading the titles and abstracts, 52 studies were selected for complete reading, of which 39 were excluded using the eligibility criteria. Finally, 13 studies were selected for this review (Fig. 1).

The inter-investigator agreement for articles selected from PubMed/MEDLINE ($\kappa = 0.82$), Embase ($\kappa = 0.89$), and the Web of Science ($\kappa = 0.92$) indicated a high level of agreement (Landis and Koch, 1977).

3.2. Study characteristics

Of the 13 studies included in this review (Jonsson et al., 1980; Tanino et al., 1997; Silva Filho et al., 2001; Friede and Enemark, 2001; Melissaratou and Friede, 2002; Johnston et al., 2004; Kulewicz and Dudkiewicz, 2010; Fudalej et al., 2012, 2013; Liao et al., 2014; Ganesh et al., 2015; Xu et al., 2015; Rossell-Perry, 2018), one was a randomized clinical study (Ganesh et al., 2015) while the

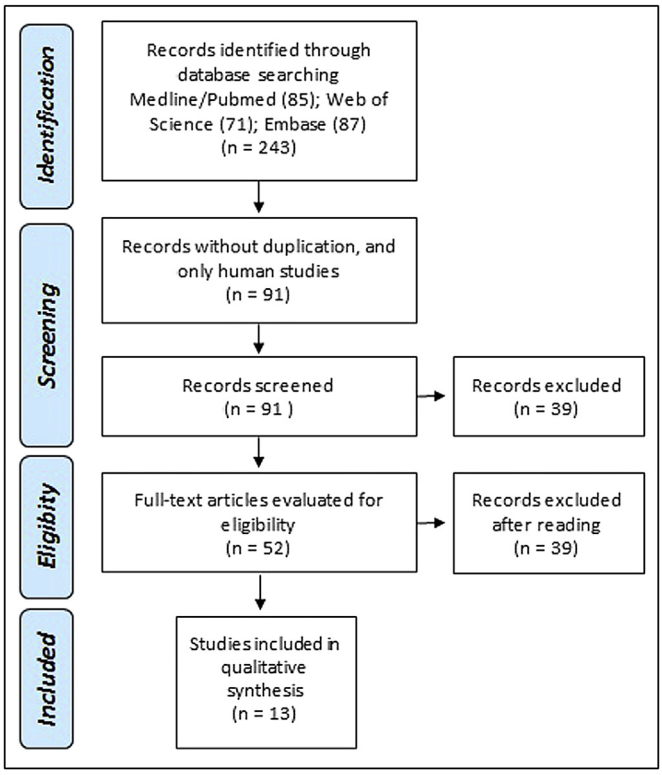

Fig. 1. Flowchart of the search strategy.

others were retrospective studies. 789 patients were evaluated: 755 with complete unilateral cleft lip and palate; 12 with complete bilateral cleft lip and palate; and 22 with incomplete unilateral cleft lip. No evaluated patient had any associated syndrome (Tables 1 and 2).

One study (Fudalej et al., 2012) did not report the gender of the patients in one of the evaluated groups, while another study (Tanino et al., 1997) did not report the gender of any of the included patients. In all, 451 male and 253 female patients were identified.

Seven of the studies (Silva Filho et al., 2001; Fudalej et al., 2013; Johnston et al., 2004; Kulewicz and Dudkiewicz, 2010; Liao et al., 2014; Xu et al., 2015; Friede and Enemark, 2001) included in this review performed cephalometric analyses, of which one study (Johnston et al., 2004) carried out a complementary evaluation using cast models. Five studies (Fudalej et al., 2012; Jonsson et al., 1980; Melissaratou and Friede, 2002; Tanino et al., 1997; Rossell-Perry, 2018) evaluated craniofacial growth using cast models, and one study (Ganesh et al., 2015) used intraoral photographs.

With regard to the number of surgeons involved in corrective surgery of the hard palate, six studies (Fudalej et al., 2012, 2013; Ganesh et al., 2015; Jonsson et al., 1980; Kulewicz and Dudkiewicz, 2010; Rossell-Perry, 2018) reported that only one surgeon performed the procedure, while three studies (Tanino et al., 1997; Melissaratou and Friede, 2002; Xu et al., 2015) did not provide information on the number of surgeons. Friede and Enemark (2001) reported that a single surgeon carried out the procedures, using one of the techniques. In the study by Liao et al. (2014), a team of eight surgeons performed the surgical intervention. Johnston et al. (2004) reported on a study involving two surgeons, while three surgeons performed the procedure in the study by Silva Filho et al. (2001).

