

**IDIOPATHIC CONDYLAR RESORPTION AFTER ORTHOGNATHIC SURGERY:
ETIOPATHOGENIC ASPECTS AND CLINICAL IMPLICATIONS**

**REABSORÇÃO CONDILAR IDIOPÁTICA APÓS CIRURGIA ORTOGNÁTICA:
ASPECTOS ETIOPATOGÊNICOS E IMPLICAÇÕES CLÍNICAS**

**RESORCIÓN CONDILAR IDIOPÁTICA TRAS CIRUGÍA ORTOGNÁTICA:
ASPECTOS ETIOPATOGÉNICOS E IMPLICACIONES CLÍNICAS**

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ABSTRACT

Idiopathic condylar resorption (ICR) is a multifactorial complication associated with orthognathic surgery, characterized by the progressive loss of volume and height of the mandibular condyle, leading to significant functional and aesthetic repercussions. This study carried out an integrative literature review aimed at identifying the main etiopathogenic mechanisms, risk factors, and clinical implications related to postoperative ICR. Studies published between 2000 and 2024 were analyzed from the PubMed, Scopus, Web of Science, and SciELO databases, encompassing clinical, radiographic, and histopathological evidence. It was observed that ICR occurs predominantly in young women and is influenced by hormonal variations, biomechanical overload, and anatomical predisposition. The magnitude of mandibular advancement and counterclockwise rotation of the occlusal plane are among the main mechanical factors associated with resorption. The pathophysiological changes involve an imbalance in bone remodeling, low-grade chronic inflammation, and failure of joint adaptation. Clinically, ICR manifests as mandibular relapse, occlusal instability, and temporomandibular joint pain, which may require treatments ranging from conservative therapy to complex surgical reconstructions. It is concluded that early diagnosis, individualized planning, and continuous three-dimensional monitoring are essential to reduce the incidence and severity of this complication, reinforcing the importance of preventive and multidisciplinary approaches in postoperative management.

Keywords: Idiopathic Condylar Resorption. Orthognathic Surgery. Temporomandibular Joint. Bone Remodeling. Risk Factors.

RESUMO

A reabsorção condilar idiopática (RCI) representa uma complicação de natureza multifatorial associada à cirurgia ortognática, caracterizada pela perda progressiva de volume e altura do côndilo mandibular, com repercussões funcionais e estéticas significativas. Este estudo realizou uma revisão integrativa da literatura com o objetivo de identificar os principais mecanismos etiopatogênicos, fatores de risco e implicações clínicas relacionados à RCI pós-cirúrgica. Foram analisados estudos publicados entre 2000 e 2024 nas bases PubMed, Scopus, Web of Science e SciELO, contemplando evidências clínicas, radiográficas e histopatológicas. Observou-se que a RCI ocorre predominantemente em mulheres jovens, sendo influenciada por variações hormonais, sobrecarga biomecânica e predisposição anatômica. A magnitude do avanço mandibular e a rotação anti-horária do plano oclusal figuram entre os principais fatores mecânicos associados à reabsorção. As alterações fisiopatológicas envolvem desequilíbrio no remodelamento ósseo, inflamação crônica de baixo grau e falha na adaptação articular. Clinicamente, a RCI manifesta-se por retrocesso mandibular, instabilidade oclusal e dor na articulação temporomandibular, podendo demandar desde terapias conservadoras até reconstruções cirúrgicas complexas. Conclui-se que o diagnóstico precoce, o planejamento individualizado e o monitoramento tridimensional contínuo são essenciais para reduzir a incidência e a gravidade dessa complicação, reforçando a importância de abordagens preventivas e multidisciplinares no manejo pós-operatório.

Palavras-chave: Reabsorção Condilar Idiopática. Cirurgia Ortognática. Articulação Temporomandibular. Remodelação Óssea. Fatores de Risco.

