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Togninalli, David; Antonarakis, Gregory; Schatz, Jean-Paul

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Review

Condylar resorption following mandibular advancement or bimaxillary osteotomies: A systematic review of systematic reviews

David Togninalli, Gregory S. Antonarakis, Jean-Paul Schatz

Department of Orthodontics, University Clinic of Dental Medicine, Faculty of Medicine, University of Geneva, Switzerland

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ABSTRACT

Several systematic reviews have been published on the effects of mandibular surgery on condylar remodeling without reaching a consensus. The purpose of this systematic review of systematic reviews was to assess the impact of mandibular advancement or bimaxillary surgeries on condylar resorption.
A literature search, using several electronic databases, was carried out by two reviewers independently. Article preselection was based on titles and abstracts, and final article selection based on full-text analysis of preselected studies. After final study selection, the quality of studies was assessed using the AMSTAR 2 tool. A decision algorithm was subsequently established to choose the best body of evidence.
From an initial yield of 1′848 articles, 23 systematic reviews were identified for further analysis, with ten studies being included in the final selection. Despite the generally low quality of the reviews, certain associations could be made: young patients, female patients, and those with a high mandibular plane angle are more prone to condylar resorption following mandibular advancement osteotomies, especially if anterior rotation of the mandible is performed during surgery. Patients undergoing bimaxillary surgery also appear to have a higher risk of developing condylar resorption.
In conclusion, these results confirm the multi-factorial nature of condylar resorption, stressing the need for well-controlled prospective studies with long-term follow-up to clearly identify potential risk factors associated with orthognathic surgery.

1. Introduction

Orthognathic surgery is a widely used procedure to correct maxillofacial deformities. This procedure has many benefits such as improved oral function, psychosocial benefits [1], favorable effects on temporomandibular disorders (TMD) [2,3] and the improvement of facial appearance [3]. While considered as the treatment of choice for correcting skeletal discrepancies in non-growing patients, post-operative complications may arise, more so when these procedures are performed by inexperienced surgeons from low-volume centers [4]. Infections (2.8%), osteomyelitis (0.2%), inferior alveolar nerve damage (2.1%) and post-operative paresthesia (9%) may sometimes occur [5]. It is important to stress that despite potential complications this procedure can be done with a very high degree of safety and good knowledge of technical reasons for these complications should help to reduce their incidence [5]. Moreover, patients having undergone orthognathic surgery to correct dentofacial deformities, despite the difficulties experienced, show satisfaction with the treatment outcome [6,7].

The morphological changes of the condyles after orthognathic surgery seem to be a natural adaptative consequence, but their extent and impact on temporomandibular joint (TMJ) functional characteristics are unclear and still a matter of debate. These morphological changes may just be part of the physiological remodeling process, or lead to condylar resorption (CR) [8]. Many etiological factors - surgical or non-surgical - have been studied in recent years such as the position of the articular disk before and after the surgical procedure, a clockwise rotation of the mandible during surgery, and an erosion or deformity of the condyle before surgery [9].

While the occurrence of CR following orthognathic surgery has been reported to vary from 0 to 31% [6,9−15], it can sometimes have a major impact on surgical outcomes often manifesting clinically as anterior open bite with posterior mandibular rotation, osteoarthritis or TMJ disorders [18]. The ability to identify at-risk patients, and to quantify the incidence and severity of CR, is critical in understanding and controlling post-operative relapse [14], as well as decreasing the potential need for condylar reconstruction procedures or specific treatments for TMDs thereafter.

Several systematic reviews assessing the available scientific evidence on the incidence of CR following orthognathic surgery and on the risk factors associated with different orthognathic procedure have been published, without a consensus being reached.

The aim of the present systematic review of systematic reviews was to perform a systematic and objective interpretation of review

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findings, by assessing the methodological quality of existing studies, and thus their ability to draw conclusions on the incidence of CR following orthognathic surgery, and on its potential risk factors.

2.Materials. and methods

The present review was based on the AMSTAR guidelines [19]. This review was not previously registered.

2.1. Research question and eligibility criteria

The research question and literature search strategy were based on the PICOS framework (population; intervention; comparator; outcomes; study type). The following eligibility criteria were selected:

- Population: patients of any age who underwent a combined orthodontic and orthognathic surgical treatment with post-operative radiographic follow-up;
- Intervention: a bilateral sagittal split osteotomy (BSSO) procedure only or in combination with other surgical procedures to correct dentofacial deformities;
- Comparator: pre- and post-surgery radiographic evaluation;
- Outcome: condylar resorption assessed radiographically;
- Study design: only systematic reviews or meta-analyses of primary studies on human subjects were considered eligible for this review.