In four studies (Jonsson et al., 1980; Kulewicz and Dudkiewicz, 2010; Fudalej et al., 2012, 2013) the test groups underwent the same surgical protocol regarding the sequence of operation involving the lip, soft palate, and hard palate, and the groups were as homogeneous as possible in terms of gender and number of patients, with the exception of the study by Fudalej et al. (2012), where there was a difference in the number of patients evaluated.

This review included studies comparing the results of the vomer flap with the other surgical techniques for hard palate repair, namely: von Langenbeck (Fudalej et al., 2012; Silva Filho et al., 2001; Kulewicz and Dudkiewicz, 2010), modified von Langenbeck (Jonsson et al., 1980; Kulewicz and Dudkiewicz, 2010; Fudalej et al., 2013), Wardill-Kilner (Johnston et al., 2004), two flap (Ganesh et al., 2015; Liao et al., 2014), Sommerlad (Xu et al., 2015), bone graft (Friede and Enemark, 2001), pushback (Tanino et al., 1997; Melissaratou and Friede, 2002), and single flap from the non-cleft side (Rossell-Perry, 2018).

3.3. Risk of bias/quality analysis of the included studies

Of the studies evaluated in this review, one (Liao et al., 2014) was assigned the maximum number of stars (nine). Two studies (Fudalej et al., 2012; Tanino et al., 1997) received eight stars; three studies (Fudalej et al., 2013; Kulewicz and Dudkiewicz, 2010; Rossell-Perry, 2018) obtained seven stars, five studies (Silva Filho et al., 2001; Friede and Enemark, 2001; Johnston et al., 2004; Melissaratou and Friede, 2002; Xu et al., 2015) received six stars, and one study (Jonsson et al., 1980) was assigned five stars according to the Newcastle-Ottawa scale (Table 3).

The Cochrane scale was applied to the study by Ganesh et al. (2015), and demonstrated a low risk of bias. This was based on six of the seven principles on the scale used for the assessment of risk of bias (Table 4).

3.4. Maxilla

Two studies (Fudalej et al., 2012; Silva Filho et al., 2001) did not report significant differences in maxillary growth outcomes between the vomer flap and von Langenbeck flap techniques. Johnston et al. (2004), who compared the vomer flap with the Wardill-Kilner technique, and Fudalej et al. (2013), who compared the vomer flap with the modified von Langenbeck technique, also did not report any differences.

Five studies (Ganesh et al., 2015; Liao et al., 2014; Kulewicz and Dudkiewicz, 2010; Jonsson et al. 1980; Tanino et al., 1997) demonstrated better results for the vomer flap when compared with the two-flap, von Langenbeck, modified von Langenbeck, and pushback techniques. However, among these studies, Jonsson et al. (1980) reported better growth of the maxilla when the vomer flap technique was used in the period between lip closure and palate closure. Tanino et al. (1997) showed better outcomes for the vomer flap technique until the age of 4 years, after which no significant differences in growth were noticed.

Three studies showed negative outcomes with the vomer flap technique. Friede and Enemark (2001) reported greater maxillary

Table 1
Summary of the qualitative analysis of included studies. Cephalometric analysis.