RESUMEN

La reabsorción condilar idiopática (RIC) es una complicación multifactorial asociada a la cirugía ortognática, caracterizada por la pérdida progresiva de volumen y altura del cóndilo mandibular, con importantes repercusiones funcionales y estéticas. Este estudio realizó una revisión bibliográfica integral para identificar los principales mecanismos etiopatogénicos, factores de riesgo e implicaciones clínicas relacionadas con la RIC posquirúrgica. Se analizaron estudios publicados entre 2000 y 2024 en las bases de datos PubMed, Scopus, Web of Science y SciELO, incluyendo evidencia clínica, radiográfica e histopatológica. La RIC se presenta predominantemente en mujeres jóvenes y está influenciada por variaciones hormonales, sobrecarga biomecánica y predisposición anatómica. La magnitud del avance mandibular y la rotación antihoraria del plano oclusal se encuentran entre los principales factores mecánicos asociados con la reabsorción. Los cambios fisiopatológicos incluyen un remodelado óseo desequilibrado, inflamación crónica de bajo grado y fallo de adaptación articular. Clínicamente, la RI se manifiesta como recesión mandibular, inestabilidad oclusal y dolor en la articulación temporomandibular, y puede requerir un tratamiento que abarca desde terapias conservadoras hasta reconstrucciones quirúrgicas complejas. Se concluye que el diagnóstico precoz, la planificación individualizada y la monitorización tridimensional continua son esenciales para reducir la incidencia y la gravedad de esta complicación, lo que refuerza la importancia de los enfoques preventivos y multidisciplinarios en el manejo postoperatorio.

Palabras clave: Reabsorción Condilar Idiopática. Cirugía Ortognática. Articulación Temporomandibular. Remodelación Ósea. Factores de Riesgo.

1 INTRODUCTION

Orthognathic surgery is one of the most sophisticated interventions in contemporary oral and maxillofacial surgery, and is widely indicated for the correction of dentoskeletal discrepancies and reestablishment of facial harmony and masticatory functionality. Despite technical advances and three-dimensional planning, postoperative skeletal stability still represents a clinical challenge, especially due to the susceptibility of the temporomandibular joint (TMJ) to adaptive or degenerative processes resulting from the biomechanical alteration imposed by bone repositioning (Catherine et al., 2016).

Among the late complications associated with orthognathic surgery, **idiopathic condylar resorption (ICR)** stands out, also called *idiopathic condylar resorption* (ICR), a condition characterized by progressive and non-inflammatory loss of condylar bone volume, in the absence of evident traumatic, infectious, or degenerative causes (Sabeh; Khoury; Nahas, 2020). It is a multifactorial condition, whose etiopathogenesis remains uncertain, but which has been related to hormonal, biomechanical, and inflammatory factors that affect TMJ bone metabolism (Yamashita et al., 2021).

ICR is predominantly described in young women, especially between 15 and 35 years of age, which reinforces the hypothesis of estrogenic hormonal influence on condylar metabolism (Kawakami et al., 2020). Estrogen acts as a modulator of osteoclastic and osteoblastic activity in the TMJ, and its relative deficiency can compromise condylar bone remodeling, resulting in a greater propensity for resorption (Murakami; Iwasaki, 2018). This endocrine vulnerability, associated with mechanical overloads caused by extensive mandibular advances and counterclockwise rotations of the occlusal plane, is among the main predisposing factors for postoperative condylar resorption (De Moraes et al., 2012).

Clinical and radiographic studies have shown that the incidence of ICR after orthognathic surgery varies between **1% and 31%**, depending on the type of osteotomy, magnitude of mandibular advancement, and extent of mandibular rotation (Bell; Proffit; White, 2018; Zenz et al., 2022). This wide variation stems from both the heterogeneity of the diagnostic and imaging methods used and individual differences in condylar biomechanical response (Papadaki et al., 2014).

From the pathophysiological point of view, ICR is understood as a process of adaptive imbalance of the TMJ, in which the increase in joint compressive forces exceeds the bone remodeling capacity of the condyle, resulting in progressive osteolysis. In addition, local inflammatory factors, with elevation of cytokines such as IL-1 β , TNF- α , and RANKL, promote

osteoclastic activation and amplification of the resorptive process (Lee et al., 2019; Murakami; Iwasaki, 2018).

These molecular changes have a direct impact on the functional integrity of the joint. The predominance of the RANK/RANKL pathway over osteoprotegerin (OPG) compromises the balance between bone resorption and neoformation, favoring condylar volumetric loss. Clinically, this imbalance translates into mandibular retrogression, loss of vertical dimension, and occlusal instability, evidencing the correlation between inflammatory processes and the clinical manifestations of idiopathic condylar resorption (Hatcher et al., 2020; Catherine et al., 2016).

Clinically, condylar resorption is manifested by **skeletal recurrence, mandibular retrogression, increased facial convexity, and loss of occlusal stability**, often accompanied by joint pain, functional limitation, and TMJ noises (Hatcher et al., 2020). Such manifestations significantly compromise functional and aesthetic results, and may require complex interventions such as arthroplasty, condylectomy, or total prosthetic joint replacement (Liebe et al., 2022).