2.2. Search strategy

The literature search was performed using the following electronic databases: Pubmed; Web of Science; Embase; and the Cochrane Library. The last search was carried out in October 2021.

The full electronic search strategy for the Pubmed database was carried out using the following MeSH terms: (orthognathic surgery [MeSH Terms]) AND (temporo-mandibular joint [MeSH Terms]); (orthognathic surgery [MeSH Terms]) AND (mandibular condyle [MeSH Terms]) and (((((orthodontic surgery [MeSH Terms]) AND (condylar resorption [MeSH Terms])) OR (progressive condylar resorption [MeSH Terms])) OR (idiopathic condylar resorption [MeSH Terms])) OR (condylar atrophy [MeSH Terms])) OR (condylolysis [MeSH Terms]) as well as non-MeSH terms: (orthognathic surgery AND temporo-mandibular joint); (orthognathic surgery AND mandibular condyle); (orthodontic surgery AND condylar resorption OR progressive condylar resorption OR idiopathic condylar resorption OR condylar atrophy OR condylolysis).

The same electronic search strategies and combination of terms were used for the Web of Science, Embase, and the Cochrane Library databases: (orthognathic surgery AND temporo-mandibular joint); (orthognathic surgery AND mandibular condyle); (orthodontic surgery AND condylar resorption OR progressive condylar resorption OR idiopathic condylar resorption OR condylar atrophy OR condylolysis).

No language or year of publication restriction was set for the literature search. The literature search was carried out by two reviewers independently.

2.3. Study selection

Study selection was performed independently by two reviewers and any possible disagreements were settled by discussion. If no consensus was found, a third reviewer was consulted until a consensus was reached. Article selection was based on screening titles and abstracts. Full-text versions of the pre-selected articles - systematic reviews that met the eligibility criteria - were read to decide on the final article selection.

2.4. Data extraction

Two reviewers performed the data extraction independently. All missing data were recorded as not reported (NR). The data collection process was carried out to extract the following information from each included study:

- Publication data: authors, year of publication, country of origin, study design;
- Individual study data: type of primary studies included in the systematic review, populations, interventions, comparators; outcomes;
- Patient data: total number of patients, age, sex, dentofacial deformity;
- Method of analysis and evaluation of condylar resorption;
- Follow-up period.

2.5. Quality assessment of the body of evidence

The quality of the selected studies was assessed using the AMSTAR 2 tool [19–21]. This multidomain tool was developed as a practical critical appraisal tool for medical care providers who wish to establish the quality of a systematic review. Shea et al. [20] propose seven so-called critical domains (out of 16 items) that should be given more weight than the other domains (**Table 1**) and which are taken into consideration in determining the overall confidence rating in the results of the review: high overall confidence for no or one non-critical weakness; moderate overall confidence for more than one non-critical weakness; low overall confidence for one critical flaw with or without non-critical weaknesses and critically low for more than one critical flaw with or without non-critical weaknesses (**Table 2**).

Two reviewers performed the assessment independently. In the case of disagreement, discussions were held until consensus was reached. A third reviewer was consulted if the two reviewers could not reach an agreement.

2.6. Selection of the best body of evidence

The selection of the best body of evidence was made with the support of the decision algorithm proposed by Jadad et al. [8]. This decisional algorithm was applied, focusing on the systematic reviews with the highest quality, when two or more systematic reviews asking comparable research questions had discordant conclusions.

3.Results

3.1. Search results

The initial electronic literature search, based on our search strategy, yielded a total of 1′848 articles. Our flowchart presents the search results only after limiting our search to systematic reviews

Table 1
AMSTAR 2 critical domains (proposed by Shea et al., 2017).

Critical domains	Description
Item 2	Protocol registered before commencement of the review
Item 4	Adequacy of the literature search
Item 7	Justification for excluding individual studies
Item 9	Risk of bias from individual studies being included in the review
Item 11	Appropriateness of meta-analytical methods
Item 13	Consideration of risk of bias when interpreting the results of the review
Item 15	Assessment of presence and likely impact of publication bias

Table 2
Quality assessment criteria of the reviews (proposed by Shea et al., 2017).

