

Mirlany Mendes Maciel Oliveira

Alterações na Articulação Temporomandibular após cirurgia ortognática diagnosticada com uso de Ressonância Magnética

*Changes in the Temporomandibular Joint Articular Disc after
Orthognathic Surgery*

Dissertação apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia como requisito parcial para obtenção do título de Mestre em Odontologia na Área de Clínica Odontológica Integrada.

Uberlândia, 2024

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*“Talvez não tenha conseguido fazer o melhor,
mas lutei para que o melhor fosse feito. Não sou
o que deveria ser, mas Graças a Deus, não sou
o que era antes”.*

Marthin Luther King

SUMÁRIO

RESUMO/PALAVRAS-CHAVE	10
ABSTRACT/KEYWORDS	11
1. INTRODUÇÃO E REFERENCIAL TEÓRICO	12
2. CAPÍTULO 1 – ARTIGO	15
REFERENCIAS	39
DECLARAÇÕES	45

RESUMO

A articulação temporomandibular é considerada uma das articulações mais complexas do organismo humano e está pode ser acometida pelas mesmas doenças e desordens que afetam outras articulações do sistema músculo-esquelético, como os deslocamentos de disco, doenças articulares degenerativas, artrites inflamatórias e sinovites. Os efeitos da cirurgia ortognática na articulação temporomandibular, principalmente as alterações ocorridas no pós-operatório, permanecem incompletamente compreendidos. A cirurgia ortognática em pacientes com disfunção temporomandibular pode ser um desafio, pois é importante corrigir as malformações esqueléticas, mas também para reduzir a artralgia, dor muscular e disfunções temporomandibulares. O presente estudo busca realizar através de uma revisão sistemática resumir as evidências disponíveis e responder à seguinte pergunta "Qual o efeito da Cirurgia Ortognática na posição do Disco Articular da Articulação Temporomandibular em pacientes com deformidade dentofacial?". Uma busca eletrônica em sete bases de dados primárias(Embase, Cochrane Library, MedLine via PubMed, SciELO, Scopus, LILACS and Web of Science) e duas adicionais (EASY and MedRxiv) para capturar parcialmente "literatura cinzenta". A estratégia PICO identificou artigos sem restrições de idioma ou ano de publicação. Dois revisores extraíram os dados, avaliaram o risco de viés do estudo individual usando o Manual JBI. Foram encontrados 4.024 registros, sete atenderam aos critérios de elegibilidade e foi realizada a avaliação das referencias bibliográficas dos artigos elegíveis sendo encontrados dois artigos elegíveis e acrescentados a esta revisão sistemática, totalizando nove artigos incluídos, publicados entre 1997 e 2020. Apesar da maioria dos artigos incluídos nesta revisão sistemática não terem notado alterações significativas na posição do disco articular após uma cirurgia ortognática, há artigos que observaram alterações na posição do disco articular, especialmente em casos de deslocamento de disco articular com redução.

Palavras-chave: Cirurgia Ortognática; Distúrbios da Articulação Temporomandibular; Disco Articular.

ABSTRACT

The temporomandibular joint is considered one of the most complex joints in the human body and can be affected by the same diseases and disorders that affect other joints of the musculoskeletal system, such as disc displacements, degenerative joint diseases, inflammatory arthritis and synovitis. The effects of orthognathic surgery on the temporomandibular joint, especially the changes that occur postoperatively, remain incompletely understood. Orthognathic surgery in patients with temporomandibular disorders can be challenging, as it is important to correct skeletal malformations, but also to reduce arthralgia, muscle pain and temporomandibular disorders. The present study seeks to carry out, through a systematic review, summarize the available evidence and answer the following question "What is the effect of Orthognathic Surgery on the position of the Joint Disc of the Temporomandibular Joint in patients with dentofacial deformity?". An electronic search in seven databases primary(Embase, Cochrane Library, MedLine via PubMed, SciELO, Scopus, LILACS and Web of Science) and two additional (EASY and MedRxiv) to partially capture "gray literature". The PICO strategy identified articles without restrictions on language or year of publication. Two reviewers extracted the data, assessed the risk of bias of the individual study using the JBI Manual. 4,024 records were found, seven met the eligibility criteria and the bibliographic references of eligible articles were evaluated, two eligible articles were found and added to this systematic review, totaling nine articles included, published between 1997 and 2020. Although the majority of articles included in this systematic review did not notice significant changes in the position of the articular disc after orthognathic surgery, there are articles that observed changes in the position of the articular disc, especially in cases of articular disc displacement with reduction.

Keywords: Orthognathic surgery; Temporomandibular Joint Disorders; Joint Disc.

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

1.1 Cirurgia Ortognática e Articulação Temporomandibular

As deformidades dento-faciais são caracterizadas por alterações significativas do sistema estomatognático que incluem alterações fonéticas, mastigatórias e respiratórias. Tais deformidades são geralmente tratadas através da ortodontia associada a cirurgia ortognática (Veldhuis et al., 2017).

A cirurgia ortognática consiste num processo em que as deformidades dentofaciais e más-oclusões são corrigidas através de intervenções cirúrgicas do esqueleto facial em combinação com a ortodontia (Panula et al. 2003). O principal objetivo e indicação da cirurgia ortognática é o de restabelecer um padrão facial considerado normal em pacientes adultos que terminaram o seu crescimento e apresentam grandes discrepâncias a nível ósseo. (Dujoncqoy et al., 2010).

Os benefícios da cirurgia ortognática incluem a melhoria da função mastigatória, deglutição e fonética (Ehmer e Broll, 1992), a diminuição da dor facial, melhoria estética, melhoria da função respiratória, maior proteção oclusal diminuindo o desgaste dentário e resultados mais estáveis na correção das discrepâncias severas (Fóltan et al., 2011).

As ATMs são um componente imprescindível do sistema estomatognático, que infelizmente com frequência são ignorados no preparo do paciente para cirurgia ortognática. Falha no diagnóstico ou tratamento adequado pode resultar resultados imprevisíveis e de baixa qualidade, recidivas, insatisfação estética e funcional, dor nas articulações e cefaleias. Em casos que a patologia de ATM não foi identificada ou tratada, a cirurgia de ATM e a repetição da cirurgia ortognática pode ser necessária para estabilizar as ATM e corrigir a mandíbula e a oclusão (WOLFORD et al., 2011).

Atualmente o diagnóstico dos distúrbios internos da ATM pode ser realizado utilizando diversos métodos e dispositivos, como radiográficas, como artrografia e tomografia, porém a ressonância magnética tem ganhado espaço no diagnóstico de distúrbios internos da ATM por apresentar alta precisão

diagnostica na determinação da posição do disco articular (GONÇALVES et al., 2015).

