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Treatments Associated with the Management of Condylar Resorption After Orthognathic Surgery: A Systematic Review

Tratamientos Asociados al Manejo de la Reabsorción Condilar Después de la Cirugía Ortognática: Una Revisión Sistemática

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ABSTRACT: Condylar Reabsorption after orthognathic surgery is a rare but well-known clinical entity that affects the temporomandibular joint (TMJ). The development of a protocol is recommended because there are few standardized treatments for the approach of this clinical consequence. The objective of this systemic review is to describe the treatments associated with the management of condylar reabsorption after orthognathic surgery. A search was made in the Pubmed, Google Scholar, Science Direct and Crochane databases from1990 to 2022 using the following keywords: orthognathic surgery adding condylar resorption, progressive condylar resorption, idiopathic condylar resorption, condylar atrophy or condylysis. All articles were selected based on the inclusion and exclusion criteria preventatively established. The systematic review began with 15,182 articles, and after applying the inclusion and exclusion criteria this number was reduced to 21 articles. The total number of patients obtained was 3,285 with a predilection for the female gender in 47.5 % (n = 1,561) and 12.75 % (n = 419) for the male. The range of ages goes from 14 to 50 years, with a mean of 23.7 +/- 6. The patients were diagnosed in 90.7 % (n = 2,979) with class II dentoskeletal deformity and 9.31 % (n = 306) with class III dentoskeletal deformity. 247 were diagnosed with condylar reabsorption after orthognathic surgery. Only three authors clearly describe the treatments indicated in patients diagnosed with condylar resorption after orthognathic surgery; one being joint replacement and orthognathic surgery, another one referring to treating condylar reabsorption with orthognathic surgery retreatment and the last one used a costochondral graft. There are few standardized treatments for the management of condylar resorption in patients that underwent orthognathic surgery. The main problem of the research was represented by the existing diversity in the literature and in the way of reporting the treatments carried out.

KEY WORDS: condylar resorption, orthognathic surgery, temporomandibular joint

INTRODUCTION

Condylar Resorption (CR) was reported for the first time in 1978 as a condylar atrophy after performing sagittal osteotomy of the bilateral advancement ramus for the correction of mandibular retrognathism, without defined cause, and associated it with a biomechanical phenomenon due to increased muscle tension. (Phillips & Bell, 1978).

CR after orthognathic surgery is a rare but well-recognized clinical entity that affects the temporomandibular joint (TMJ). The literature commonly defines it as a progressive alteration in the shape and volume of the mandibular condylar head following bilateral sagittal split ramus osteotomy, bimaxillary surgery, or isolated Le Fort I osteotomy (Kerstens *et al*., 1990; Hoppenreijs *et al*., 1998). Several theories have been proposed to explain its pathophysiology. The most widely accepted suggests that the condyle undergoes adaptive responses to mechanical stress in an effort to maintain morphology, function, and occlusal homeostasis referred to as functional condylar remodeling. However, when mechanical stress exceeds the adaptive capacity of the host, dysfunctional condylar remodeling may occur, ultimately leading to CR (Wolford *et al*., 2003; Gunson *et al*., 2012).

CR produces significant clinical and radiographic manifestations, including loss of vertical dimension, progressive retrognathism, and anterior open bite; some patients may also present with temporomandibular symptoms (Moore *et al*., 1991; Merkx *et al*., 1991; Hwang *et al*., 2004). Several theories have been proposed to explain the etiology of this condition. It has been associated with hormonal influences in young female patients presenting with Class II (CII) deformities and anterior open bite. CR has also been described in relation to local factors such as microtrauma, trauma, and congenital malformations or systemic conditions, including inflammatory or infectious diseases. These factors can be further categorized into surgical and non-surgical contributors, all of which should be identified prior to orthognathic surgery to determine which patients may be at increased risk (Arnett *et al*., 1996; De Clercq *et al*., 1994).

The treatment is very little discussed in the literature (Hoppenreijs *et al*., 1998; Wolford & Gonçalves, 2015), there are conservative treatments such as the use of splints, physiotherapy, drug therapy and slightly more radical treatments such as orthognathic surgery, bone distraction, condylectomy with reconstruction using autologous grafts and joint prostheses. However, despite the rarity of the condition, the scientific study of it has been subjected to different types of research including the most rigid research parameters such as systematic reviews and meta-analyses, purging the scientific content with the strictest possible methodological matrices, seeking parity, standardization of data and treatments. (López Alonso & Rivero-Sánchez, 2006; Liberati, *et al*., 2009; Urrútia, *et al*., 2010).