Study	Study design	Country	Nº of patients and gender	Cleft type	Operation sequence	Technique of repair of hard palate	Method
Xu et al. (2015)	Retrospective	China	G1: 18 (13M; 5F) G2: 22 (15M; 5F) G3: 20 (15M; 5F)[a]	UCLP and UICL	G1: L + HP (6–12m) – SP (18–30m) G2: L (3–6m) – HP + SP (18–30m) G3: L (6–12m)	G1: Vomer flap G2: Sommerlad G3: Cheilotoplasty only	Cephalometric
Liao et al. (2014)	Retrospective	China	G1: 45 (23M; 22F) G2: 50 (28M; 22F)	UCLP	G1: L (6m) – HP (14.7m) – SP (21.4m) G2: L (5.5m) – HP (13m) + SP (13m)	G1: Vomer flap G2: Two flap	Cephalometric
Fudalej et al. (2013)	Retrospective	Poland	G1: 37 (21M; 16F) G2: 37 (21M; 16F)	UCLP	G1: L + SP + HP (10m) G2: L + HP + SP (9m)	G1: Modified von Langenbeck G2: Vomer flap	Cephalometric
Kulewicz and Dudkiewicz (2010)	Retrospective	Poland	G1: 22 (16M; 6F) G2: 22 (14M; 8F) G3: 22 (16M; 6F)	UCLP	G1: L + HP + SP (7.4m) G2: L + HP + SP (7.2m) G3: L + HP + SP (7.3m)	G1: von Langenbeck G2: Modified von Langenbeck G3: Vomer flap	Cephalometric
Johnston et al. (2004)	Retrospective	Ireland	G1: 13 (10M; 3F) G2: 21 (13M; 8F)	UCLP	G1: L (3–6m) – HP + SP (12–18) G2: L + HP (3–6m) – SP (12–18m)	G1: Wardill-Kilner G2: Vomer flap + von Langenbeck	Cephalometric and cast
Friede and Enemark (2001)	Retrospective	Sweden	G1: 30 (25M; 5F) G2: 30 (23M; 7F)	UCLP	G1: L + HP (3m) – SP (22m) G2: L (2m) – SP (8m) – HP (104m)	G1: Vomer + pushback G2: Bone graft	Cephalometric
Silva Filho et al. (2001)	Retrospective	Brazil	G1: 53 (33M; 20F) G2: 22 (12M; 10F)	UCLP	G1: L (9m) – SP + HP (19m) G2: L + SP (5.5m) – HP (20m)	G1: von Langenbeck G2: Vomer flap	Cephalometric

Key: G1: group 1; G2: group 2; G3: group 3; M: male; F: female; UCLP: unilateral complete clef lip and palate; UICL: unilateral incomplete cleft lip and palate; L: lip; PM: soft palate; PD: hard palate.
[a] Control group: patients with cleft lip only.

Table 2
Summary of the qualitative analysis of included studies. Cast analysis.

Study	Study design	Country	Nº of patients and gender	Cleft type	Operation sequence	Technique of repair of hard palate	Method
Rossell-Perry (2018)	Retrospective	Peru	G1: 28 (21M; 7F) G2: 32 (22M; 10F)	UCLP	G1: L + HP (3m) − SP (6m) G2: L (3m) − HP + SP (12m) − AC (60m)	G1: Vomer flap G2: Single flap from the non-cleft side	Cast
Ganesh et al. (2015)	RCT	India	G1: 40 (24M; 16F) G2: 45 (23M; 22F)	UCLP	G1: L + HP (5.22m) − SP (12.3m) G2: L (6.3m) − HP + SP (12.9m)	G1: Vomer flap G2: Two flap	Intraoral photographs
Fudalej et al. (2012)	Restrospective	Poland	G1: 47 (27M; 20F) G2: 61	UCLP	G1: L + SP + HP (10.4m) G2: L + SP + HP (9.1m)	G1: von Langenbeck G2: Vomer flap	Cast
Melissaratou and Friede (2002)	Restrospective	Sweden	G1: 16 (12M; 4F) G2: 12 (8M; 4F)	UCLP and BCLP	G1: L (3–7m) − SP (12m) − HP (102–111m) G2: L + HP (2–5m) − SP (12m)	G1: Vomer flap G2: Pushback	Cast
Tanino et al. (1997)	Retrospective	Japan	G1: 6 G2: 6	UCLP	G1: L − SP (4.6m) − HP (19.3m) G2: L − SP (4.6m) + HP (19m)	G1: Pushback G2: Vomer flap + full thickness skin graft	Cast
Jonsson et al. (1980)	Retrospective	Sweden	G1: 11 (8M; 3F) G2: 11 (8M; 3F)	UCLP	G1: L (41m) − HP + SP (18m) G2: L (41m) − HP + SP (21m)	G1: Vomer flap + autogenous skin graft G2: Modified von Langenbeck	Cast

Key: G1: group 1; G2: group 2; RCT: randomized controlled trials; M: male; F: female; UCLP: unilateral complete clef lip and palate; UICL: unilateral incomplete cleft lip and palate; BCLP: bilateral complete cleft lip and palate; L: lip; SP: soft palate; HP: hard palate; AC: alveolar cleft.