Quando as DTMs não são diagnosticadas ou não tratadas podem levar a resultados desfavoráveis e de baixa qualidade, além de complicações pós-operatórias (NADERSHAR et al., 2015, WOLFORD, 2003). Algumas dessas patologias intra-articulares podem ainda ser a causa direta de uma deformidade dento-facial como as hiperplasias condilares ativas, reabsorções condilares ativas e/ou idiopáticas, deslocamento anterior do disco crônico, osteocondromas dentre outras (AL-MORAISINI & WOLFORD, 2017; GOLÇALVES et al., 2015; PEREZ & LIDELL, 2017; WOLFORD & DHAMEJA, 2011).

O desarranjo interno, representado principalmente pelo deslocamento de disco, é a disfunção da articulação temporomandibular que está mais relacionada com a reabsorção condilar progressiva. O disco deslocado (com ou sem redução) provoca uma pressão na superfície articular, quando da rotação do côndilo, e isso favorece a diminuição da adaptação da ATM (Liporaci Junior et al., 2007).

Em casos onde existe a presença de deformidades dentofaciais e patologias articulares ativas como hiperplasias condilares, reabsorções idiopáticas e osteocondromas, a cirurgia ortognática e a cirurgia de ATM tornam-se complementares para proporcionar resultados mais previsíveis, visto que apenas a intervenção na articulação é capaz de reduzir, interromper ou eliminar estes processos e em casos de disfunções articulares como o deslocamento crônico do disco articular a cirurgia ortognática pode agravar os sintomas presentes, além de iniciar processos degenerativos (Wolford & Dhameja, 2011).

Segundo Gonçalves et al., (2015) Patologias preexistentes na ATM, sejam elas sintomáticas ou não, podem causar resultados desfavoráveis quando apenas a cirurgia ortognática é realizada, que inclui luxação do disco articular, condilar interno do adolescente reabsorção, hiperplasia condilar, osteocondroma, deformidades congênitas, artrite reativa, tecido conjuntivo / doenças auto-imunes, articulações não salváveis e outras. A patologia mais comum da ATM é o deslocamento anterior e / ou medial do disco articular podendo levar a diversos eventos inclusive a evolução de artrite ou outros sintomas relacionados a ATM.

Quanto a estabilidade pós-operatória, a estabilidade pós-operatória do plano oclusal e do ponto B sofreram relapso quando o deslocamento crônico do disco não foi tratado, em virtude de ocorrer o aumento da altura facial posterior e subsequente estiramento dos músculos massetéricos, pterigoideos e supra hioideos que acarretam maior pressão na região dos côndilos, levando a alterações de sua morfologia e relapso do movimento (Wolford e Al-Moraissi (2017).

2. CAPÍTULO 1 – ARTIGO

Alterações no disco articular da articulação temporomandibular após cirurgia ortognática: uma revisão sistemática

*Changes in the Temporomandibular Joint Articular Disc after Orthognathic
Surgery: A Systematic Review*

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ABSTRACT

Introduction: The effects of orthognathic surgery on the temporomandibular joint (TMJ), especially the changes that occur postoperatively, remain incompletely understood. Orthognathic surgery in patients with temporomandibular disorders can be challenging, as it is important to correct skeletal malformations, but also to reduce arthralgia, muscle pain, and temporomandibular disorders. **Objective:** To carry out a systematic review to investigate changes in the position of the TMJ articular disc after orthognathic surgery, using pre- and postoperative magnetic resonance imaging. **Methods:** Inclusion criteria included prospective or retrospective cohort studies involving patients with Class II and Class III facial profiles undergoing orthognathic surgeries of bilateral sagittal osteotomy of the mandibular ramus with or without Le fort I osteotomy with pre- and

postoperative magnetic resonance imaging. Exclusion criteria included especially the absence of magnetic resonance imaging in the pre- and postoperative period. An electronic search of seven primary (Embase, Cochrane Library, MedLine via PubMed, SciELO, Scopus, LILACS and Web of Science) and two additional (EASY and MedRxiv) databases to partially capture "gray literature." The PICO strategy identified articles without restrictions on language or year of publication. Two reviewers extracted data, assessed individual study risk of bias using the JBI Manual. *Results:* Of the 4,024 records were found, seven met the eligibility criteria and the bibliographic references of eligible articles were evaluated, two eligible articles were found and added to this systematic review, totaling nine articles included, published between 1997 and 2020. None presented a low risk of bias. Most of the studies included did not observe any significant change in the position of the articular disc after orthognathic surgery, however, one study found significant changes. *Conclusion:* Although most of the articles included in this systematic review did not notice significant changes in the position of the articular disc after orthognathic surgery, there are studies that reported changes in the position of the articular disc, especially in cases of articular disc displacement with reduction.

Keywords: Orthognathic surgery; Temporomandibular Joint Disorders; Temporomandibular Joint Disc.

RESUMO

Introdução: Os efeitos da cirurgia ortognática na articulação temporomandibular (ATM), principalmente as alterações ocorridas no pós-operatório, permanecem incompletamente compreendidos. A cirurgia ortognática em pacientes com disfunção temporomandibular pode ser um desafio, pois é importante corrigir as malformações esqueléticas, mas também para reduzir a artralgia, dor muscular e disfunções temporomandibulares. *Objetivo:* Realizar uma revisão sistemática para investigar as alterações na posição do disco articular do ATM após cirurgia ortognática, utilizando avaliação de ressonância magnética pré e pós-operatória. *Métodos:* Critérios de inclusão incluíram estudos de coorte prospectivos ou retrospectivos envolvendo pacientes com perfis faciais de Classe II e Classe III submetidos a cirurgias ortognáticas de osteotomia Le fort I com ressonância magnética pré-e pós-operatória. Critérios de exclusão incluíram especialmente a ausência de Ressonância Magnética no pré e pós-operatório. Uma busca eletrônica em sete bases de dados primárias (Embase, Cochrane Library, MedLine via PubMed, SciELO, Scopus, LILACS and Web of Science) e duas adicionais (EASY and MedRxiv) para capturar parcialmente "literatura cinzenta". A estratégia PICO identificou artigos sem restrições de idioma ou ano de publicação. Dois revisores extraíram os dados, avaliaram o risco de viés do estudo individual usando o Manual JBI. *Resultados:* Foram encontrados 4.024 registros, sete atenderam aos critérios de elegibilidade e foi realizada a avaliação das referencias bibliográficas dos artigos elegíveis sendo encontrados dois artigos elegíveis e acrescentados a esta revisão sistemática,

totalizando nove artigos incluídos, publicados entre 1997 e 2020. Nenhum apresentou baixo risco de viés. A maioria dos estudos incluídos não observou nenhuma mudança significativa na posição do disco articular pós-cirurgia ortognática, entretanto 01 estudo observou mudanças significativas. *Conclusão:* Apesar da maioria dos artigos incluídos nesta revisão sistemática não terem notado alterações significativas na posição do disco articular após uma cirurgia ortognática, há artigos que observaram alterações na posição do disco articular, especialmente em casos de deslocamento de disco articular com redução.