The purpose of this study is to evaluate all the available literature on condylar resorption after orthognathic surgery, to discuss the pathophysiology and clinical features of this disease, as well as surgical and non-surgical factors that can lead to it.

MATERIAL AND METHOD

This systematic review was developed using the PRISMA statement or matrix (Preferred Reports for Systematic Reviews and Meta-Analyses) as a guide and establishing a research question with the PICO question parameter (P: definition of the problem or patient; I: intervention to be analyzed, refers to interventions, treatments, causes, among others; C: comparison intervention [if applicable]; O: results, which must be clinically, socially or economically relevant). PICO question posed to this research: What treatments can be performed to prevent and correct condylar resorption in patients who have been treated with orthognathic surgery? The PRISMA framework consists of a 27-item checklist and a four-phase flow diagram that correspond to the title, abstract, introduction, methods, results, discussion, and funding sections of scientific articles. The flow diagram begins at the earliest stage of the review process, documenting the total number of records or citations identified through searches conducted in all databases or additional sources. It then reports the number of unique records remaining after duplicate removal and concludes with the individual studies included in the qualitative synthesis and quantitative synthesis. PRISMA also clarifies the distinctions at each stage between records or bibliographic references, full-text articles and individual studies.

In the first search, abstracts were reviewed and all articles containing the keywords were retained. Full versions were obtained for all articles that met the inclusion criteria. In the second search and evaluation, the reference lists of all articles withheld after the first round were manually screened for appropriate studies relevant to the review topic. A search of unpublished literature was not performed. Reports and case series were also evaluated, with the aim of identifying reported cases. The electronic search was complemented by a manual search of the reference lists of the articles already identified. In the third search, each of the publications was critically reviewed for validity assessment and the following data were extracted from the accepted

articles and recorded in a standardized spreadsheet: age, gender, type of dentoskeletal deformity, shape of neck inclination, hormonal changes, history of previous condylar pathology, type of surgery performed, type of fixation, follow-up and type of treatment for CR. The search strategy in the literature was carried out independently by two calibrated evaluators (C.R. and H.G.) following the same search pattern, using as inclusion criteria: articles in English and Spanish, clinical studies in humans, randomized studies, prospective, multicenter, comparative articles, case series and retrospective (with the aim of identifying risk factors for CR), studies with a follow-up of more than one year. As well as the following exclusion criteria: case report, descriptive studies, opinion articles and CR cases associated with systemic diseases.

The following databases were incorporated into the systematic search for relevant literature: PubMed, Sciencedirect, Cochrane, Google Scholar, considering the literature from 1990 to 2022. Manual search was included in this protocol, including articles in the area published in journals of high-quality impact on selected languages (Journal of Oral and Maxillofacial Surgery, British Journal of Oral and Maxillofacial Surgery, Asian Journal of Oral and Maxillofacial Surgery).

The following search terms were used: “orthognathic surgery” with “condylar resorption”, “progressive condylar resorption”, “idiopathic condylar resorption”, “condylar atrophy” or “condylysis” in the Spanish and English language. Searches were performed using the term "orthognathic surgery" as the basis of the search algorithm and it was combined with each of the keywords to perform the search in each literature system.

The Checklist SIGN Methodology 3 (2012) was used to assess the quality of the study and its risk of bias. For standardized clinical studies, case series and clinical cases, quantitative methodological quality and case report synthesis were used and case series (Murad *et al*., 2018).

RESULTS

The systematic review began with 15,182 articles, of which, after complying with the systematic review parameters established in the methodology and the inclusion criteria, they were reduced to a total of 21. One of them was a series of cases and 20 articles of cohort studies (Fig. 1).

The total number of patients obtained was 3,285 with a predilection for the female gender in 47.5 % (n=1,561) and 12.75 % (n=419) for the male. Six articles did not specify the gender of the patients attended. The range of ages goes from 14 to 50 years, with a mean of 23.7 ± 6. Six articles did not specify the ages of the treated patients. The follow-up period for the cases ranged from 12 to 210 months, with a mean of 111± 99 months. The patients were diagnosed in 90.7 % (n=2.97) with class II dentoskeletal deformity and 9.31 % (n = 306) with class III dentoskeletal deformity. Regarding the type of fixation, 81.8% (n=2,609) used rigid internal fixation and wire fixation in 20.57% (n=676) of the patients reported in the study (Table I.)