Table 3
Risk of bias of the non-RCT (prospective) studies, according to the Newcastle-Ottawa scale.

Studies	Selection				Comparability		Outcome			Total
	Exposed cohort	Non exposed cohort	Ascertainment of exposure	Outcome of interest not present at start	Main factor	Additional factor	Assessment of outcome	Follow-up long enough	Adequacy of follow-up	
Rossell-Perry (2018)	☆	☆	☆	☆	0	☆	☆	0	☆	7
Xu et al. (2015)	☆	☆	☆	☆	☆	0	0	0	☆	6
Liao et al. (2014)	☆	☆	☆	☆	☆	☆	☆	☆	☆	9
Fudalej et al. (2013)	☆	☆	☆	☆	☆	0	0	☆	☆	7
Fudalej et al. (2012)	☆	☆	☆	☆	☆	0	☆	☆	☆	8
Kulewicz and Dudkiewicz (2010)	☆	☆	☆	☆	☆	0	0	☆	☆	7
Johnston et al. (2004)	☆	☆	☆	☆	☆	0	0	0	☆	6
Friede and Enemark (2001)	☆	0	☆	☆	☆	☆	0	☆	0	6
Melissaratou and Friede (2002)	☆	☆	☆	☆	☆	0	0	☆	0	6
Silva Filho et al. (2001)	☆	☆	☆	☆	☆	0	0	0	☆	6
Tanino et al. (1997)	☆	☆	☆	☆	☆	☆	0	☆	☆	8
Jonsson et al. (1980)	☆	☆	☆	☆	☆	0	0	0	0	5

retrusion in patients treated using with this type of flap. Xu et al. (2015) found that repair of the hard palate with vomer flap inhibited vertical maxillary growth, and Melissaratou and Friede (2002) demonstrated that patients treated with mucoperiosteal flaps in the delayed hard palate repair protocol frequently showed slightly better development of maxillary arch width. In addition, the depth of the arch was also found to increase, while in the group undergoing vomer flap treatment, growth remained approximately the same.

3.5. Facial development

Five studies (Silva Filho et al., 2001; Xu et al., 2015; Fudalej et al., 2013; Kulewicz and Dudkiewicz, 2010; Friede and Enemark, 2001) evaluated the influence of the hard palate repair techniques on facial development. Three studies (Silva Filho et al., 2001; Xu et al., 2015; Fudalej et al., 2013) that compared vomer flap with von Langenbeck, modified von Langenbeck, and Sommerlad techniques did not report any difference in facial development between groups. In contrast, Friede and Enemark (2001) demonstrated worse facial convexity, and Kulewicz and Dudkiewicz (2010) demonstrated higher craniofacial development in patients treated with vomer flap.

Table 4
Risk of bias of RCT studies, according to the Cochrane scale.

	Ganesh et al. (2015)
Sequence generation	LOW
Allocation concealment	LOW
Blinding of participants, personnel, and outcome assessors	HIGH
Incomplete outcome data	LOW
Selective outcome reporting	LOW
Other sources of bias	LOW

3.6. Mandible

The studies that evaluated the growth of the mandible (Silva Filho et al., 2001; Xu et al., 2015; Liao et al., 2014) demonstrated that the surgical technique used to repair the palate did not influence mandibular growth in patients.

3.7. Jaws relations

Kulewicz and Dudkiewicz (2010) and Fudalej et al. (2012) reported a decrease in maxillary–mandibular discrepancy and thereby more favorable results in patients treated with the vomer flap technique. Liao et al. (2014) revealed that a Le Fort I advancement was required in 44% of patients undergoing the two-flap technique, compared with 20% of patients treated with the vomer flap. Rossell-Perry (2018) demonstrated no statistically significant

differences between one- and two-stage palatoplasty with respect to dental arch relationships at 5 years of age.

3.8. Occlusion

Ganesh et al. (2015) evaluated occlusion using the GOSLON scale, and showed better outcomes in patients treated with the vomer flap. In the study by Johnston et al. (2004), although no statistically significant difference was observed between the groups, it was revealed that four of the 13 patients treated with the Wardill-Kilner technique presented with bad or very bad category GOSLON scores (grades 4 or 5), while only one of the 21 patients treated with vomer flap received grade 4 or 5.