Palavras-chave: Cirurgia Ortognática; Distúrbios da Articulação Temporomandibular; Disco Articulação Temporomandibular

Introduction

The temporomandibular joint (TMJ) is a synovial joint comprised of the mandibular condyle and glenoid fossa of the temporal bone. An intermediate articular disc of fibrocartilage divides the joint cavity into upper and lower compartments (Stocum & Roberts, 2018). TMJ plays a crucial role in determining mandibular position, facial growth, development, function, occlusion, and facial balance. If the TMJs are not stable and healthy, patients requiring orthognathic surgery may experience unsatisfactory outcomes relative to function, aesthetics, occlusion, skeletal stability, and pain (Goncalves et al., 2013; Wolford, 2003; Wolford & Dhameja, 2011; Wolford LM, Movahed, 2014).

Temporomandibular disorder (TMD) is an umbrella term for musculoskeletal conditions in the temporomandibular region, characterized by pain and dysfunction in the masticatory muscles and the temporomandibular joints (List & Jensen, 2017). TMD is a major cause of nondental pain in the orofacial region (Gauer & Semidey, 2015), involving a broad spectrum of syndromes including myofascial pain disorder, disc derangement disorders, and osteoarthritis (Gauer & Semidey 2015).

Therapy for patients with dentoskeletal malformations and temporomandibular disorders can be challenging, as it is important to correct skeletal malformation while also reducing arthralgia, muscular pain, and TMJ dysfunctions (Di Paolo et al., 2017).

The treatment of dentofacial deformities and temporomandibular disorder through orthognathic and TMJ surgery remains controversial. Pakula et al. (2000) and Dervis & Tuncer (2002) stated that the functional status of the TMJ

can be significantly improved and pain levels reduced with orthognathic surgery. Conversely, Wolford (2003) argued that patients with preexisting TMJ pathology undergoing orthognathic surgery would likely experience a significant worsening of TMD after surgery. According to the author, TMJ dysfunction must be closely evaluated, treated if necessary, and monitored in the orthognathic surgery patient (Wolford, 2003).

The most common TMJ pathology is an anterior and/or medial displaced articular disc, which can initiate a cascade of events leading to arthritis and other TMJ-related symptoms (Wolford, 2003; Nickerson & Boring, 1989). Preexisting TMJ pathology (symptomatic or not) can result in unfavorable outcomes when only orthognathic surgery is performed, including articular disc dislocation, idiopathic condylar resorption, condylar hyperplasia, osteochondroma, congenital deformities, reactive arthritis, autoimmune/connective tissue diseases, and nonsalvageable joints (Wolford, 2003). All these conditions can be associated with dentofacial deformities, TMJ pain, headaches, myofascial pain, TMJ dysfunction, and others (Wolford, 2003).

Correct positioning of the mandibular condyle in the glenoid fossa is an important component in orthognathic surgery. Despite recent advancements in orthognathic procedures, maintaining condylar position in the glenoid fossa in patients with mandibular deformities remains a challenge in achieving a physiological TMJ position (Gerressen et al., 2007). Any changes in the condyle's position in the glenoid fossa or proximal segment (condylar-ramal segment) will be reflected postoperatively as occlusal discrepancies, leading to new or worsened TMJ symptoms (Kim, 2017).

Recognizing the significant role of TMJs and that the current understanding of the effects of orthognathic surgery on these intra-articular components remains incomplete is crucial to enhance patient outcomes, encompassing aspects of function, aesthetics, overall well-being, and, most importantly, the long-term stability of surgery. Thus, this study aimed to conduct a systematic review to investigate changes in the position of the TMJ articular disc after orthognathic surgery, using pre- and postoperative magnetic resonance imaging.

Methods

Protocol and registration

The protocol was developed according to the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (Shamseer et al., 2015). This systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021), conducted according to the Joanna Briggs Institute Manual (JBI), and registered on the PROSPERO platform under the code CRD42024500127.

Research Question and Eligibility Criteria

This review aimed to answer the question: “What is the effect of orthognathic surgery on the position of the articular disc of the temporomandibular joint in patients with dentofacial deformity?”, following the PICO structure: P (population): patients with dentofacial deformity, I (intervention): orthognathic surgery, C (comparison): articular disc position, and O (outcome): occurrence of internal derangements.

Regarding the inclusion criteria, this study included only planned or non-randomized clinical trials, and also prospective or retrospective cohort studies involving patients with Class II and Class III facial profiles undergoing orthognathic surgeries with Le Fort I and bilateral sagittal split (BSSO) osteotomies to correct maxillomandibular discrepancies. We focused on articles that evaluated the temporomandibular joint articular disc using magnetic resonance imaging before and after orthognathic surgery. There were no language or publication year restrictions.

Magnetic resonance imaging (MRI) of the TMJ is the most effective method for evaluating and diagnosing intra-articular disorders. This multidimensional and non-invasive imaging technique produces high-quality soft tissue images without the use of ionizing radiation and accurately displays the intra and extra-articular structures of the TMJ (Serindere et al., 2020).

As for the exclusion criteria, studies outside the topic; absence of MRI in the pre- and postoperative period; studies with sample overlap (in this case, considering the most recent study that best described the methodology and results); books, book chapters, case reports, case series, conference papers,

editorials, letters to the editor, literature reviews, and animal studies were excluded.

Study selection

Electronic searches were conducted in May 2023 in the Embase, LILACS (Latin American and Caribbean Literature in Health Sciences), MedLine (via PubMed), Cochrane Library and SciELO databases as well as in the Scopus and Web of Science. The EASY and MedRxiv and Open Access Theses and Dissertations (OATD) databases partially captured “gray literature”. These steps were taken to minimize selection bias. The search in MedLine was continuously updated with electronic alerts until October 2023. Descriptors were selected according to MeSH (Medical Subject Headings), DeCS (Health Sciences Descriptors), and Emtree (Embase Subject Headings) resources. Boolean operators “AND” and “OR” provided several combinations between descriptors, respecting the syntax rules of each database. The flowchart provides more details on search strategies and databases.

Before selecting the studies, a calibration exercise was carried out, in which the examiners discussed the eligibility criteria. Two reviewers performed a calibration exercise discussing the eligibility criteria and applying them to a sample of 20% of the retrieved studies to determine agreement between the examiners. Selection began after reaching a substantial agreement ($\text{Kappa} \geq 0.81$) and occurred in two phases.