Overall confidence	Description
High	No or one non-critical weakness: the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest.
Moderate	More than one non-critical weakness*: the systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies that were included in the review.
Low	One critical flaw with or without non-critical weaknesses: the review has a critical flaw and may not provide an accurate and comprehensive summary of the available studies that address the question of interest.
Critically low	More than one critical flaw with or without non-critical weaknesses: more than one critical flaw and should not be relied on to provide an accurate and comprehensive summary of the available studies.
*	multiple non-critical weaknesses may diminish confidence in the review and it may be appropriate to move the overall appraisal down from moderate to low confidence

and meta-analyses (**Fig. 1**). No references were identified from other sources. Following removal of duplicates, 24 reviews were selected for further assessment. Reviews which did not meet the eligibility criteria were excluded (**Table 3**). Excluded reviews concerned Class III or unilateral osteotomies [22,23], surgery relating to idiopathic condylar resorption or estrogenic effects [24–26], the management of condylar resorption or the assessment of risk factors [27,28], or orthognathic surgery performed for other indications such as mandibular fractures [29], osteomyelitis [30] or condylar hyperplasia [31]. Some studies were excluded as condylar resorption was not the main outcome [32–36] and only one study was excluded because it was not a systematic review of primary studies [37]. As a result, 10 systematic reviews were considered eligible for the present study.

3.2. Characteristics of the included studies

The characteristics of the included studies are reported in **Table 4**. The number of studies selected in the systematic reviews varied from 6 to 76, with a pool of patients incorporating 202 to 3′399 individuals. The method of analysis of condylar resorption was either based on panoramic and cephalometric radiographs, cone-beam computed

