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REVIEW ARTICLE

Surgical Management of Growing Patients through Orthognathic Surgery: A Review

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Abstract

Facial aesthetics has a meaningful relationship with the capacity of people to form interpersonal relationships, which can lead to cases of harassment when there are severe facial disharmonies. For a long time, orthognathic surgery has been indicated in patients whose growth has ended in order to achieve more stable and predictable results over time. However, there are cases where psychosocial stress due to dentofacial deformities makes necessary to intervene patients at a younger age. This review article aims to describe the surgical management and stability of growing patients through orthognathic surgery attained from the reported English literature during the last 50 years. From all the information gathered, a surgical protocol has been proposed at the end of this article, based on the expected results and the surgical technique carried out, in order to obtain the most stable and predictable results possible. Despite the lack of existing evidence regarding this subject and the quality of these studies, orthognathic surgery in growing patients is a surgical procedure that should be performed in cases where patients could develop more severe problems in the future, mainly in the psychosocial aspect.

Keywords

Orthognathic surgery, Growth, Development, Dentofacial deformities

Introduction

The management of growing patients with severe dentofacial anomalies often presents a challenge for both orthodontists and surgeons, largely due to the lack of published articles regarding the times of various surgical procedures, their effects on the continuity of dentofacial development and its stability over time, which is why orthognathic surgery is usually indicated after the end of its growth.

However, there are situations in which postponing surgical intervention may lead to several problems, whether functional or aesthetic, the latter being one of the main indications to anticipate the surgical procedure for psychosocial reasons, both in the short and long term, where it has been seen that facial appearance is a important factor in the determination of interpersonal relationships.

Following this, it is essential to possess a detailed knowledge of normal craniofacial growth, where the vertical, sagittal and transversal maxillary development differs both in their peak of development and the finalization of it. Likewise, the different surgical techniques used in orthognathic surgery allow the surgeon, in certain occasions, a management of the maxillofacial growth axes.

Due to this, it becomes necessary to carry out and individualized evaluation of each of these patients to determine an adequate diagnosis and phase of maxillofacial growth in which it is found. This information will allow us to define a surgical treatment plan in the short and long term, establishing a sequence of systematized surgical procedures, responding to the problems of each patient in particular.

Material and Methods

A structured sensitive literature search was per-

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Table 1: Search strategy.

Database	Search strategy
PubMed	("Orthognathic Surgery" OR "Le Fort" OR "Sagittal Split Ramus Osteotomy") AND ("Early" OR "Growth" OR "Adolescent" OR "Child" OR "Development") NOT (“Cleft” OR “Syndrome” OR “Cleft Palate” OR “Adult”) (“Osteotomy, Le Fort”[Mesh] OR “Osteotomy, Sagittal Split Ramus”[Mesh] OR “Orthognathic Surgery”[Mesh]) AND (“Child”[Mesh] OR “Adolescent”[Mesh] OR “Growth and Development” [Mesh]) NOT (“Syndrome”[Mesh] OR “Adult”[Mesh] OR “Cleft Palate”[Mesh])
EBSCO Dentistry & Oral Sciences Source	("Orthognathic Surgery" OR "Le Fort" OR "Sagittal Split Ramus Osteotomy") AND ("Early" OR "Growth" OR "Adolescent" OR "Child" OR "Development") NOT (“Cleft” OR “Syndrome” OR “Cleft Palate” OR “Adult”)
Scopus	("Orthognathic Surgery" OR "Le Fort" OR "Sagittal Split Ramus Osteotomy") AND ("Early" OR "Growth" OR "Adolescent" OR "Child" OR "Development") NOT (“Cleft” OR “Syndrome” OR “Cleft Palate” OR “Adult”)
The Cochrane Library	(((“Orthognathic Surgery”) OR (“Le For t”) OR (“Sagittal Split Ramus Osteotomy”)) AND ((“Adolescent”) OR (“Child”) OR (“Growth”) OR (“Development”) OR (“Early”)) NOT ((“Cleft”) OR (“Syndrome”) OR (“Cleft Palate”) OR (“Adult”)))
Epistemonikos	(((“Orthognathic Surgery”) OR (“Le For t”) OR (“Sagittal Split Ramus Osteotomy”)) AND ((“Adolescent”) OR (“Child”) OR (“Growth”) OR (“Development”) OR (“Early”))