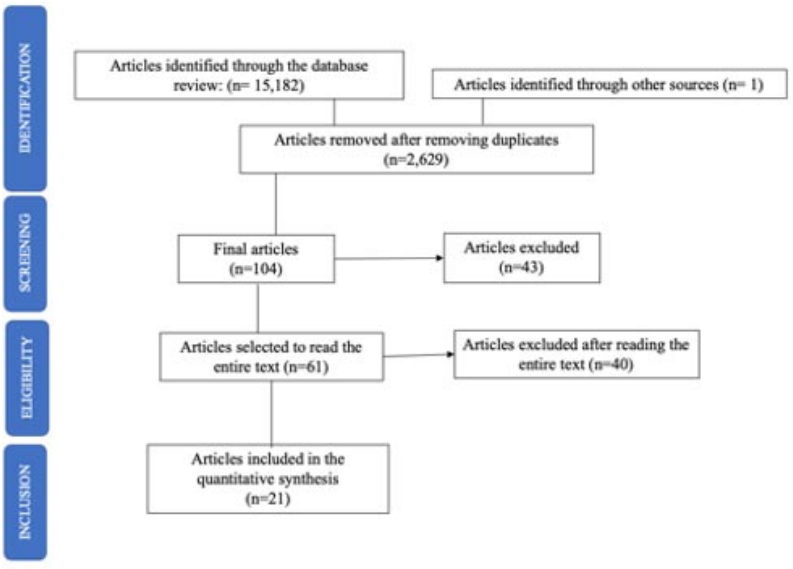

Fig 1. Flowchart for the selection of articles based on the PRISMA matrix

Due to the little standardization, in terms of the description of the procedure performed, it was not possible to obtain information on the total number of orthognathic surgery procedures performed in the entire population (bimaxillary surgery, Le Fort I osteotomy, sagittal osteotomy of the mandibular ramus), more yes of the cases associated with CR.

Of the total number of patients studied in this systematic review, 247 were diagnosed with CR after orthognathic surgery, presenting a higher percentage in female patients with 88.8% (n = 219) and 11.2 % in male patients of the male gender

Table I. General results associated with the study population

Author	Type of study	Size	Age	Gender	Subject with CR
Kerstens *et al*. (1990)	Cohort study	206	ND	ND	12
Moore *et al*. (1991)	Serie de casos	421	18-25	F	5
De Mol Van Otterloo *et al*.	Cohort study	16	21-36	13F- 3M	2
De Clercq *et al*. (1994)	Cohort study	329	20-27	F	8
Bouwman *et al*. (1994)	Cohort study	93	ND	ND	9
Merkx & Van Damme (1994)	Cohort study	158	ND	143F- 15M	32
Scheerlinck *et al*. (1994)	Cohort study	103	ND	71F – 32M	8
Huang *et al*. (1997)	Cohort study	28	15-36	26 F – 2 M	
Hoppenreijs *et al*. (1998)	Cohort study	259	ND	203F-56M	40
Cutbirth *et al*. (1998)	Cohort study	100	23.7	70 F- 30 M	10
Hoppenreijs *et al*. (1999)	Cohort study	26	14.8-37.9	23F- 3M	26
Hwang *et al*. (2000)	Cohort study	240	16-28	ND	11
Wolford *et al*. (2003)	Cohort study	25	15-49	23F-2M	6
Hwang *et al*. (2004)	Cohort study	452	15-29	286F- 166M	17
Borstlap *et al*. (2004)	Cohort study	222	ND	169F- 53M	8
Wohlwender *et al*. (2011)	Cohort study	23	18-50	ND	2
Kobayashi *et al*. (2011)	Cohort study	505	16-26	472F-33M	6
Park *et al*. (2012)	Cohort study	22	17-23	11F-11M	22
Nogami *et al*. (2017)	Cohort study	26	26-39	25F-1M	4
Yin *et al*. (2020)	Cohort study	31	23.7-24.3	21F-10M	7

(n = 27). Of the 247 patients who presented CR after orthognathic surgery, 63.8 % (n = 157) reported CR after bimaxillary orthognathic surgery, 29.55% (n=73) after bilateral sagittal ramus osteotomy, and 6 % (n = 15) after Le Fort I osteotomy (Table II).

Regarding the type of fixation, CR occurred in 170 cases (68.82 %) where rigid internal fixation was used and 67 cases (27.12 %) with wire fixation were reported, in 10 cases (4 %) it was not reported what type of fixation was used. The association of CR with hormonal changes, both in the preoperative and postoperative evaluation, was only reported by Politis *et al*. (2019), who presented a case of a pregnant female patient 7 months postoperatively, who presented deviation of the midline and anterior open bite.