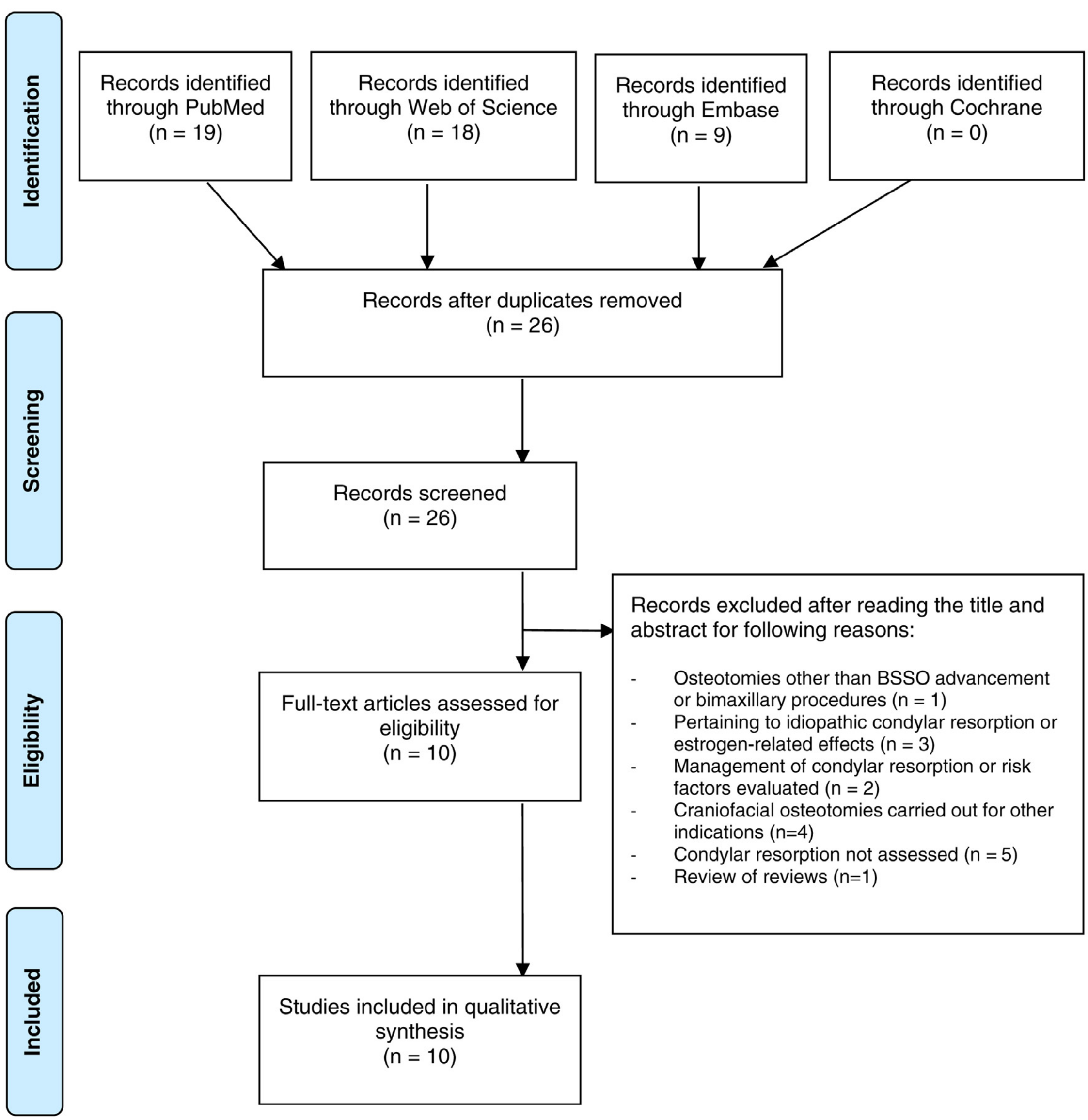

Fig. 1. Flow diagram of the study selection process.

Table 3
List of excluded studies and reasons for exclusion.

Author and Year	Reasons for exclusion
Abrahamsson et al. 2007	Condylar resorption not assessed
Nasser et al. 2013	Craniofacial osteotomies carried out for other indications
Al-Baghadi et al. 2014	Condylar resorption not assessed
Sansare et al. 2015	Pertaining to idiopathic condylar resorption or estrogen-related effects
Ghawsi et al. 2016	Craniofacial osteotomies carried out for other indications
Campos et al. 2017	Management of condylar resorption or risk factors evaluated
Nicolielo et al. 2017	Pertaining to idiopathic condylar resorption or estrogen-related effects
Rozeboom et al. 2017	Craniofacial osteotomies carried out for other indications
Mari et al. 2014	Craniofacial osteotomies carried out for other indications
Vandeput et al. 2019	Osteotomies other than BSSO advancement or bimaxillary procedures
He et al. 2019	Management of condylar resorption or risk factors evaluated
Ahmedi et al. 2020	Condylar resorption not assessed
Ji et al. 2020	Pertaining to idiopathic condylar resorption or estrogen-related effects
Mda et al. 2021	Condylar resorption not assessed
Niño-Sandoval et al. 2021	Review of reviews
Pachnicz et al. 2021	Condylar resorption not assessed

tomographic imaging or magnetic resonance imaging (MRI). Follow-up periods ranged from 6 weeks to 10 years [11−17,42−45].

Concerning the individual studies included in each systematic review, there were no primary studies that were included in all 10 systematic reviews. Two studies were included in 6 of the 10 systematic reviews [18,38], 2 studies were included in 5 of the 10 systematic reviews [39,40] and one study was included in 4 of the 10 systematic reviews [41]. All other primary studies were included in three or less of the systematic reviews.

3.3. Methodological quality of the included studies (risk of bias)

The use of the AMSTAR 2 tool - judging each criterion as fulfilled completely ('yes'), partially ('partial yes') or not fulfilled ('no') - denoted a strong heterogeneity within the reviews included in the selection (**Table 5**). Of the ten systematic reviews that met our inclusion criteria, only two studies - Mousoulea et al. [14] and Verhelst et al. [22] - were highlighted as bearing the best quality among the included systematic reviews.

3.4. Choice of the best body of evidence

Based on the AMSTAR scores, the two studies considered as providing the best body of evidence were the studies from Mousoulea et al. [14] and Verhelst et al. [22]. These two studies had the most 'yes' or 'partial yes' scores out of the 10 included studies, which gives them more weight compared to the others. However, according to the criteria proposed by Shea et al. [7] (**Table 2**), these two reviews still had an overall score considered critically low because they contain more than one critical flaw (two for Mousoulea et al. [5] and three for Verhelst et al. [22]) with non-critical weaknesses.

Applying the Jadad algorithm, one can see that these two studies do not answer the same question (**Fig. 2**). The study of Mousoulea et al. [14] pertains mainly to the amount of condylar resorption after BSSO surgery, whereas Verhelst et al. [22] focus on the protocols used to assess this condylar resorption. According to these observations, the conclusions published by Mousoulea et al. [14] were considered as the best current body of evidence.