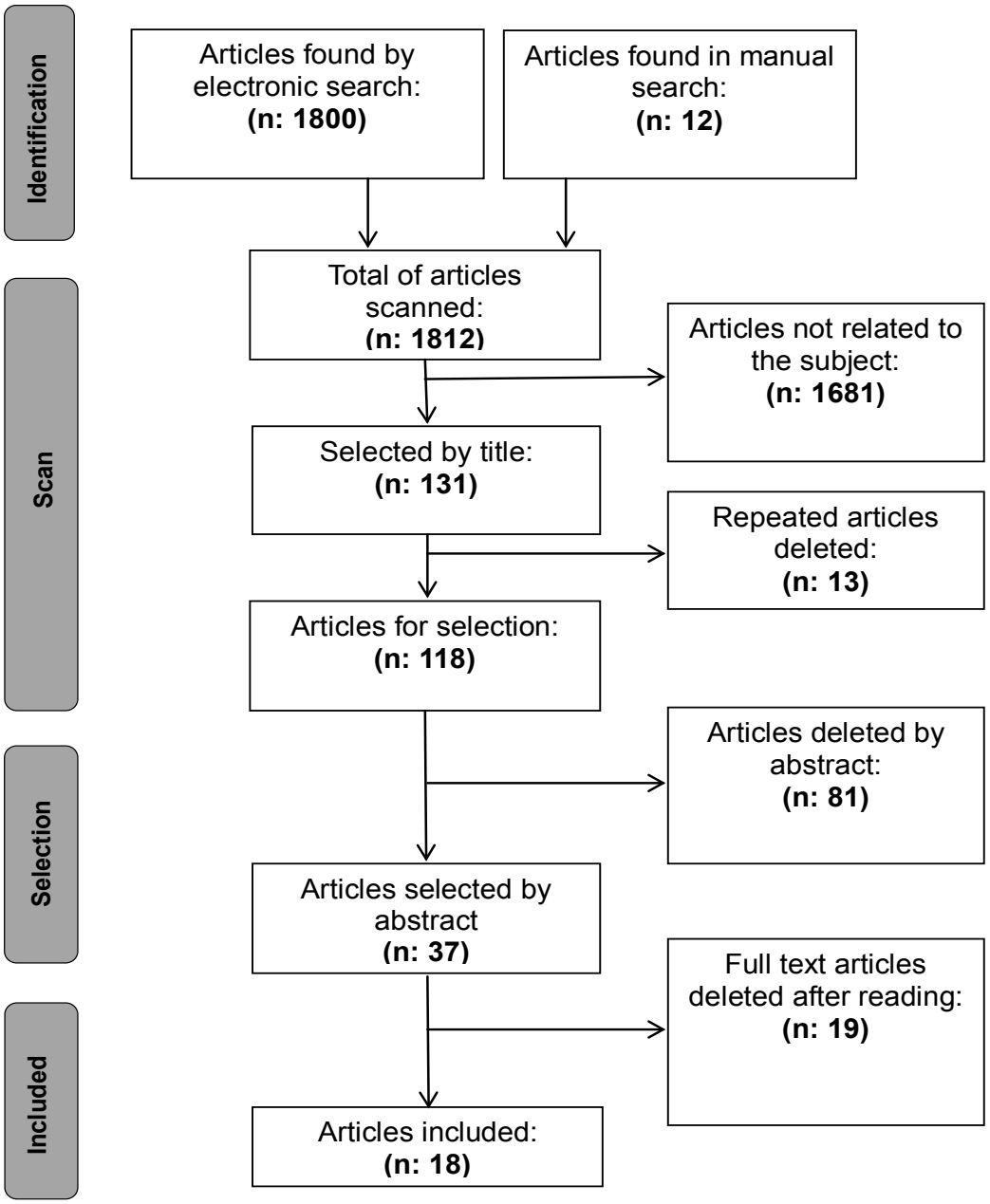

Figure 1: Articles selection flow chart.