Table II. Reported cases of CR by type of surgery.

Author	Subject with CR	Bimaxillary	OSRMB	Lefort I
Kerstens *et al*. (1990)	12	11	1	
Moore *et al*. (1991)	5	2	3	
De Mol Van Otterloo *et al*. (1993)	2	-	ND	2
De Clercq *et al*. (1994)	9	9	ND	-
Bouwman *et al*. (1994)	32	32	ND	-
Merkx & Van Damme (1994)	8	-	8	-
Scheerlinck *et al*. (1994)	40	27	-	13
Huang *et al*. (1997)	10	ND	10	-
Hoppenreijs *et al*. (1998)	26	19	7	-
Cutbirth *et al*. (1998)	11	10	1	-
Hoppenreijs *et al*. (1999)	6	6	ND	-
Hwang *et al*. (2000)	17	16	1	-
Wolford *et al*. (2003)	8	ND	8	-
Hwang *et al*. (2004)	2	ND	2 -	-
Borstlap *et al*. (2004)	6	ND	6	-
Wohlwender *et al*. (2011)	22	ND	22	-
Kobayashi *et al*. (2011)	4	4	ND	-
Park *et al*. (2012)	7	6	ND	-
Nogami *et al*. (2017)	7	7	ND	-

The condylar morphology classification described by Hoppenreijs *et al*. (1998) was used to classify the patients studied, obtaining as a result: 18 type A, 79 type B, 42 type C, 20 type D and 3 type E. Being the most predominant type B (Fig. 2). Only two authors (Wolford, *et al*. 2003; Yin *et al*., 2020) reported the existence of pre-surgical joint pathology without specifying any classification criteria for it. On the other hand, only three authors clearly describe the treatments indicated for patients diagnosed with condylar resorption after orthognathic surgery. Wolford *et al*. (2003) report management through joint replacement combined with orthognathic surgery. Merkx & Van Damme (1994) recommend retreatment with orthognathic surgery, whereas Huang *et al*. (1997) describe the use of a costochondral graft for the management of CR.

Condyle Type	A	B	C	D	E
A/A	≥1	<1	<1	<1	<1
Condyle location	Leaning towards posterior	Leaning towards posterior	Same condylar axis direction	Leaning towards anterior	Iimposible to identify
Condylar Shape	Rounded	Curva hacia posterior	Rounded	Curve towards posterior	Finger spear shape
Frequency %	18	79	42	20	3

Fig 2. Classification of condylar morphology (according to Hoppenreijs) and frequency of reported cases.

In relation to the risk of bias, the Checklist SIGN Methodology system was used for the cohort studies. For the case series, the quantitative methodological quality and synthesis of case reports and case series were used. We obtained 10 studies of high quality (low risk of bias), 8 of acceptable quality (medium risk of bias) and 1 of low quality (high risk of bias). Regarding the series of cases, it was only found that it had a medium risk of bias (Table III).

Table III. Assessment of Risk of Bias.

Authors	Check list	Valuation	Interpretation
	COHORT STUDIES		
Kerstens *et al*. (1990)	Checklist SIGN Methodology 3 (cohort studies). (32)	Acceptable	Medium risk
De Mol Van Otterloo *et al.* (1993		Acceptable	Medium risk
Merkx & Van Damme (1994)		High quality	Low risk
De Clercq *et al.* (1994)		Low quality	High risk
Bouwman *et al.* (1994)		High quality	Low risk
Scheerlinck *et al.* (1994)		Acceptable	Medium risk
Huang *et al.* (1997)		Acceptable	Medium risk
Hoppenreijs *et al.* (1998)		High quality	Low risk
Cutbirth *et al.* (1998)		High quality	Low risk
Hoppenreijs *et al.* (1999)		High quality	Low risk
Hwang *et al.* (2000)		High quality	Low risk
Wolford *et al.* (2003)		High quality	Low risk
Hwang *et al.* (2004)		Acceptable	Medium risk
Borstlap *et al*. (2004)		Acceptable	Medium risk
Wohlwender *et al.* (2011)		Acceptable	Medium risk
Kobayashi *et al*. (2011)		High quality	Low risk
Park *et al.* (2012)		High quality	Low risk
Park *et al.* (2012)		Acceptable	Medium risk
Politis *et al*. (2019)		Acceptable	Medium risk
Yin *et al.* (2020)		Acceptable	Medium risk
	SERIES OF CASES		
Moore *et al.* (1991)	Murad *et al*. Methodological quality and synthesis of case series and case reports.	4/5	Medium risk