3.5. Best body of evidence

When performing a surgical procedure such as a BSSO, there is an obvious risk of post-operative condylar resorption. Despite the limitations expressed as for the best body of evidence, it appears that the major risk factors are mainly related to the patients' gender, age, skeletal characteristics as well as the movement imposed on the mandible during surgery. Young women with a large mandibular plane angle present a greater risk of condylar resorption, especially if anterior rotation of the mandible is performed during surgery.

4. Discussion

The scientific evidence assessed in the present systematic review bears some limitations as the quality of included primary studies is generally poor. The results of these primary studies are heterogeneous due to the use of different radiological examination procedures, monitoring protocols and data analyses [5,23,24]. Moreover, included samples were heterogeneous with regard to aspects such as baseline characteristics, dentofacial characteristics, follow-up periods, surgical procedures, and surgeon expertise. Three out of 10 reviews included studies with a follow-up of less than 1 year [13,14,43], which is somewhat short when evaluating condylar resorption. Bermell-Baviera et al. [43] included 5 out of their 18 studies with a follow-up period of less than 12 months. Likewise for Mousoulea et al. [14] in 2 out of their 14 included studies, and for Kersey et al. [13] in 4 out of the 6 included studies.

The systematic reviews included in our study also collected studies involving a wide range of surgical procedures, performed to correct very different dento-maxillo-facial discrepancies, such as prognathic and retrognathic mandibles. While there is no doubt that every orthognathic surgical procedure has the potential to induce condylar resorption, combining their specific results could limit the interpretation of the overall results. According to our results and decision algorithm, the systematic review published by Mousoulea et al. [14] was considered the most appropriate to properly address the desired research questions. Moreover, its design and quality assessment, as demonstrated by the use of the AMSTAR tool, seem to provide reliable evidence, with greater scientific weight than the other systematic reviews identified.

The results of the present study confirm that a mandibular advancement osteotomy with a BSSO procedure carries the risk of condylar resorption, especially in young women with a large mandibular plane angle when anterior rotation of the mandible is performed during surgery. The reported incidence of condylar resorption following mandibular osteotomies varies between studies from 0% and 31% [6,9−11,13−15]. However, the discrimination between condylar resorption and the remodeling processes, pointed out in several studies, may appear challenging and somewhat confusing, both in the clinical and in research settings, and could be a serious limitation of all the studies screened for review. Condylar remodeling, which in theory will not produce secondary changes to the occlusion, will most likely be clinically innocuous as it will not lead to complications or relapse. Condylar resorption on the other hand is more critical as it can lead to a posterior rotation of the mandible which can create an openbite and an increased overjet, as well as a reduction in the predictability of surgical stability [9,44].

Orthognathic surgery, although an excellent approach for restoring occlusal and facial balance in patients with dentofacial deformities, also leads to an inflammatory response in the temporomandibular joint which causes condylar remodeling [45]. This condylar remodeling and its extent seem to depend on the direction of condylar displacement [46]. When can this condylar remodeling, which can be said to be a post-surgical adaptation, lead to pathological resorption is a question that to date does not have a clear answer. The distinction between condylar remodeling and pathological

Table 4
Characteristics of the included studies.