formed in multiple web-based search engines and bibliographic databases that catalogue published research: PubMed/MEDLINE, EBSCO Dentistry & Oral Science Source, Scopus and The Cochrane Library (until June 2018). The MeSH terms used were "Osteotomy, Le Fort", "Orthognathic Surgery", "Osteotomy, Sagittal Split Ramus", "Adolescent", "Child", "Syndrome", "Cleft Palate" and "Adult". The used non-MeSH terms were: "Growth", "Development", "Early" and "Cleft", with boolean operators "AND", "OR" & "NOT" (Table 1). There was no publication date filter, however language filters were applied to the search (english/spanish). Additionally, a manual search for references, to explore filtered findings, was conducted. A total of 18 articles, published between 1979 and 2017 were included in this review (Figure 1). Articles that included growing patients with diagnosis of dentofacial anomalies of non-syndromic origin treated by orthognathic surgery were included, while those that included cleft patients or an adult population, without distinction in the sample, were discarded. The collected data was then organized and validated using the Oxford Centre for Evidence-based Medicine (CEBM)-Levels of Evidence criteria and its corresponding recommendation grades. The CONSORT statement [1] was used for reporting randomized clinical trials, the STROBE statement [2] for reporting observational studies, and the CARE statement [3] for case reports.

Results

Our systematized structure literature search identified 18 articles, categorized as follows: 1 clinical trial, 11 observational studies, 4 cases reports and 2 narrative reviews. These articles were classified according to 1) Treated dentofacial deformity; 2) Surgical technique

Table 2: Articles selection results.

	Authors	Year	Journal	Article	Surgical technique	Dentofacial deformities	Average age
1	Wolford, et al. [15]	2001	Am J Orthod Dentofacial Orthop	Review	Sagittal split ramus osteotomy Inverted "L" Osteotomy Vertical ramus osteotomy High condylectomy Anterior mandibular osteotomy Mandibular body osteotomy Genioplasty	Mandibular hypoplasia Mandibular hypoplasia Anterior mandibular dentoalveolar deformities Condilar hyperplasia	--
2	Wolford, et al. [12]	2001	Am J Orthod Dentofacial Orthop	Review	Le Fort I maxillary osteotomy Horseshoe maxillary osteotomy Anterior maxillary osteotomy	Maxillary osteotomy Sagittal maxillary excess Vertical maxillary hyperplasia	--
3	Villegas, et al. [6]	2010	J Clin Orthod	Case series	Le Fort I osteotomy Sagittal split ramus osteotomy High condylectomy Genioplasty	Vertical maxillary hyperplasia Mandibular hyperplasia Maxillary hypoplasia	Girls: 13.5 years
4	Capelli, et al. [7]	2012	Dental Press J Orthod	Case series	Le Fort I osteotomy Vertical ramus osteotomy	Mandibular hyperplasia Maxillary hypoplasia	Doesn't specify
5	Huang, et al. [21]	1982	Am J Orthod	Observational	Vertical ramus osteotomy Sagittal split ramus osteotomy Anterior maxillary osteotomy Genioplasty	Mandibular hypoplasia	Boys: 14.1 years Girls: 13.4 years