The results were exported to EndNote Web™ software (Clarivate™ Analytics, Philadelphia, USA), where duplicates were automatically removed, and the remaining ones were manually removed. Afterward, the results were exported to Rayyan QCRI (Qatar Computing Research Institute, Doha, Qatar) software (Ouzzani et al., 2016), where titles and abstracts were read using the previous eligibility criteria. Subsequently, full texts of eligible preliminary studies were obtained and evaluated. Two eligibility reviewers (MMMO and VLA) performed the entire process independently. Discrepancies were resolved after consulting a third reviewer (MDMAC). Excluded articles in the full-text analysis were listed separately, and exclusion reasons were specified. In cases of articles not found, other study centers were contacted to retrieve the studies in their libraries via COMUT (Bibliographic Switching Program). In the case of

publications in languages other than English or Portuguese, the full text was translated.

Data collection

A calibration exercise was carried out before data extraction to ensure consistency among reviewers, and data from three eligible studies were extracted jointly. After calibration, two reviewers (MMMO and VLA) independently and blindly extracted data from eligible studies. A third reviewer (MDMAC) analyzed conflicts in cases of disagreement. From the articles, the following data were extracted: study identification (author, year, and ethical criteria application), study type, sample characteristics (sample size, sex distribution, and mean age), objective, type of facial deformity, intervention, presence of magnetic resonance imaging in pre- and postoperative periods, and the main results. In case of incomplete or insufficient data, corresponding authors were contacted via email up to three times at weekly intervals.

Risk of bias assessment

Two reviewers (MMMO and MDMAC) extracted data and independently assessed each domain for potential risk of bias, using the JBI Manual (Page et al., 2020), as recommended by the PRISMA statement (Page et al., 2020).

Each study was classified based on the percentage of positive responses to the questions. Bias risk was considered “High” when the study obtained 49% or less “yes” responses, “Moderate” when the study obtained 50% to 69% “yes” responses, and “Low” when the study achieved more than 70% “yes” score.

Any discrepancies among reviewers were resolved through discussion and consultation with a third reviewer (LRP).

Summary of measurements and results synthesis

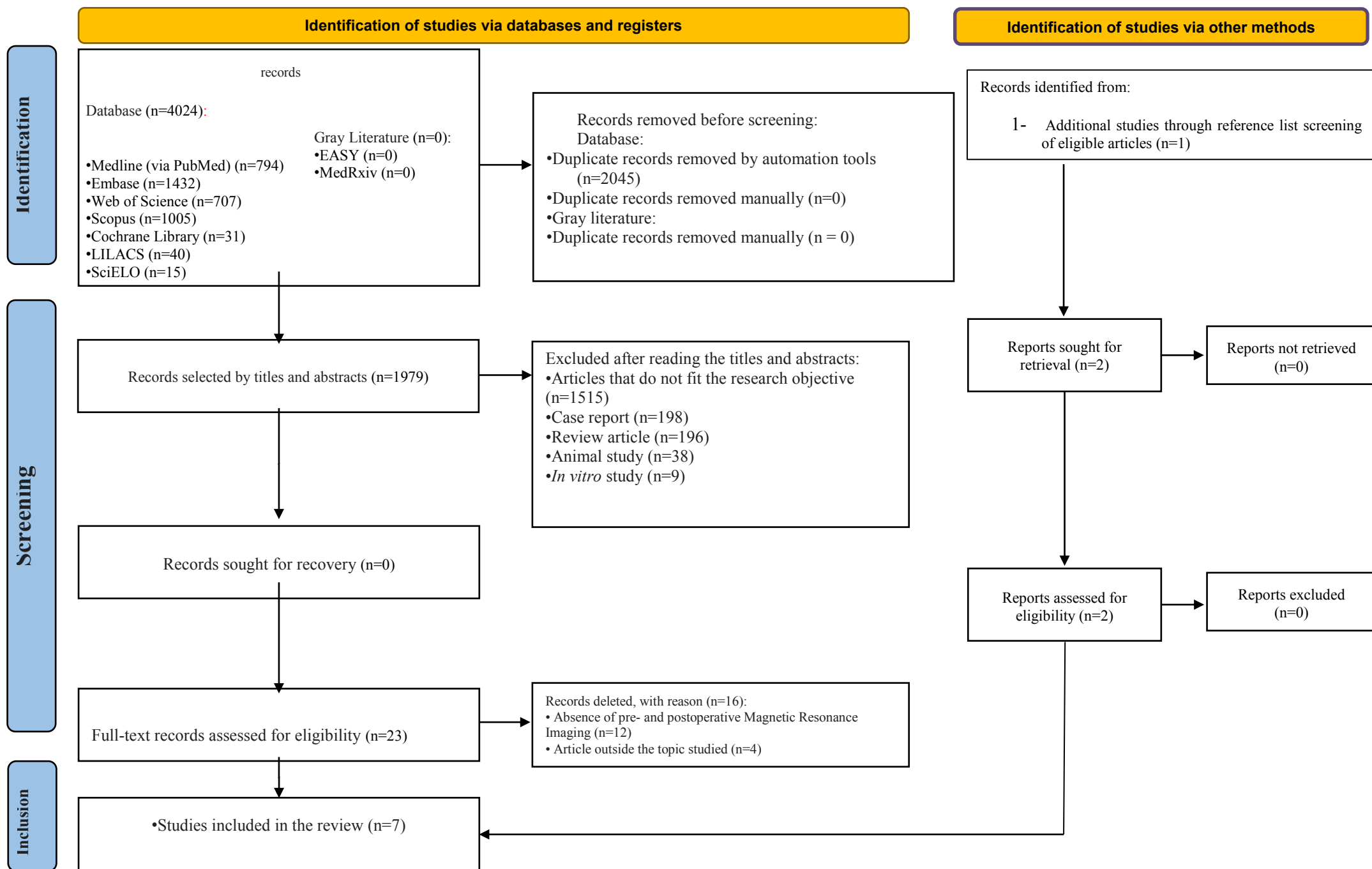
The data collected from the selected studies were organized into spreadsheets in Microsoft Excel™ 2019 (Microsoft™ Ltd., Washington, USA) and described narratively (qualitative synthesis). A meta-analysis was planned but not developed due to the high heterogeneity of the studies.

Results

Study selection

Electronic searches yielded 4,024 results in the databases. After removing duplicate titles, 1,979 remained. The examination of titles and abstracts excluded 1,956 articles. Thus, 23 studies were read in full. A total of 16 articles did not meet the eligibility criteria. Therefore, seven studies were included in the qualitative synthesis.

Additionally, a search through other methods, including reference list screening of eligible articles, found two eligible articles added to this systematic review, totaling nine included articles (Figure 1).