Therefore, an in-depth understanding of the **etiopathogenic mechanisms** and **clinical implications** of postoperative ICR is essential to optimize surgical planning and prevent recurrences. The option for **an integrative literature review** is justified because it allows the critical synthesis of evidence from different methodological, clinical, radiographic, and experimental designs, enabling a comprehensive and updated analysis of this multifactorial condition. The present study, therefore, aims to systematize the scientific evidence on idiopathic condylar resorption after orthognathic surgery, identifying its etiological factors, clinical manifestations, and therapeutic implications.

2 METHODOLOGY

2.1 TYPE OF STUDY

The present study consists of an **integrative literature review**, a method that allows the critical synthesis of results from research with different designs, favoring the construction of a comprehensive overview of a given clinical phenomenon (Whittemore; Knafl, 2005). This approach was chosen because it enables the integration of clinical, radiographic, and experimental studies on idiopathic condylar resorption (ICR) after orthognathic surgery, offering robust theoretical support for the analysis of available evidence and identification of scientific gaps.

Integrative review differs from narrative reviews in that it follows systematized steps and explicit methodological criteria, which ensures greater reproducibility and reliability of the results (Souza; Silva; Carvalho, 2010). In addition, the descriptive-analytical model proposed by Ganong (1987) was adopted, adapted to the PRISMA 2020 guidelines, which guides qualitative reviews with an emphasis on transparency and traceability of the stages (Page et al., 2021).

2.2 GUIDING QUESTION

The research question was structured according to the PICO (Population, Intervention, Comparison and Outcome) strategy:

- **P** – Patients undergoing orthognathic surgery;
- **I** – Occurrence of idiopathic condylar resorption;
- **C** – Absence of resorption or patients with stable TMJ;
- **O** – Identification of etiopathogenic factors, clinical manifestations and therapeutic implications.

Thus, the question was formulated: *"What are the etiopathogenic factors and clinical implications of idiopathic condylar resorption in patients undergoing orthognathic surgery?"*

2.3 SEARCH STRATEGY

The bibliographic search was carried out between **February and April 2025**, in the **PubMed/MEDLINE, Scopus, Web of Science, and SciELO** databases, internationally recognized for the indexing of peer-reviewed scientific journals. The controlled descriptors of the **MeSH (Medical Subject Headings)** and **DeCS (Health Sciences Descriptors)** vocabularies were used, combined by the Boolean operators *AND* and *OR*: ("idiopathic condylar resorption" OR "condylar resorption after orthognathic surgery") AND ("orthognathic surgery" OR "bimaxillary surgery" OR "jaw deformities") AND ("temporomandibular joint" OR "risk factors" OR "etiology" OR "treatment outcomes").

The research considered the period from **2000 to 2024**, including publications in English and Portuguese. We also screened the reference lists of included studies (*snowball sampling*) to identify additional potentially relevant work (Greenhalgh; Peacock, 2005). To reinforce the topicality of the review, recent publications (2023–2024) that met the eligibility criteria were included, including systematic reviews of high methodological quality on etiopathogenesis and hormonal factors associated with condylar resorption.

2.4 INCLUSION AND EXCLUSION CRITERIA

Original articles, systematic reviews, high-level narrative reviews, clinical series, and imaging studies that addressed idiopathic condylar resorption associated with or subsequent to orthognathic surgery were included.

The following were excluded:

- a) isolated case reports without comparative analysis;
- b) studies with animal samples or in vitro models;
- c) publications in languages other than English and Portuguese;
- d) articles with no full text available; and
- e) brief communications or letters to the editor.

The selection was conducted by two independent reviewers, who evaluated the titles and abstracts, followed by a full reading of the eligible texts. Divergences were resolved by consensus, ensuring rigor and impartiality in screening (Moola et al., 2020).

2.5 DATA EXTRACTION AND ANALYSIS PROCESS

After the final selection, the studies were organized in a Microsoft Excel® 2021 spreadsheet, registering: author, year, country, type of study, sample, surgical technique used, follow-up time, incidence of condylar resorption, risk factors described, diagnostic imaging methods, and proposed therapeutic conducts.

Data analysis was qualitative and thematic, grouping the findings according to the following categories:

1. **Incidence and risk factors,**
2. **Etiopathogenic mechanisms,**
3. **Clinical and diagnostic aspects,**
4. **Management and prognosis.**

Due to methodological heterogeneity and the absence of uniform quantitative data, **no meta-analysis was performed**, as recommended by Ganong (1987) and Page et al. (2021).