	PICO	Sample	Type of primary studies	Total patients	Age	Sex	Dentofacial deformity	Method of analysis	Approximate follow up
Bermell-Baviera et al. 2016	P: patients with or without TMD I: BSSO (advancement surgery) C: NR O: TMD increased / decreased after surgery	*N* = 22	4 SR 5 P 13 R	623	29.5	313 F 257 M 53 NR	NR	Pre/postoperative clinical examination (*n* = 22); lateral cephalometric radiographs (*n* = 7); CBCT (*n* = 3); CT (*n* = 3); MRI (*n* = 3)	3 months to 5 years
Catherine et al. 2016	P: NR I: Bimaxillary surgery; BSSO or Le Fort 1 C: Not reported O: number of CROS	*N* = 17	8 XSS 1 CS 4 ODS 1 P 1 R 1 CCS 1 AC	2994	14.8 to 50	NR	NR	NR	1 to 10 years
de Moraes et al. 2012	P: NR I: bimaxillary surgery; BSSO or Le Fort 1 C: NR O: number of CROS	*N* = 8	NR	2567	14 to 67	NR	NR	NR	1 to 6 years
Gill et al. 2008	P: retrognathia and high mandibular plane, skeletal class II I: bimaxillary surgery; BSSO or LeFort 1 C: NR O: condylar resorption	*N* = 9	2 P 7 R	3059	NR	NR	Class II	OPG; lateral cephalometric radiographs	1 to 6 years
Kersey et al. 2003	P : Class II patients I : BSSO with RIF C: NR O: morphology of TMJ	*N* = 6	NR	NR	NR	NR	Class II	Transcranial radiographs; lateral cephalometric radiographs; SMV; CT; MRI	6 weeks to 12 months
Mousoulea et al. 2017	P: NR I: BSSO alone or with other surgical procedures C: NR O: condylar resorption	*N* = 14	3 P 10 R 1 RCT	1069	NR	NR	Mandibular hypoplasia / retrognathism; ± anterior open bite; ± pre-existing TMD	OPG; lateral cephalometric radiographs; transcranial radiographs; CBCT	6 months to 5 years
Nunes de Lima et al. 2018	P : patients with skeletal dentofacial deformities I: mandibular setback using SSRO with RIF ± Le Fort 1 C: mandibular advancement using SSRO with RIF ± Le Fort 1 O: condylar resorption and relapse	*N* = 6	3 P 3 R	202	24.34	83 F 70 M 49 NR	Class II; class III	CT; CBCT; OPG	12 to 16 months
te Veldhuis et al. 2017	P : NR I : BSSO ; VRO ; Le Fort 1 and bimaxillary surgery C: class I occlusion O: mandibular movements and maximum mouth opening; pain on palpation TMJ; Bite force; imaging (condylar remodeling / position)	*N* = 76	NR	3399	25.4	NR	NR	Helkimo Index; questionnaire; RDC/TMD; CT; CBCT; MRI; OPG; tomography; lateral cephalometric radiographs; transcranial radiographs; fluoroscopic imaging; antero-posterior cephalometric radiographs	1 to 2 years

(*continued on next page*)

Table 4 (*Continued*)

	PICO	Sample	Type of primary studies	Total patients	Age	Sex	Dentofacial deformity	Method of analysis	Approximate follow up
Valladares-Neto et al. 2014	P: NR I: NR C: NR O: condylar resorption	*N* = 12	NR	NR	NR	NR	NR	NR	NR
Verhelst et al. 2020	P: human patients of all ages and any sex and non-syndromic dento-facial deformity I: Bimaxillary surgery (Le Fort 1 + BSSO) or BSSO only C: similar studies (condylar remodeling based on CBCT > 6 months postop) O: condylar remodeling	*N* = 10	NR	421	NR	287 F 134 M	Class II; class III	CBCT	1 to 3 years

AC = analytic cohort; BSSO = bilateral sagittal split osteotomy; CBCT = cone-beam computed tomography; CCS = case control study; CROS = condylar resorption after orthognathic surgery; CS = case series *F* = female; *M* = male; MRI = magnetic resonance imaging; NR = not reported; ODS = observational descriptive study; OPG = orthopantomogram; *P* = prospective study; *R* = retrospective study; RCT = randomized control trial; RDC/TMD = research diagnostic criteria for TMD; SSRO =; sagittal split ramous osteotomy; SMV = submental vortex radiograph; SR = systematic review; TMD = temporo-mandibular disorders; TMJ = temporo-mandibular joint; VRO = vertical ramous osteotomy; XSS = cross sectional analytic study.

Table 5
AMSTAR 2 scores with individual criterion responses.

First author Year	Bermell-Baviera et al. 2016	Catherine et al. 2016	de Moraes et al. 2012	Gill et al. 2008	Kersey et al. 2003	Mousoulea et al. 2017	Nunes de Lima et al. 2018	te Veldhuis et al. 2017	Valladares-Neto et al. 2014	Verhelst et al. 2020
AMSTAR 2										
1	No	No	No	No	No	Yes	Yes	Yes	No	Yes
2	No	No	No	No	No	Partial Yes	Partial Yes	No	No	Partial Yes
3	No	No	No	No	No	No	No	No	No	No
4	No	No	No	No	No	No	No	Partial Yes	No	Partial Yes
5	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes
6	No	No	No	No	No	Yes	No	No	No	Yes
7	No	No	No	No	No	No	No	No	No	No
8	No	No	No	No	No	Partial Yes	No	No	No	No
9 (RCTs)	No	No	No	No	No	Partial Yes	No	No	No	No
9 (NRSI)	No	No	No	No	No	Partial Yes	No	No	No	No
10	No	No	No	No	No	No	No	No	No	No
11 (RCTs)	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
11 (NSRI)	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
12	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
13	No	No	No	No	No	Yes	No	No	No	Yes
14	No	No	No	No	No	Yes	No	No	No	No
15	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
16	Yes	Yes	No	No	No	Yes	Yes	Yes	No	Yes

RCT = randomized controlled trials; NRSI = non-randomized studies intervention.