Study characteristics

The included studies had publication dates ranging from 1997 (Sanromán et al., 1997) to 2020 (Castro et al., 2020; Sharma et al., 2020). Three articles (Castro et al., 2020; Fang et al., 2009; Sharma et al., 2020) were retrospective observational studies, and six (Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002; Ueki et al., 2007) were prospective observational studies. All studies shared among their main objectives to assess the temporomandibular joint disc position before and after orthognathic surgery. However, the articles used MRI analysis methods differently, such as in the study by Castro et al. (2020), which assessed MRI according to the criteria described by Orsini et al. (1998), and Fang et al. (2009), who used the method reported by Nebbe et al. (1998) to quantify the joint disc on MRI and disc displacement. In turn, Firoozei et al. (2017) used the technique described by Ueki et al. (2007), and Ueki et al. (2007) used the method reported by Ueki et al. (2000).

The total number of eligible participants was 244 patients, aged between 16 and 60 years. Regarding the type of deformity, three studies (Castro et al., 2020; Firoozei et al., 2017; Sharma et al., 2020) included Class II patients, and six studies (Fang et al., 2009; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002, Ueki et al., 2007) included Class III patients. Table 2 shows a comprehensive overview of the key characteristics of each eligible article.

All studies used pre- and post-orthognathic surgery magnetic resonance imaging. Six articles (Castro et al., 2020; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Ueki et al., 2002; Ueki et al., 2007) also assessed clinical aspects related to the patients involved in the studies, two studies observed reduction of TMJ sounds/noises (Castro et al., 2020; Firoozei et al., 2017), and three articles reported improvement in joint symptoms after orthognathic surgery (Fang et al., 2009; Ueki et al., 2002; Ueki et al., 2007). The surgical technique predominantly involved bilateral sagittal split osteotomy, sometimes with Le Fort I osteotomy. However, two studies investigated beyond this approach. Ueki et al. (2002) discussed the effects of intraoral vertical ramus osteotomy on the temporomandibular joint, and Castro et al. (2020) evaluated the articular disc position after orthognathic surgery with concomitant TMJ

surgery for articular disc repositioning. For data standardization, only information regarding orthognathic surgery by mandibular ramus sagittal osteotomy was considered in this systematic review.

The follow-up duration ranged from 3 months (Firoozei et al., 2017; Kim et al., 2009) to 51 months (Castro et al., 2015). Notably, eight of the nine studies (Castro et al., 2015; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002; Ueki et al., 2007) did not found statistically significant changes in the temporomandibular joint disc position after orthognathic surgery. However, Sharma et al. (2020) reported significant changes in the articular disc position after orthognathic surgery, and seven patients achieved normal disc position after anterior disc displacement with reduction. Nevertheless, this was not the case for the patients with anterior disc displacement without reduction because the disc loses its capability to recapture. Importantly, Castro et al. (2020) found that, for the patients treated with orthognathic surgery only, 36.1% of TMJs had normally positioned discs in the preoperative phase, after surgery 38.5% of discs were in normal position, and 33.3% of displaced discs with reduction had worsening their position with a 50%-increase of discs displaced without reduction. Firoozei et al. (2017) revealed that after surgery, 5 patients (8 joints) showed evidence of disc deformation and degeneration.

Table 01 – Main data of the eligible studies

Author and Year of Publication	Type of study	Objective	Sample (age and sex)	Dentofacial deformity	Intervention	Magnetic Resonance Imaging pre- and postoperatively	Follow-up	Main results
Castro et al., 2020	Retrospective observational	To investigate the spatial position of the articular disc, before and after orthognathic surgery, using MRI, in individuals undergoing bimaxillary surgical advancement (maxillomandibular advancement, MMA) with counterclockwise rotation, with or without concomitant TMJ surgical disc repositioning.	39 patients 74 TMJs Mean age: 29.86 years 18 patients (Group I)	Class II	Orthognathic surgery with or without concomitant TMJ surgery for articular disc repositioning	Preoperative MRI and postoperative MRI at least 6 months after surgery	Mean = 16.2 months (range 6 to 51 months)	Changes in disc position were not statistically significant
Fang et al., 2009	Retrospective observational	To compare the changes in TMJ morphology and clinical symptoms after orthognathic surgery and evaluate the relationship between a change in condylar position and improvement in anterior disc displacement using MRI.	24 patients (7 men and 17 women) Age range = 17–33 years	Class III with condylar hyperplasia	Orthognathic surgery with sagittal osteotomy of the mandibular ramus and with or without Le Fort I osteotomy	Before surgery and 6 months after the surgical approach	Mean = 20.3 months	The combined orthodontic and orthognathic treatment can be used safely to correct skeletal class III malocclusion with mandibular hyperplasia without causing additional TMJ symptoms.
Firoozeei et al., 2017	Prospective observational	To determine and compare the position of the articular disc before and after orthognathic surgery in skeletal class II patients and to assess whether orthognathic surgery led to changes in temporomandibular disc position	15 patients	Class II	Bimaxillary orthognathic surgery (LeFort I and bilateral sagittal osteotomy (BSSO))	1 day before the surgical procedure and 3 months after surgery	3 months	Orthognathic surgery does not alter the disc-condyle relationship. Therefore, it has minimal effects on intact and functional temporomandibular joint.
Lee et al., 2008	Prospective observational	To evaluate the influence of orthognathic surgery on articular disc position and temporomandibular disorder symptoms of skeletal class III patients using TMJ MR images.	36 patients (22 women and 14 men)	Class III	Sagittal mandibular ramus osteotomy	1 month preoperatively and 1–4 months postoperatively	Uninformed	It can be suggested that orthognathic surgery does not significantly alter the position of the joint disc.