DISCUSSION

Morphological alterations of the mandibular condyle following orthognathic surgery have been extensively discussed in the literature. Such alterations may progress to condylar resorption, potentially leading to relapse of dentoskeletal deformities (Kobayashi *et al*., 2012). The temporomandibular joint (TMJ) is a highly dynamic structure with the capacity to adapt to mechanical stress to preserve its morphology and maintain occlusal function. When postoperative mechanical stress remains within the joint's adaptive limits, the resulting changes are referred to as functional remodeling. Conversely, when the mechanical load exceeds the adaptive capacity of the individual, dysfunctional remodeling may occur, which can ultimately lead to condylar resorption (Arnett *et al*., 1996; Gunson *et al*., 2012).

Gunson *et al*. (2012) describe that any type of injury whether direct or indirect can alter local blood perfusion, generating hypoxic conditions that activate free radicals. This process triggers cytokine-mediated pathways that stimulate osteoblast activity but ultimately promote osteoclastic activation, leading to the release of metalloproteinases responsible for extracellular matrix degradation. According to several authors (Arnett *et al*., 1996; Zerené-Reyes *et al*., 2019), the mean age at which CR typically occurs is approximately 23 years, with a reported range from 14 to 50 years. These values align with the age distribution observed in our study. However, other investigators, such as De Clercq *et al*. (1994), did not identify a direct association between age and the development of CR.

According to the literature (De Clercq *et al*., 1994; Cutbirth *et al*., 1998), females show a markedly higher prevalence of condylar resorption, with ratios reported as high as 5:1 compared with males. However, this contrasts with findings by Hwang *et al*. (2004), who reported no significant association between gender and CR. One of the most consistent clinical characteristics observed across affected patients is Class II malocclusion. Individuals with this malocclusion may have an increased risk of developing CR, particularly when features such as anterior open bite, divergent mandibular plane angles exceeding 40°, and reduced vertical dimension are present (Huang *et al*., 1997; Posnick & Fantuzzo, 2007). Nevertheless, other authors, including Park *et al.* (2012), have documented cases of CR in patients with Angle CIII malocclusion, suggesting a broader spectrum of dentoskeletal presentations. Scheerlinck *et al*. (1994) concluded that dentoskeletal deformities alone do not demonstrate statistical significance in predicting the development of acquired condylar resorption, indicating that malocclusion patterns should be interpreted with caution and within a multifactorial framework.

The diagnosis of CR is given by a combination of clinical and radiological signs (Fig. 3); however, the patient

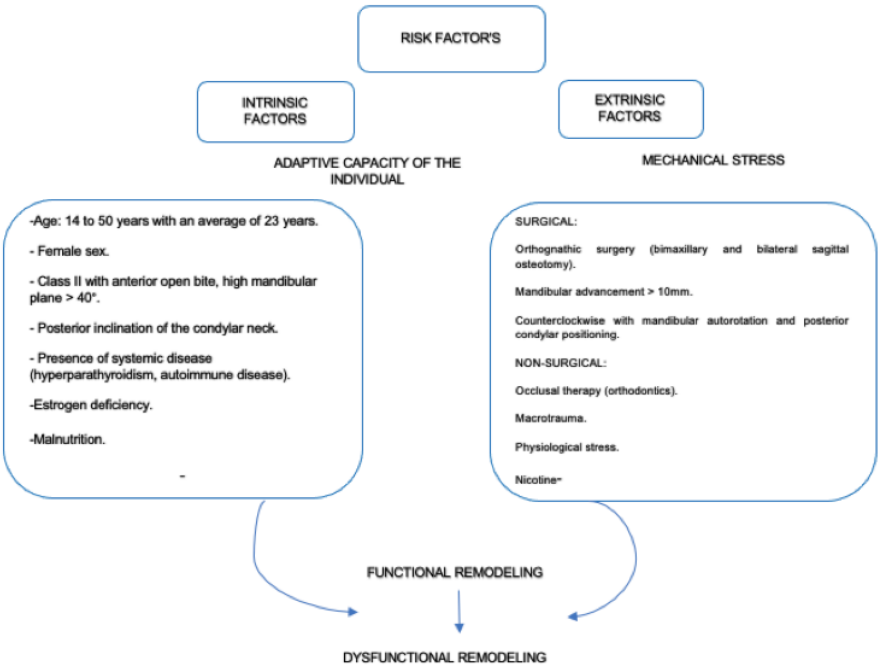

Fig 3. Risk factors in Condylar Reabsortion

generally reports worse occlusion and aesthetic appearance with or without joint symptoms. The clinical characteristics will depend on the location of the CR, that is, whether it is unilateral or bilateral. When it is unilateral, they usually present laterognathia, Angle class II molar relationship with contralateral open bite, in the case of bilateral cases, anterior open bite and mandibular retrusion are presented (Hoppenreijs *et al*., 1998; Wolford *et al*., 2003). Symptoms can appear 6 months after surgery and have been reported up to 6 years after orthognathic surgery. (de Mol van Otterloo *et al*., 1993)