Jonsson et al. (1980) reported a 64% frequency of crossbite in patients treated with vomer flap, while 73% of patients treated with the modified von Langenbeck technique reported a crossbite at 5 years. Similarly, Tanino et al. (1997) revealed severe crossbite in two patients who underwent treatment with the pushback technique that would require orthognathic surgery with intensive orthodontic procedures. On the other hand, Liao et al. (2014) found no significant difference in the percentage of patients with anterior crossbite between the evaluated groups, while Melissaratou and Friede (2002) reported worse occlusion results for patients treated with the vomer flap technique.

3.9. Fistula

Two studies (Ganesh et al., 2015; Liao et al., 2014) reported the occurrence of a fistula. Ganesh et al. (2015) reported one fistula in the vomer flap patient group, and no occurrence of fistula in the two-flap technique group. Liao et al. (2014) reported the occurrence of six fistulas in patients treated with vomer flap, and no fistulas with the use of the two-flap technique. Rossell-Perry (2018) reported no significant difference in functional vestibular oronasal fistula development between the studied techniques for unilateral cleft palate repair.

3.10. Speech

Four studies (Friede and Enemark, 2001; Ganesh et al., 2015; Tanino et al., 1997; Rossell-Perry, 2018) reported on the effects of surgical technique on speech development. Friede and Enemark (2001) reported that both groups of patients (vomer and bone graft) demonstrated good speech development; however, in some patients who underwent delayed hard palate closure with bone graft, speech development was normalized only after closure of the hard palate. Ganesh et al. (2015) reported better speech development in patients treated with the two-flap technique, and Tanino et al. (1997) reported better speech outcomes in patients treated with the pushback technique. Rossell-Perry (2018) reported a mean index score for 5-year-olds of 2.43 in the vomer flap protocol group, and 2.69 in the second group. These scores were not significantly different ($p = 0.88$).

4. Discussion

Several methodological challenges may be encountered while evaluating the superiority of surgical techniques performed for closure of cleft palate. This is largely a result of the number of related variables, such as the number of surgeons involved, surgical repair time, center-to-center comparison, and other postoperative treatments (Johnston et al., 2004). In the light of these factors, this systematic review needs to be evaluated with caution.

Four studies (Hotz and Gnoinski, 1979; Blocksma et al., 1975; Slaughter and Pruzansky, 1954; Tanino et al., 1997) revealed that the sequence of corrective surgeries can influence the final outcome. These studies concluded that two-stage palatoplasty would result in better speech outcomes, without interfering with maxillary growth. Three other studies (Capelozza Filho et al., 1996; Silva Filho et al., 2001, 2018) reported that palate repair in a single surgical procedure increases the chances of a retrognathic jaw, which could be attributed to increased surgical time rather than the repair technique used (Capelozza Filho et al., 1996; Silva Filho et al., 2018; Semb, 1991; Molsted et al., 1992; Agrawal and Panda, 2006). On the other hand, two studies (Semb, 1991; Molsted et al., 1992) showed that a protocol involving two-stage surgery resulted in a reduction in facial height and sagittal length of the maxilla.

Xu et al. (2015) reported that the time of repair of the hard palate was more important than the sequence of corrective surgery for the hard and soft palate. In agreement with this, two other studies (Richard et al., 2006; Mommaerts et al., 2006) demonstrated that there were no differences in outcome between one- and two-stage repair of the hard palate, owing to the similar time for repair.

A review of the literature suggests that the time of closure of the hard palate could have a major influence on craniofacial development. Some authors (Tanino et al., 1997; Graber, 1949; Fara and Brousilova, 1969) argue that delaying cleft palate surgery to a later age may cause less interference with maxilla growth. Friede and Enemark (2001) demonstrated better results when delayed closure of the hard palate was performed. The study cited the following reasons for success: when surgery was performed at a later age, the growth of the maxilla was almost complete, and therefore the chances of interference in maxillary development were lower (Bardach et al., 1984; Schweckendiek and Doz, 1978); when the soft palate was closed, the remaining cleft on the hard palate was found to narrow spontaneously, facilitating late repair of the hard palate, and thereby providing support for the technique of palatal closure in two surgical stages.

Some studies (Silva Filho et al., 2001; Johnston et al., 2004) suggest that corrective surgical intervention of the palate in the precocious stage can improve function; however, it is unclear if this intervention will cause morphological growth disturbances.