2.6 EVALUATION OF METHODOLOGICAL QUALITY

The included studies were assessed according to quality and risk of bias criteria adapted to the **Joanna Briggs Institute (JBI)** guidelines for integrative reviews (Moola et al., 2020). Aspects such as clarity of objectives, design, representativeness of the sample, standardization of imaging methods, control of confounding factors, and coherence between

results and conclusions were considered. Systematic reviews, when present, were examined based on the **AMSTAR 2** instrument (Shea et al., 2017), while observational studies were analyzed for the level of evidence and internal validity.

2.7 ETHICAL ASPECTS

As this is a literature review, the study **did not involve experimentation on humans or animals**, and is therefore exempt from approval by the Research Ethics Committee. All information was obtained from public databases and duly referenced, ensuring scientific integrity and respect for intellectual property rules.

3 RESULT AND DISCUSSION

3.1 INCIDENCE AND RISK FACTORS

The incidence of idiopathic condylar resorption (ICR) after orthognathic surgery varies widely in the literature, ranging from **1% to 31%** of the cases analyzed (Papadaki et al., 2014; Zenz et al., 2022). This variation is largely due to the lack of standardization in the diagnostic criteria and the methodological differences between the studies, especially regarding the type of osteotomy, magnitude of bone displacements, and fixation techniques (Catherine et al., 2016).

According to **De Moraes et al. (2012)**, the highest incidence of ICR occurs in patients undergoing **mandibular advances greater than 7 mm** or significant counterclockwise rotations of the occlusal plane, which increases the compressive load vector on the condyle and joint capsule. Other authors, such as **Bell, Proffit, and White (2018)**, highlight that the combination of advancement and anterior rotation of the mandible can alter the condylo-disc relationship, generating cumulative microtraumas and failure of bone adaptation.

Female gender is one of the main predisposing factors reported. Clinical studies suggest that **85% to 90%** of cases occur in young women, indicating a possible hormonal influence on condylar bone metabolism (Kawakami et al., 2020; Murakami; Iwasaki, 2018). The presence of **facial hyperdivergence, elevated mandibular plane, and previous mandibular deficiency** is also pointed out as an anatomical risk factor, as it intensifies the posterior compressive vector on the TMJ after surgical repositioning (Hatcher et al., 2020).

In a systematic review, **Liebe et al. (2022)** observed that patients with a history of preoperative temporomandibular disorder (TMD) had a two-fold increased risk of developing

ICR after orthognathic surgery. This correlation suggests that previous inflammatory processes may compromise the condylar adaptive response, favoring osteolysis.

3.2 ETIOPATHOGENIC MECHANISMS

The etiopathogenesis of ICR is multifactorial, involving **hormonal, biomechanical, and inflammatory components**. According to **Yamashita et al. (2021)**, estrogen acts to modulate the expression of pro-resorptive cytokine receptors, such as RANKL (nuclear factor κ B activator receptor ligand) and OPG (osteoprotegerin), determining the balance between bone resorption and formation. Relative estrogen deficiency, observed in young women in periods of hormonal variation, can intensify osteoclastic activity in the condylar head, predisposing to bone resorption.

More recent systematic reviews have broadened the understanding of this hormonal relationship. A study published in 2024 identified a consistent association between variations in estrogen levels and the occurrence of idiopathic condylar resorption, suggesting that endocrine changes modulate the balance between osteogenesis and osteolysis in the temporomandibular joint (Al-Moraissi et al., 2024). In addition, a comparative systematic review demonstrated that patients undergoing orthognathic surgery with a Class II skeletal pattern have a higher incidence of condylar resorption compared to Class III patients, indicating a relevant role of biomechanical factors in etiopathogenesis (Kim et al., 2024).

From a biomechanical point of view, **Bell, Proffit and White (2018)** highlight that the redistribution of occlusal loads after mandibular repositioning alters the biomechanics of the TMJ. Extensive mandibular advancements or sharp counterclockwise rotations result in increased compressive forces at the posterior pole of the condyle, exceeding the adaptive remodeling capacity of the subchondral bone (Zenz et al., 2022).

In addition, **Lee et al. (2019)** demonstrated that inflammatory cytokines, such as interleukin-1 β (IL-1 β) and tumor necrosis factor α (TNF- α), are elevated in condylar tissues subjected to excessive mechanical stress, which induces osteocyte apoptosis and stimulates osteoclast resorption. Activation of the IL-1 β /TNF- α $\rightarrow$ RANKL axis $\rightarrow$ NF- κ B has been described as a central mechanism in condylar osteolysis (Sabeh; Khoury; Nahas, 2020).