Kim et al., 2009	Prospective observational	To analyze the changes in the location of the articular disc, presence of internal derangement of the disc and the correlation between the amount of mandibular set-back and the changes in the location of articular disc.	23 patients Mean age = 22.09 years Male/female ratio = 1:1.3	Class III	Bilateral sagittal mandibular ramus osteotomy One surgeon performed the operations.	Preoperative and 3 months postoperative	3 months	Although there were significant differences of the disc positions in the open mouth state, the orthognathic surgery appears to have no effect on the TMJ.
Sanromán et al., 1997	Prospective observational	To investigate, with magnetic resonance and computed tomography, the influence of mandible osteotomy and jaw in position ATM components.	24 patients Age 14-38 (mean age = 23.8 years) 20 women and 4 men	Class III	Orthognathic surgery with sagittal osteotomy of the mandibular ramus and with or without Le Fort I osteotomy -	T1) within 2 weeks preoperatively; (T2) during the first week postoperative period (median 3 days, SD=0.64 days); (T3) 8 weeks after the operation, before removal intermaxillary fixation (median 47.7 days, SD = 3.2 days); and (T4) 1 year after the surgical procedure (median 370.2 days, SD = 8.5 days)	12 months	Although different changes in the position of the TMJ bone components that occurred after MSO, these appeared to be transient, without major changes in patients' final outcome
Ueki et al., 2002	Prospective observational	To compare changes in TMJ morphology, including disc tissue and TMJ clinical symptoms after orthognathic surgery	43 patients aged 15 to 37 years, with a mean age of 23.0 years	Class III	Sagittal ramus osteotomy (SSRO) and intraoral vertical osteotomy ramus osteotomy (IVRO) with and without Le Fort I osteotomy	1 month preoperative and 6 months postoperative	Uninformed	Sagittal split ramus osteotomy does not improve anterior disc displacement, but it may improve TMJ symptoms
Sharma et al., 2020	Retrospective radiology	To measure the changes in the disc position, condylar translation, secondary bony changes, and joint effusion on MRI before and after treatment	36 patients (19 women and 17 men). Mean age = 20.52 ± 3.1 years (range, 18 to 25 years)	Class II	Bilateral sagittal split ramus osteotomy	Before beginning orthodontic treatment and 1 year after completion of postoperative orthodontic treatment	12 months	Orthognathic surgery can increase secondary bone changes, improve disc position in cases of articular disc displacement without reduction, and control excessive TMJ translation. No improvement was seen in disc position in those with anterior disc displacement without reduction, hypomobility, and joint effusion.

Ueki et al., 2007	Prospective observational	To examine the changes in TMJ morphology and clinical symptoms after sagittal split ramus osteotomy (SSRO) with and without a Le Fort I osteotomy.	45 patients (13 men and 32 women) Ages from 15 to 37 years Mean age = 23.3 years	Class III	Sagittal ramus osteotomy with or without a Le Fort I osteotomy	1 month before surgery and 6 months after surgery	6 months	SSRO, either with or without Le Fort I osteotomy, could not change the preoperative disc position or correct anterior disc displacement, although these procedures did improve the symptoms associated with TMJ dysfunction
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Table 02 – Main data of the articular disc position

	Sample	Class	Outcome measurement method (N/DL)	Preoperative assessment	Postoperative assessment	There was a change in the position of the articular disc	Conclusion
Castro et al., 2020	18 patients (Group I)	II	Orsini et al. (1998)	Normal disc position in 12 joints (33%) and disc displacement in 24 joints (67%) (12 reducing and 12 non-reducing)	36.1% of TMJs had normally positioned discs preoperatively, after surgery 38.5% of discs in normal position and 33.3% of discs displaced with reduction worsened their position with an increase of 50% of discs displaced without reduction.	AT THE	Changes in disc position were not statistically significant
Fang et al., 2009	24 patients	III	Nebben et al. (1998)	Previous displacement that occurred prior to treatment in four TMJs meant that their length could not be measured. Only 44 of the 48 ATMs were measured	The length of the articular disc after treatment varied; however, the differences were not significant on the right and left sides.	AT THE	Orthodontic and orthognathic treatment has no significant effect on TMJ morphology or position
Firoozei et al., 2017	15	II	Ueki et al.	Initial click was present in 5 patients (10 joints). However, MRI results did not indicate any deformation or displacement	5 patients (8 joints) showed evidence of disc deformation and degeneration; After surgery, initial click was not present in any of the patients.	AT THE	Although the TM disc tended to move anteriorly after surgery for bilateral sagittal osteotomy of the mandibular ramus, this difference was not statistically significant. Therefore, orthognathic surgery has minimal effects on the intact and functional temporomandibular joint
Kim et al., 2009	23 patients			10 ATM with disc displacement with reduction; 2-disc displacement without reduction; 13 normal patients	10 ATM with disc displacement with reduction; 4-disc displacement without reduction; 13 normal patients.	AT THE	Orthognathic surgery has no effect on the TMJ. Orthognathic surgery has proven to be unrelated to internal articular disc derangement
Lee et al., 2008	36	III		24 patients had an articular disc in a normal position, 6 patients had anterior disc displacement with	The articular disc in all 3 categories had a tendency to be displaced posteriorly after sagittal mandibular ramus osteotomy.	AT THE	Orthognathic surgery does not significantly alter the position of the disc joint

				reduction, and 6 patients had anterior disc displacement without reduction.			
Sanromán et al., 1997	24 patients	III	Mavreas and Thanasiou (1992)	40 joints with normal articular disc position without changes in their morphology; 08 previously displaced discs with reduction in maximum mouth opening (Stage 1 or 2 in Wilkes)	Immediately post-surgery, the disc suffered anteroinferior displacement ('meniscal drop') only when a condylar laxity occurred (after bimaxillary surgery).	AT THE	Different changes in the position of the TMJ bone components occurred after sagittal osteotomy of the mandible, these seemed to be transient, without major changes in the patients' final result
Ueki et al., 2002	23 patients	III		Anterior displacement with reduction 4 Anterior displacement without reduction 4	No changes were observed after sagittal osteotomy of the mandibular ramus.	AT THE	Orthognathic surgery, through sagittal osteotomy of the mandibular branch, does not improve the anterior displacement of the disc, but it can improve symptoms in the TMJ region.
Sharma et al., 2020	36 patients	II		Preoperatively, 3 patients had had anterior disc displacement without reduction and 29 had had anterior disc displacement with reduction. Mobility of the TMJ was excessive in 16 patients and restricted in 2. Secondary bony changes were present in 3 patients, and joint effusion was present in 2 patients.	The same 3 patients continued to have anterior disc displacement without reduction. However, the number of patients with anterior disc displacement with reduction had decreased to 22. The number of patients with excessive translation had decreased to 12 but had remained restricted in 2 patients. The patients with secondary bony changes had increased to 11 from 3, and the number of patients with joint effusion had remained the same	YES	Changes in the TMJ are inevitable. Significant MRI changes will occur in the disc position, resulting in secondary bone changes and excessive translation of the TMJ.
Ueki et al., 2007	45 patients	III	Ueki et al. (2000)	Previous displacement with reduction 4 Previous displacement without reduction 1	Joints preoperatively classified as anterior type, fully covered type, or posterior type showed no postoperative changes in either group. Preoperative anterior disc displacement with reduction and without reduction did not change postoperatively in either group	AT THE	SSRO either with or without Le Fort I osteotomy cannot alter the preoperative disc position, including anterior disc displacement, although these procedures can improve the symptoms of TMJ dysfunction.