Hoppenreijs *et al*. (1998), consider that the condylar shape and the inclination of the condyle neck are predisposing factors in CR. The authors developed a classification based on the contour, location of the most cephalic portion of the condyle in relation to the direction of the condylar neck and its radius (width/height). Type B condyles (which have a height/width ratio ratio of less than 1, with the most cephalad portion of the condyle located posteriorly and the axis of the condylar neck curved posteriorly) were observed in patients with class II angle malocclusion with open bite.

CR has been reported with all types of fixations. Bouwman *et al*. (1994) demonstrated that intermaxillary fixation increases the risk of CR (26.4 % vs. 11.9 %, P = 0.03), likely because restricting normal joint function reduces nutritional supply to the condyle, altering the condyle–fossa relationship. Scheerlinck *et al*. (1994) suggested improved outcomes in patients treated with rigid internal fixation using miniplates and monocortical screws. Cutbirth *et al*. (1998) reported the use of miniplates combined with a single bicortical screw without observing significant changes. Similarly, Hwang *et al*. (2004) found no statistical differences between fixation types or the use of intermaxillary fixation with respect to the development of CR. further proposed that posterior inclination of the condylar neck may leave the anterosuperior surface unloaded and therefore less dense, increasing susceptibility to CR when condylar rotation or upward (cephalad) displacement occurs during surgery (Hwang *et al*., 2004).

Hormonal changes are associated with estrogen deficiency, which has been widely discussed as a risk factor for CR. Estrogen receptors have been found at the synovial fluid level in symptomatic patients (Abubaker *et al*., 1996). It was determined that there are endogenous estrogens (17-β-estradiol) together with cytokines (RANKL and OPG) that play a fundamental role in maintaining bone integrity. Gunson *et al*. (2009), reported that 25 of 27 female patients with CR had low levels of 17-β-estradiol, concluding that low estrogen levels may be a risk factor for joint resorption due to an increase in protein-producing cytokines. inflammation and proliferation of peri-articular tissue.

According to authors such as Wolford *et al*. (2003) and Yin *et al*. (2020), preoperative temporomandibular dysfunction is considered a predisposing factor for developing CR, particularly when combined with excessive compressive forces on the condyle that restrict vascular supply and trigger resorptive processes. Likewise, disc position should be carefully assessed prior to orthognathic surgery, as it may help predict postoperative TMJ stability (Posnick *et al*., 2007; Gunson *et al*., 2009). In contrast, Hwang *et al*. (2004) did not identify any association between CR and preexisting joint pathology.

According to the literature, CR can occur with any type of osteotomy. According to Arnett *et al*. (1996)., the impaction of the maxilla with counterclockwise rotation in which changes are made in the occlusal plane and that these have posterior inclinations of the condylar neck is a risk factor for CR. Similarly, Kerstens *et al*. (1990) report that the posterior positioning of the mandibular condyle produced 87 % CR in the cases studied. No article mentions any type of condylar repositioning device that can help prevent CR. Likewise, none of the selected articles indicates that there is any kind of relationship between the modifications of the sagittal ramus osteotomy and CR.

Mandibular advancement generates mechanical stress on the soft tissue of the TMJ. It was observed that the range of advancement within the selected studies was from 5 mm to 14 mm. (Arnett, *et al*. 1996). Scheerlinck *et al*. (1994) compared joint changes after mandibular advancements of 5 mm or less compared to advancements greater than 10 mm, showing that the risk increased from 5 to 20 times more in patients who underwent advancements greater than 10 mm. However, many authors (Hoppenreijs *et al*., 1998; Hwang *et al*., 2004) found no difference in their studies.

According to Wolford *et al*. (2003), there is no protocol with sufficient scientific evidence to be accepted as standard treatment. Different authors agree that surgical correction to manage occlusal changes and recurrence after orthognathic surgery should be considered after a period of

at least 6 months, likewise authors such as Arnett *et al*. (1996), state that it is essential to know the factors of risk prior to surgery. Likewise, this was the only article that mentioned risk factors in its study, such as nicotine, hyperparathyroidism, autoimmune disease, and malnutrition.