6	Proffit, et al. [18]	2010	Int J Oral Maxillofac Surg	Observational	Doesn't specify	Mandibular hypoplasia	Boys: 17.5 years Girls: 15 years
7	Washburn, et al. [13]	1982	J Oral Maxillofac Surg	Observational	Le Fort I osteotomy	Vertical maxillary hyperplasia	14.2 years
8	Mogavero, et al. [14]	1997	Am J Orthod Dentofac Orthop	Clinical Trial	Le Fort I osteotomy	Vertical maxillary hyperplasia	14.5 years
9	Mojdehi, et al. [4]	2001	Am J Orthod Dentofac Orthop	Observational	Le Fort I osteotomy	Vertical maxillary hyperplasia	12.8 years
10	Marangoni, et al. [22]	2016	J Cranio-Maxillofac Surg	Observational	Le Fort I osteotomy Sagittal split ramus osteotomy Genioplasty	Maxillary hyperplasia Mandibular hypoplasia Vertical maxillary hyperplasia Mandibular hyperplasia	14.5 years
11	Wolford, et al. [17]	1979	J Maxillofac Surg	Observational	Sagittal split ramus osteotomy	Mandibular hypoplasia	13.5 years
12	Precious, et al. [23]	1985	Int J Oral Surg	Observational	Le Fort I osteotomy Sagittal split ramus osteotomy Anterior maxillary osteotomy Vertical ramus osteotomy Mandibular body osteotomy Anterior mandibular subapical osteotomy Coronoidectomy	Vertical maxillary hyperplasia Mandibular hypoplasia Mandibular hyperplasia Maxillary hypoplasia Sagittal maxillary excess	13.9 years
13	O'Keefe, et al. [9]	2016	J Irish Dent Assoc	Case report	Le Fort I osteotomy Sagittal split ramus osteotomy	Maxillary hypoplasia Mandibular hyperplasia	15.5 years
14	Schendel, et al. [16]	1978	Oral Surg Oral Med Oral Pathol	Observational	Sagittal split ramus osteotomy	Mandibular hypoplasia	13.5 years
15	Wolford, et al. [5]	2009	Proc (Bayl Univ Med Cent)	Observational	Le Fort I osteotomy Sagittal split ramus osteotomy High condylectomy	Condylar hyperplasia	Group 1: 17.5 years Group 2: 16.6 years
16	Bodine, et al. [19]	2016	Progress in Orthodontics	Observational	Doesn't Specify	Adolescent internal condylary resorption	15.2 years
17	Hedge, et al. [8]	2012	Kathmandu Univ Med J	Case report	Anterior maxillary osteotomy	Vertical maxillary hyperplasia	Boys: 14 years
18	Galiano, et al. [20]	2017	CRANIO®	Observational	Doesn't specify	Adolescent internal condylary resorption	16.5 years

Anomaly	Concomitant anomaly	Growth rate	Surgical technique	Considerations
Vertical maxillary hyperplasia	---	Increased	Le Fort I osteotomy	Sagittal growth inhibition
			Anterior maxillary osteotomy	Favorable vertical growth pattern
		Increased	Horseshoe maxillary osteotomy	Favorable vertical growth pattern
				Sagittal growth with possible few alterations
Sagittal maxillary excess	---	Increased	Le Fort I osteotomy	Sagittal growth inhibition
				A skeletal class III could be developed post-surgery
		Increased	Horseshoe maxillary osteotomy	
				Sagittal growth with possible few alterations
				Election technique in these cases
	Vertical maxillary hyperplasia	Increased	Le Fort I osteotomy	Favorable vertical growth pattern
				Sagittal growth inhibition
	Vertical maxillary hyperplasia	Increased	Horseshoe maxillary osteotomy	Favorable vertical growth pattern
				Sagittal growth with possible few alterations
Maxillary hypoplasia	---	Decreased	Le Fort I osteotomy with overcorrection	A second surgery will probably be necessary at the end of growth
				Skeletal class III relapse
				Perform as closest to growth cessation as possible
	---	Decreased	Horseshoe maxillary osteotomy with overcorrection	Due to sagittal growth deficit, a second surgery will probably be necessary
				Skeletal class III relapse
				Perform as closest to growth cessation as possible
	Mandibular hyperplasia	Increased/ decreased	Le Fort I osteotomy + BSSO + high condylectomy	Vertical mandibular growth inhibited in most part
				Perform as closest to growth cessation as possible
Mandibular hyperplasia	---	Normal	Uni/bilateral sagittal split ramus osteotomy	Unaltered post-surgical mandibular growth
		Increased	BSSO + high condylectomy	Most of mandibular growth inhibited.
				It can be simultaneous with the high condylectomy.
				At first a high condylectomy and in a second surgical time perform the orthognathic surgery
	Maxillary hypoplasia	Normal	Le Fort I osteotomy + BSSO + high condylectomy	Mandibular and sagittal maxillary growth inhibited with post-surgical stability
Mandibular hypoplasia	---	Normal	Uni/bilateral sagittal split ramus osteotomy + genioplasty	Mandibular post-surgical growth unaltered.
	---	Decreased	Uni/bilateral sagittal split ramus osteotomy + genioplasty	Another surgery will probably be necessary due to mandibular growth deficit
	Adolescent internal condylar resorption	Normal	Le Fort I osteotomy + BSSO + removal of bilaminar tissues and disc reposition	No post-surgical mandibular growth alterations. Stability in the long term.