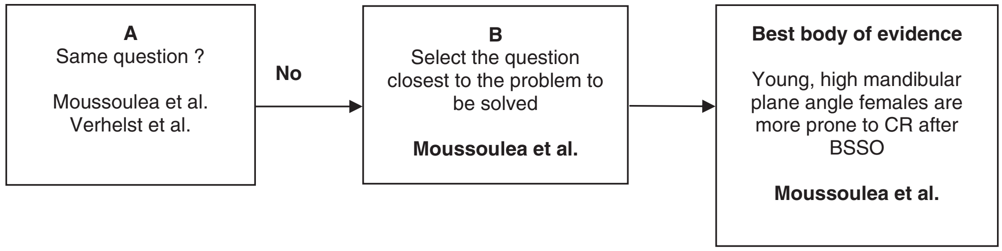

Fig. 2. Best body of evidence for association between condylar resorption and risk factors (adapted from the decision algorithm of Jadad et al., 1997).

resorption is not differentiated in studies, which may create some issues with the interpretation of results. Perhaps the extent of condylar displacement and particularly whether transverse displacement has occurred can be related to temporomandibular dysfunction and possibly condylar resorption [47].

Several studies have observed that women are more at risk of developing condylar resorption than men [5,23,24,26,27], especially if they are young [14], aged between 16 and 26 years [27] while De Moraes et al. [26], on the contrary, concluded that there is no real difference between age groups. Beyond the gender and age of patients, much attention has been paid to the size and position of the mandible, as well as the mandibular plane angle. A mandibular deficiency [14], mandibular retrognathia [23,27,28], a high mandibular plane angle [23] and a posterior inclination of the condylar neck [27] would appear to be risk factors for developing greater condylar resorption. These studies also suggest that the pre-operative size and morphology of the condyle itself may prove critical [28], with small condyles showing reduced adaptative mechanisms to increased postoperative condylar loads, leading to more condylar resorption. Due to condylar compression in its new position, a clinical relapse may be observed 9 to 18 months after surgery [29].

Some authors mention an increasing prevalence of condylar resorption when an anterior rotation of the mandible is performed during the BSSO procedure [5,23], particularly in cases with large mandibular advancement (up to 20 times more with mandibular advancement larger than 10 mm [23]) and when posterior displacement of the condyle occurs during the orthognathic intervention [23]. Condylar resorption can be observed regardless of the mandibular fixation method [24,26] but there does not seem to be any difference in the degree of resorption between the various techniques [6].

Two-jaws surgical procedures have also been shown to have a greater risk of condylar resorption than single-jaw BSSO procedures [24–26]. Moreover, it has been suggested that a Le Fort I osteotomy or a unilateral mandibular segmental osteotomy may give rise to less condylar resorption than a conventional BSSO [24].

5. Conclusion

While the current overview of systematic reviews confirms CR as a potential adverse effect of orthognathic surgical procedures with prevalence rates ranging from 0 to 31%, it also shows that great heterogeneity exists among studies. Most of the systematic reviews included were of low quality, with several methodological limitations leading to an overall poor level of evidence.

Nonetheless, the present investigation provides some insight and assumptions about CR following orthographic surgical procedures:

1. current evidence suggests a relationship between the incidence of CR and age, gender and certain dento-facial characteristics;
2. due to the low-level quality of the currently available systematic reviews, the best body of evidence should not be considered as unequivocal evidence and for that reason no convincing conclusions can be drawn;
3. there is a need for future prospective long-term clinical trials, including well-defined methodology and reliable imaging techniques, to be able to better define the etiology, incidence and extent of CR following orthognathic surgical procedures. Moreover, a differentiation between adaptive condylar remodeling following orthognathic surgery and pathological condylar resorption is essential in being able to more accurately assess potentially deleterious outcomes.

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