Individual study results

Regarding changes in the position of the temporomandibular joint disc, only the study by Ueki et al. (2002) did not provide information on the initial aspects of articular disc imaging. In the remaining studies (Castro et al., 2015; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997), most articular discs were in a normal position before orthognathic surgery, with some showing displacement, with or without reduction. Table 3 depicts the findings related to the position of the articular disc before and after orthognathic surgery using magnetic resonance imaging.

Regarding changes in the position of the temporomandibular joint disc, most included studies considered these changes statistically significant (Castro et al., 2015; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002; Ueki et al., 2007). However, Sharma et al. (2020) designed a retrospective radiological study evaluating Class II patients through pre- and postoperative magnetic resonance imaging. The results revealed that changes in the TMJ are inevitable and orthognathic surgery can increase secondary bone changes, improve the disc position in cases of anterior disc displacement with reduction, and control excessive TMJ translation. No improvement was observed in disc position in those with anterior disc displacement without reduction, hypomobility, and joint effusion.

Although most included studies (Castro et al., 2015; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002; Ueki et al., 2007) did not observe changes in the position of the TMJ disc, Firoozei et al. (2017) showed evidence of disc deformation and degeneration in 5 patients (8 joints), consistent with Castro et al. (2020), indicating that 33.3% of initially displaced discs had worsening their position, with a 50%-increase of discs displaced without reduction. According to Lee et al. (2008), the articular disc tended to be displaced posteriorly after bilateral sagittal split osteotomy in Class III patients.

Table 03 – Clinical and imaging results

Clinical Aspects		Imaging Aspects
Castro et al., 2020	TMJ sound/noise reduction	After surgery, 38.5% of discs in normal position and 33.3% of discs displaced with reduction worsened their position, with an increase of 50% in discs displaced without reduction.
Fang et al., 2009	Mouth opening unchanged; patients without joint symptoms preoperatively remained asymptomatic postoperatively	Joint disc length unchanged; unchanged articular disc displacement.
Firoozei et al., 2017	Initial click was present in 5 patients (10 joints). However, MRI results did not indicate any deformation or displacement. These 5 patients also reported sensitivity in their masticatory muscles. After surgery, initial click was not present in any of the patients.	Five patients (8 joints) showed evidence of disc deformation and degeneration although the difference between pre- and post-surgical images was not significant in this regard.
Kim et al., 2009	The patients had no clinical symptoms, including limited mouth opening, TMJ pain, etc. Distance between condyle and disc increased after orthognathic surgery.	No change in the classification of articular disc displacement; In the healthy control group where no anterior displacement of the articular disc was observed before orthognathic surgery, 5 patients presented displacement with reduction postoperatively.
Lee et al., 2008		The articular disc had a tendency to be displaced posteriorly after sagittal osteotomy of the mandibular ramus.
Sanromán et al., 1997		Change in articular disc position, No sign of remodeling in the mandibular condyle or glenoid fossa. Disc suffered anteroinferior displacement (meniscal sag); Intra-articular edema; subperiosteal effusion in the areas of masseter dissection.
Ueki et al., 2002	All joints with preoperative anterior disc displacement showed no postoperative changes.	Joints with preoperative anterior disc displacement that underwent sagittal osteotomy of the mandibular ramus did not present postoperative changes.
Sharma et al., 2020		Secondary bony changes, improve the disc position in cases of anterior disc displacement with reduction, and control excessive translation of the TMJ. No improvement was noted in the position of the disc in those with anterior disc displacement without reduction, hypomobility, and joint effusion
Ueki et al., 2007	Symptoms were improved by surgery in 80% of patients who underwent SSRO only and in 75% of patients who underwent SSRO with Le Fort I osteotomy; however, no statistically significant difference was found between both groups.	Preoperative anterior disc displacement with reduction and without reduction did not change postoperatively in either group

Individual study bias

Only one study (Sanromán et al., 1997) had a true comparison group (Q4). None of the studies had pre- and post-treatment measures (Q5), but one (Sanromán et al., 1997) had three post-treatment measurements. Table 5 displays further details on the individual assessment of each study.

Few concerns were raised regarding individual bias risk in the eligible studies. Firstly, there was a significant lack of true comparison groups in almost all studies, except one (Sanromán et al., 1997). Although studies used baseline measurements from the same participants as their comparator, the inclusion of an independent and separate group is highly recommended to enhance the validity of causal inferences (Tufanaru et al., 2020). Furthermore, none of the studies included multiple measures at both pre- and post-treatment periods, which could have favored a more robust analysis of cause-and-effect associations. Given the circumstantial challenges of conducting multiple imaging examinations, it is understandable that studies had a limited number of measures. However, multiple pre-treatment measurements play a key role in exploring the plausibility of other factors related to outcome changes in the absence of causality, while multiple post-treatment measurements examine changes in effect over time (Tufanaru et al., 2020). Therefore, further studies with multiple pre- and post-treatment measures are recommended to explore causality between variables. Nonetheless, the results of eligible studies can still be used to better understand the association between orthognathic surgery and changes in TMJ components, but the data should be interpreted with caution.

Table 4. Bias risk assessed by the “Joanna Briggs Institute Critical Appraisal Tools for use in JBI Critical Appraisal Checklist for Analytical Quasi-experimental Studies” (Tufanaru et al., 2020).

Author, year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Sanromán et al., 1997	√	√	√	√	--	√	√	√	√
Ueki et al., 2002	√	√	√	--	--	√	√	√	√
Ueki et al., 2007	√	√	√	--	--	√	√	√	√
Lee et al., 2008	√	√	√	--	--	√	√	√	√
Fang et al., 2009	√	√	√	--	--	√	√	√	√
Kim et al., 2009	√	√	√	--	--	√	√	√	√
Firoozzi et al., 2017	√	√	√	--	--	√	√	√	√
Castro et al., 2020	√	√	√	--	--	√	√	√	√
Sharma et al., 2020	√	√	√	--	--	√	√	√	√

Q1 - “Is it clear in the study what is the ‘cause’ and what is the ‘effect’ (i.e., there is no confusion about which variable comes first)?”; Q2 - “Were the participants included in any comparisons similar?”; Q3 - “Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?”; Q4 - “Was there a control group?”; Q5 - “Were there multiple measurements of the outcome both pre and post the intervention/exposure?”; Q6 - “Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed?”; Q7 - “Were the outcomes of participants included in any comparisons measured in the same way?”; Q8 - “Were outcomes measured in a reliable way?”; Q9 - “Was appropriate statistical analysis used?”; √ - Yes; -- - No; NC – Not clear

Discussion

The effects of orthognathic surgery on the TMJ are not yet fully understood. Currently, there is limited information on what happens to the various intra-articular components after this surgery.