and 3) Patients mean age at the moment of the surgery (Table 2). Eleven articles did not make a distinction between male and female patients, which have different growth peaks. Regarding the age of the patients at the moment of surgery, Mojdehi, et al. [4] has the lowest average age (12.8 years), meanwhile Wolford, et al. [5] has the highest (17.5 years). The amount of maxillary anomalies is 16 (47%), where the most prevalent is the vertical maxillary hyperplasia (50%) in the maxilla and the mandibular hypoplasia (39%) in the mandible, followed closely by the mandibular hyperplasia (33%), from the 18 mandibular anomalies. For the treatment of maxillary deformities, the most used technique was the Le Fort I maxillary osteotomy (67%), followed by the

anterior maxillary osteotomy (27%) and the horseshoe maxillary osteotomy (1%). On the other hand, the most commonly used mandibular techniques were the sagittal split ramus osteotomy (36%), the vertical ramus osteotomy (16%) and the genioplasty (16%). The complementary use of the high condylectomy technique was described in 3 articles.

Discussion

The current evidence contains a large number of articles that mention the surgical techniques used in orthognathic surgery; however, the greater number of these procedures are carried out in adult patients who have already completed their growth, which is why there is not enough studies regarding surgical protocols in patients who haven't completed their development and who, for many reasons, should be treated. Among the reasons that can lead to a premature intervention in this kind of patients, it can be found the excessive dentofacial anomalies, functional problems, and the psychosocial stress, being the last one the main reason for surgery [6-9]. In these cases, self-esteem, physical affection and the ability to establish interpersonal relationships can be affected, with serious complications in the long term, where a relationship between being a victim of bullying during childhood and suicide attempts along life has been observed, with an odds ratio of 3.75 [10]. It has also been established that the social and psychosocial influence of dental and facial appearance is an important factor in the perception of people regarding the kindness, social status, popularity and intelligence of an individual, with teeth being the main mocking reason in bullying [11].

Vertical maxillary hyperplasia

According to Wolford, et al. [12], when treating these kind of anomalies, regardless of the surgical technique performed, the vertical growth will remain unaffected, contrary to the development in the sagittal axis. Regarding the stability after maxillary replacement in patients with residual growth, the maxillary reposition is a stable procedure during growth in patients between 10 and 16 years of age, seen at a 12-78 months post-surgical follow-up, and even early intervention may favor the disproportionate growth characteristic of vertical excess [13]. The reduction of the vertical height produces a mandibular self-rotation and decrease of the lower facial third [13], indicative of adaptive compensations due to the mandibular surgical replacement and self-rotation, without changes in the vertical growth pattern both maxillary and mandibular [14].

Finally, a relationship between postoperative stability and the type of fixation used was found, where in a study of 48 patients with an average age of 14.63 years (DE = 1.37 years), it was concluded that the segmented osteotomy has little or null effect on maxillary vertical growth, and that rigid fixation provides superior stability in the sagittal axis in the long term, when compared with wire fixation [14].

Sagittal maxillary hyperplasia

Only 2 articles evaluate the maxillary excess in the sagittal axis [12,13], where both stated that the continuity of growth in this axis is dependent on the surgical technique performed, where this is related to the integrity of the septal cartilage. This could mean that the Le Fort I maxillary osteotomy would completely inhibit sagittal development, while the horseshoe maxillary osteotomy (dentoalveolar osteotomy) would allow continuity in growth. Despite this, none of the authors supports this theory with post-operative growth studies, therefore it is correct to indicate that evidence is needed to support this hypothesis.