The literature also suggests the influence of **genetic and metabolic factors**. Polymorphisms in genes related to bone remodeling, such as *IL1B* and *TNFRSF11B*, may modulate individual susceptibility to condylar resorption (Yamashita et al., 2021). In general,

the process is interpreted as a **model of adaptive failure**, in which the mechanical overload exceeds the biological responsiveness of the condylar tissue, triggering pathological remodeling and progressive volumetric loss (Murakami; Iwasaki, 2018).

3.3 DIAGNOSIS AND IMAGING FINDINGS

The diagnosis of ICR requires a multidimensional approach, integrating **clinical evaluation, imaging tests, and occlusal analysis**. Clinically, the first signs include **alteration of the facial profile** with progressive mandibular retroposition, anterior open bite, and joint noises (Hatcher et al., 2020).

Cone-beam computed tomography (CBCT) is the method of choice for volumetric and morphological evaluation of the condylar head, allowing the detection of cortical erosions, condylar flattening, and reduction in the height of the mandibular ramus (Catherine et al., 2016). **Zenz et al. (2022)** demonstrated, in long-term follow-up, that volumetric reductions greater than 10% of the condyle within the first 12 months after orthognathic surgery are predictors of clinical ICR.

Magnetic resonance imaging (MRI), in turn, is essential to identify soft tissue alterations, such as disc displacement, synovial inflammation, and the presence of joint effusion (Papadaki et al., 2014). These findings often precede bone resorption and reflect the multifactorial and progressive nature of the disease.

3.4 CLINICAL IMPLICATIONS AND MANAGEMENT

The clinical repercussions of ICR after orthognathic surgery are wide-ranging and affect both facial function and aesthetics. **Skeletal recurrence** is the most common complication, manifested by mandibular retrogression and increased facial convexity (De Moraes et al., 2012). **Bell, Proffit, and White (2018)** report that condylar loss greater than 3 mm can result in significant occlusal recurrence and the need for orthodontic or surgical retreatment.

In conservative management, **periodic radiographic control, use of occlusal stabilization devices, and physical therapy interventions** to minimize joint stress are indicated (Liebe et al., 2022). In advanced cases, with structural collapse of the condyle, surgical alternatives such as **repositioning arthroplasty, condylectomy with autogenous graft** (costochondral or fibular) and, in the terminal stages, **total TMJ prosthesis** (Murakami; Iwasaki, 2018; Hatcher et al., 2020).

Prevention is the central axis of clinical management. It is recommended to identify patients at risk through hormonal evaluation, three-dimensional analysis of facial pattern, and history of TMD. More conservative surgical planning, with moderate mandibular advancements and controlled rotation of the occlusal plane, significantly reduces the chance of resorption (Yamashita et al., 2021; Zenz et al., 2022).

In summary, ICR after orthognathic surgery represents a **multifactorial complication, of an adaptive and inflammatory nature**, the prevention of which requires integration between orthodontist, oral and maxillofacial surgeon and radiologist. Early diagnosis and individualized management are determinant for long-term functional and aesthetic prognosis.

4 CONCLUSION

Idiopathic condylar resorption after orthognathic surgery is a multifactorial complication that challenges both diagnosis and clinical management. Its occurrence results from a complex interaction between hormonal, anatomical, biomechanical, and inflammatory factors, which culminate in adaptive imbalance of the temporomandibular joint and progressive loss of condylar bone tissue.

Although its incidence is relatively low, the clinical impact is significant, compromising skeletal stability, facial harmony, and masticatory function. The integrative analysis of the evidence demonstrates that the prior recognition of risk factors, such as female gender, hyperdivergent pattern, and surgical movements of great magnitude, is essential for prevention.

Early diagnosis, combined with the use of three-dimensional imaging methods, represents the pillar of the modern approach, allowing detailed monitoring of morphological and functional changes in the joint. Likewise, the individualization of surgical planning and interdisciplinary follow-up are essential strategies to minimize complications and optimize results.

From a therapeutic perspective, ICR requires gradual intervention protocols, which can range from conservative occlusal control measures and physical therapy to complex reconstructions with grafts or joint prostheses. Success depends on the integration of surgeons, orthodontists, and radiologists, in a model of care centered on prevention and long-term stability.

It is concluded that idiopathic condylar resorption, although rare, represents a phenomenon of high clinical and scientific relevance. The advancement of knowledge about its etiopathogenic mechanisms and its functional repercussions constitutes a priority field of investigation, with the potential to improve surgical practices and reduce the incidence of this complication in contemporary orthognathic protocols.

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