The surgical technique used has also been indicated as an influencing factor for craniofacial development. The scar tissue resulting from surgical intervention in the palatal area has been demonstrated to create a rigid fibrous region that would impair the separation of the maxillary bones required for maxilla development (Delaire and Precious, 1985; Melissaratou and Friede, 2002). Three studies (Liao et al., 2014; Kulewicz and Dudkiewicz 2010; Fudalej et al., 2012) categorized the groups based on gender, age, and the sequence of lip, soft, and hard palate surgeries, using surgical technique as the sole variable, and observed favorable results with the vomer flap technique, thus demonstrating the influence of the surgical procedure on final outcomes. Furthermore, Kulewicz and Dudkiewicz (2010), who performed a comparison between three groups based on the same protocol, and altering only the surgical technique used for closure of the hard palate, showed differences in craniofacial morphology in all three groups.

The vomer flap has been reported to result in favorable outcomes for craniofacial morphology due to limited elevation of the mucoperiosteal flap of the hard palate (Kulewicz and Dudkiewicz, 2010; Friede et al., 1991; Pigott et al., 2002; Ross, 1987). The favorable results seen with this technique can be attributed to minimization of the area of palate that needs to heal. In addition, the mucosa of the vomer can be used as an additional source of soft tissue to cover areas of raw bone and thus reduce scar formation (Jonsson et al., 1980; Pigott et al., 2002; Karsten et al., 2003).

Tanino et al. (1997) reported that the vomer flap technique ensures creation of a deeper palate, especially in the middle

portion, which is favorable for the intraoral environment in that it can accommodate the tongue in a better position and consequently allow better speech development. A low tongue position and shallow palate may also be a factor in the induction of mandibular prognathism.

The experience and ability of the surgeon is another factor that has been reported to influence the outcome of growth in many studies (Fudalej et al., 2012, 2013; Ross, 1987). Ganesh et al. (2015) reported worse speech results and the occurrence of a fistula in one of the patients treated using the vomer flap technique, and linked this to the skills of the surgeon, because this technique had only recently been introduced in that institution, whereas the surgeons operating on the (two-flap) control group had 10 years of experience. However, Liao et al. (2014) did not consider that the experience of the surgeon could affect outcome, because the vomer flap technique, which had been in use for a shorter period of time in their study, showed better results compared with the two-flap technique that had been in use for a longer period of time.

Fudalej et al. (2012) reported that the initial width of the cleft could influence the outcome of corrective surgery. Some retrospective studies (Peltomaki et al., 2001; Honda et al., 2002) have suggested that individuals with a wide cleft lip and palate show decreased facial growth, whereas Johnston et al. (2004) found no relationship between crevice width and growth deficiency. Jonsson et al. (1980) equated the comparative groups to the initial cleft size, and demonstrated that the transverse maxillary width in the canine region increased by 11% from the time of lip closure to closure of the palate in the vomer flap group, compared with 5% in the modified von Langenbeck group, after which the width remained practically unchanged in both groups.

Caution must be exercised in interpretation of the results presented in this review because of the number of variables involved. Additionally, in spite of the studies presenting a low risk of bias, most analyses were performed without randomization and may be subject to failure. Some studies (Liao et al., 2014; Johnston et al., 2004; Jonsson et al., 1980) reported the loss of patient information (cephalometric analyses and/or cast models). Follow-up visits are a significant factor in assessing the outcome of craniofacial growth; however, most studies failed to conduct an adequate number of follow-up visits.

Despite the discordance in results of the included studies, the vomer flap technique was found to be favorable in five studies (Ganesh et al., 2015; Liao et al., 2014; Kulewicz and Dudkiewicz, 2010; Jonsson et al., 1980; Tanino et al., 1997), while four studies (Fudalej et al., 2012, 2013; Silva Filho et al., 2001; Johnston et al., 2004) did not find significant differences between the surgical techniques. One possible explanation for disagreement could be the difference in investigation protocols with regard to the technique used and timing of surgeries, which may have caused facial growth disturbances, thereby influencing the final results.

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Competing interests

The authors declare that there were no conflicts of interest in the elaboration of this study.

Ethical approval

Not applicable.

Patient consent

Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2019.03.011.

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