The most common treatment to correct CR reported in the literature was orthognathic surgery and, in some cases carried out in conjunction with the replacement of the articular disc (Merkx & Van Damme, 1994; Hwang, *et al*. 2004). Condylectomy and condylar reconstruction through costochondral graft have also been reported or joint replacement combined with orthognathic surgery, the latter is controversial because it is considered a very invasive treatment (Hwang *et al*., 1997; Wolford *et al*. 2003; 2015). Various conservative treatments have been described, such as the administration of anti-inflammatories, occlusal splints and physiotherapy (Hoppenreijs *et al*., 1998; Gunson *et al*., 2009; 2012). Until the date of this systematic review, most of the protocols are based on recommendations or randomized treatments in rheumatoid arthritis (McCarey *et al*., 2004; Gunson, *et al*. 2012; Conaghan *et al*., 2014). The Gunson *et al*. (2012) protocol is still under study and consists of therapy with doxycycline 50 mg twice a day for three months, piroxicam 20 mg daily, fatty acids and omega 3.

He *et al*. (2019) proposed a flowchart outlining an algorithm for the preventive and curative management of CR. However, their contribution is theoretical in nature and does not include clinical validation. The model is presented in a simplified format and is based primarily on the authors' interpretation of the typical clinical course of CR cases, rather than on empirical data (Fig. 4). There are currently 4 other systematic reviews that cover the topic of CR associated with orthognathic surgery. In general, the quality of the articles was concentrated on series or clinical cases and with a priority focus on diagnosis and risk factors, without finding more elaborate discussions on topics such as type of fixation and treatment of CR. In addition, in the current systematic review, a higher number of cases is presented, which allows a larger comparison by the total population. Based on the foregoing, we justify carrying out this systematic review (Wolford *et al*., 1999; Catherine *et al*., 2016; NiÑo-Sandoval *et al*., 2021).

Based on the literature reviewed in this systematic analysis, there are few standardized treatment approaches for managing CR in patients who have undergone orthognathic surgery. A major challenge lies in the considerable heterogeneity across studies regarding how treatment protocols are described and reported. Nevertheless, three curative post-surgical protocols can be identified: (1) repeat