Sagittal maxillary hypoplasia

Is mainly characterized by a deficit in the growth in the sagittal axis of the maxilla, being necessary in many cases a new surgical intervention once the development is finished. Despite this, there are situations where it is necessary to carry out orthognathic surgery due to functional alterations, such as the psychosocial stress that patients present due to dentoskeletal anomalies [7,9]. In a series of cases [7] where 6 patients with severe facial anomalies were analyzed, 5 were skeletal class III and presented severe functional and psychosocial problems, which is why they were operated at approximately 15 years, with a new class III in the long term due to continuous mandibular development. Despite this, at the time of finishing the growth, only 1 patient was re-intervened, mainly due to the satisfaction of the rest with the results achieved and the greater stability of the new skeletal class III.

Mandibular hyperplasia

In cases where there is an accelerated growth pattern at the mandibular level, it is recommended to perform a sagittal split ramus osteotomy (SSRO) with a complementary high condylectomy, in order to stop the growth. It can also be performed a single bilateral high condylectomy when there are no alterations in the mandible at that point [5,7,12,15]. Studies comparing the long-term stability of a group of patients where orthognathic surgery (Le Fort I maxillary osteotomy + SSRO) was complemented with a high condylectomy in relation to those which only orthognathic surgery was performed, showed that patients belonging to the first group obtained stable results in the long term, even in cases where the age of patients does not exceed 14 years; while those of the second group presented higher recurrence [5-7].

Mandibular hypoplasia

When analyzing the long-term results of pediatric

patients after bilateral SSRO, it has been seen good skeletal balance and an harmonious posterior dentofacial development [16,17]. When comparing the stability of these patients with adults, in those patients who had already finished their growth, achieved more stable results in the long term, however, from the psychosocial point of view, changes were similar [18]. In cases where there is a pattern of insufficient mandibular growth, it has been described the adolescent internal condylar resorption (AICR) as a cause [19,20]. When comparing the mandibular growth pattern after the removal of the bilaminar tissues surrounding the condyles and bimaxillary orthognathic surgery with healthy patients, it was possible to determine that the subsequent development was normalized [19]. The removal of the bilaminar tissues is performed because there is an increase in receptors that may predispose an exaggerated response in this tissue [19]. Galiano, et al. [20] in a retrospective study conducted in 24 patients with an average age of 16.5 years, analyzed the results of AICR by means of disc replacement and orthognathic surgery. It was seen a significant reduction in temporomandibular and facial pain, along with fewer headaches. Improvements in the chewing function and a good skeletal and occlusal stability were maintained in the long term [20].

From all this data gathered, a surgical protocol has been proposed for the treatment of different dentoskeletal anomalies and their various combinations when accompanied by other alterations

Limitations

One of the main limitations of the present review is the quality of the selected articles. Despite having carried out a sensitive search in multiple databases and search engines, the information collected dates from many years back, with unstandardized variables and shortcomings in the report of information, such as the age of each patient at the time of surgery, type of surgical technique performed and the orthodontic treatment duration. On the other hand, the level of evidence in these articles consist mainly of observational studies, partly due to the difficulty of carrying out randomized clinical trials in this kind of patients due to the ethical considerations that this implies.

Conclusion

Although it is advisable to wait for patients to finish their growth to perform surgery, there are cases where it is not possible due to psychosocial factors that are positively altered after surgical interventions. Regarding the available evidence, although this is scarce and the available articles date back many years, with small samples and a little impact, these tend to yield similar results in terms of long-term stability, with multiple reports of cases with acceptable results regarding the improvement in the psychosocial aspect and the increase in the quality of life of these patients. Due to the differences in the type and magnitude of the dentoskeletal anomaly of each patient, it is necessary to carry out individual evaluations where the altered growth patterns are defined and the influence of these alterations in the psychosocial profile of each individual. Because of the circumstances in which these interventions are carried out (psychosocial stress), it is important to manage the expectations of both parents and children, and to warn about the possibility of a second surgical intervention after the cessation of growth.

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