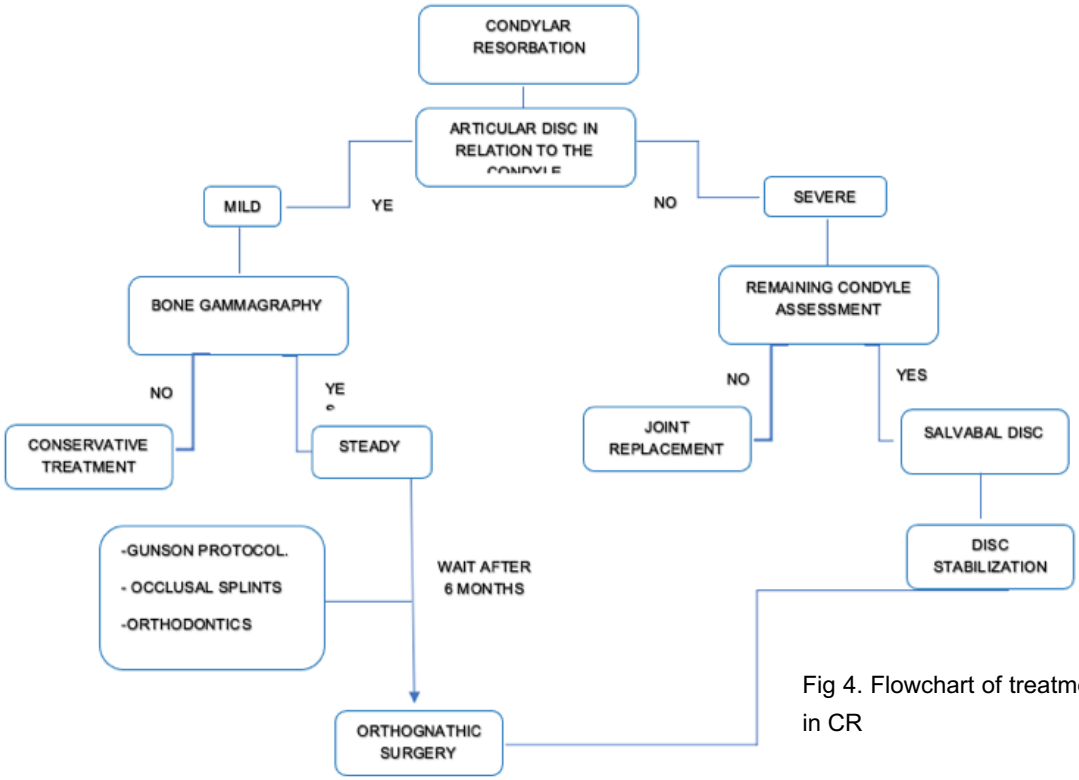

Fig 4. Flowchart of treatment algorithm in CR

orthognathic surgery after a six-month interval (Merkx & Van Damme, 1994); (2) condylectomy followed by costochondral graft reconstruction (Huang *et al*., 1997); and (3) placement of a TMJ prosthesis combined with orthognathic surgery (Wolford *et al*., 2003). None of the selected articles can be identified as standardized preventive treatments, however, the article by Gunson *et al*. (2012) describes in detail a preventive treatment protocol that establishes the use of fatty acids, omega 3 and doxycycline as a treatment protocol for CR preventively. As it was not accompanied by clinical data, it could not be included in the articles selected in this review.

CONCLUSION

We can conclude that there remain substantial variability and limited evidence regarding the management of CR associated with orthognathic surgery. Based on the findings of this study, several recommendations can be proposed: 1) clinicians should review and identify preoperative risk factors; 2) in cases involving large mandibular advancements, adjunctive procedures such as deprogramming splints, myotomies, or botulinum toxin therapy should be considered; 3) for Class II patients between 20 and 30 years of age, it is advisable to assess for potential estrogen deficiencies; 4) during surgery, a neutral and physiologic repositioning of the mandibular condyle should be pursued; 5) postoperative occlusion should be prospectively evaluated to reduce the risk of instability; 6) finally, early TMJ function should be encouraged in the postoperative period, with long-term follow-up maintained for more than six years.

SUAREZ C, GARCIA-GUEVARA, H, GUDIÑO R, ACERO J, SOLANO N, RIVERA E, JENSEN D. Tratamientos asociados al manejo de la reabsorción condilar después de la cirugía ortognática: revisión sistemática. *Craniofac Res. 2025; 4(2)*:66-75.

RESUMEN: La reabsorción condilar posterior a la cirugía ortognática es una condición clínica poco frecuente pero bien documentada que afecta a la articulación temporomandibular (ATM). La creación de protocolos de tratamiento estandarizados es necesaria, ya que los enfoques terapéuticos actuales presentan una elevada variabilidad. El objetivo de esta revisión sistemática fue identificar y describir los tratamientos reportados para el manejo de la reabsorción condilar después de cirugía ortognática. Se realizó una búsqueda exhaustiva en las bases de datos PubMed, Google Scholar, ScienceDirect y Cochrane Library, incluyendo publicaciones entre 1990 y 2022. La estrategia de búsqueda incorporó las palabras clave "cirugía ortognática" combinada con "reabsorción condilar", "reabsorción condilar progresiva", "reabsorción condilar idiopática", "atrofia condilar" o "condilólisis". Los artículos fueron seleccionados según criterios de inclusión y exclusión establecidos previamente. De un total inicial de 15.182 artículos, 21 cumplieron los criterios de inclusión. En conjunto, se analizaron 3.285 pacientes, con predominio del sexo femenino (47,5%, n = 1.561) en comparación con el masculino (12,75%, n = 419). Las edades oscilaron entre 14 y 50 años, con una media de 23,7 $\pm$ 6 años. Entre los pacientes estudiados, 90,7% (n = 2.979) presentaban deformidad dentoesquelética clase II, mientras que 9,3% (n = 306) correspondían a clase III. Un total de 247 pacientes fueron diagnosticados con reabsorción condilar posterior a cirugía ortognática. Solo tres estudios describen de manera clara los tratamientos utilizados en estos casos: uno combinó reemplazo articular y cirugía ortognática, otro realizó retratamiento ortognático, y un tercero empleó injerto costocondral. Esta revisión evidencia una falta de protocolos de tratamiento estandarizados para el manejo de la reabsorción condilar después de cirugía ortognática. El principal desafío identificado radica en la heterogeneidad de la literatura y en la inconsistencia en la forma de reportar los tratamientos y resultados, lo que resalta la necesidad de criterios diagnósticos unificados y estrategias terapéuticas basadas en evidencia.

PALABRAS CLAVE: reabsorción condilar, cirugía ortognática, articulación temporomandibular

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