TMJ pathologies or conditions are a source of skeletal and occlusal instability late after orthognathic surgery, as well as continuous pain, headaches, and mandibular dysfunction. The instabilities are usually a result of preexisting untreated TMJ pathology or TMJ conditions created by the orthognathic surgery, such as excessively traumatic surgery that damages the joints or overloading the TMJs by intentionally creating posterior open bites at surgery (Wolford, 2019).

According to Tomas et al. (2006), in the presence of anterior disc displacement with reduction, the articular disc will move to an anteromedial position, following the shape of the condyle and anterior inclination of the glenoid fossa under the influence of the lateral pterygoid muscle. For McLaughlin (1988), in Class II skeletal malocclusion, due to the mandibular retrusion in relation to the maxilla/base of the skull, the disc will mainly be anteriorly displaced. Reduction occurs due to the condyle’s ability to negotiate

around the disc and the disc's ability to assume a normal position in relation to the condyle and glenoid fossa.

The main point of agreement among most of the included articles (Castro et al., 2020; Fang et al., 2009; Firoozei et al., 2017; Lee et al., 2008; Kim et al., 2009; Sanromán et al., 1997; Ueki et al., 2002; Ueki et al., 2007) relates to the absence of changes in the articular disc position after orthognathic surgery evaluated using MRI. In contrast, Sharma et al. (2020) found changes in the position of the articular disc after orthognathic surgery.

In line with the included articles, Zhai et al. (2020) performed a retrospective cohort study with adult patients aiming to assess the difference in TMD prevalence before and after orthognathic surgery. The authors found a significant 26.5% reduction in TMD prevalence, from 60.9% preoperatively to 34.4% at 1 year postoperatively. Additionally, they concluded that corrective orthognathic surgery for dentofacial deformities may provide a secondary benefit in treating TMD. However, surgeons should be aware that a small number of patients may experience a worsening of their TMD condition, and preoperative asymptomatic patients may develop TMD symptoms after surgery.

Concurrently, Bianchi et al. (2018) conducted a retrospective cohort study aimed to assess, three-dimensionally, using cone-beam computed tomography, the mandible and maxilla changes following maxillomandibular advancement (MMA), with and without repositioning of TMJ articular discs. In conclusion, there were no significant differences in skeletal stability between the two groups. The maxillomandibular advancement surgeries, with rotation of the occlusal plane, had stable outcomes for both groups immediately after surgery and at 1-year follow-up. However, the authors could not assure that the repositioned discs were kept in place because post-surgical MRI data were not available.

Regarding the improvement of TMD symptoms after orthognathic surgery, the study by Ueki et al. (2007) found improvements in symptoms, which is in agreement with the study by Ploder et al. (2021), who conducted a longitudinal cohort study focusing on TMJ function, symptoms of TMD with periodic follow-up of patients for up to 2 years, with a sample of 375 patients treated with bilateral sagittal split osteotomy or Le Fort I and bilateral sagittal split osteotomy. The investigators observed that, in most cases, TMD symptoms

can be significantly reduced, and only in some cases they can be induced with orthognathic surgery.

Still regarding the improvement of TMD after orthognathic surgery, Di Paolo et al. (2017) investigated the prevalence of TMDs in patients scheduled for orthognathic surgery. They reported that both the functional status and pain levels related to TMDs can be significantly improved with a multidisciplinary approach and concluded that the surgeon's intervention needs to be modified in the presence of pre-surgical TMDs.

In the study by Sanromán et al. (1997), postoperative magnetic resonances were carefully evaluated, and signs of intra-articular edema (joint fluid in the upper or lower compartment) were observed in 24 TMJs of the 15 patients treated with bimaxillary orthognathic surgery. In most cases, intra-articular edema appeared in both; however, in 3 cases, it was unilateral. A high association was found between intra-articular edema and condylar sag greater than 2 mm. This appeared only immediately after surgery, and in all cases the joint effusion disappeared in magnetic resonances performed 8 weeks postoperatively. The high association between the presence of intra-articular edema and condylar sag greater than 2 mm suggests that edema may be related to anteroinferior displacement of the condyle after surgery, explained by the anatomical configuration of the glenoid fossa. Thus, the reabsorption of edema would contribute to normalization of the condylar position in a posterior and superior direction.

Consistent with the study of Sanromán et al. (1997), Firoozei et al. (2017) evaluated the morphometric and morphological changes in temporomandibular joint following orthognathic surgery using MRI and computed tomography (CT) scan. The authors concluded that although changes were observed in bony structures of the TMJ after bimaxillary surgery, these alterations are temporary and do not affect the final outcome of the surgery. Firoozei et al. (2017) also reported that the articular disc tended to move anteriorly after bilateral sagittal split osteotomy surgery, but this difference was not statistically significant. This is in agreement with the findings of Kim et al. (2009), where MRI revealed that the disc position in closed mouth did not change after sagittal split ramus osteotomy. These results are in line with the study by Fang et al. (2009), as the

disc position did not change significantly after sagittal split ramus osteotomy for correction of Class III skeletal deformity.

Toll et al. (2010) carried out a study using MRI and observed that patients with Class II malocclusion have the highest incidence of articular disc displacement before orthognathic surgery, and this group may be more vulnerable after surgery, suggesting MRI as part of the investigation.

However, according to Wolford & Mehra (2003), patients with preexisting TMJ dysfunction undergoing orthognathic surgery, particularly mandibular advancement, are likely to have significant worsening of the TMJ dysfunction postsurgery. TMJ dysfunction must be closely evaluated, treated if necessary, and monitored in orthognathic surgery patient.

Regarding orthognathic surgery for displaced articular discs (confirmed by magnetic resonance imaging), Wolford (2003) evaluated 25 patients who were treated solely with orthognathic surgery, including mandibular advancement and stabilization with rigid fixation. In the postoperative period, relapse at point B was 36% of mandibular advancement, and distance from the condyle to point B decreased by 34%, indicating condylar resorption. Six patients (24%) developed condylar resorption (3–8 mm) postsurgically, resulting in class II open bite malocclusion. The increased loading of the TMJs as a result of the mandibular advancement most likely stimulated the resorption process. The appearance of new onset or aggravation of TMJ symptoms (e.g., pain, TMJ dysfunction) averaged 14.1 months after surgery. In conclusion, 48% of patients required TMJ treatment and repeat orthognathic surgery.

Diverging from the studies included in this systematic review, Castro et al. (2020) compared changes in the TMJ after orthognathic surgery and TMJ surgery. In this study, there was a worsening trend in articular disc positions in the orthognathic surgery only group, with a 50%-increase of discs displaced without reduction. However, these data still differ from those obtained by Sharma et al. (2020), who found that orthognathic surgery can increase secondary bone changes, improve the disc position in cases of anterior disc displacement with reduction, and control excessive TMJ translation. No improvement was noted in disc position in those with anterior disc displacement without reduction, hypomobility, and joint effusion.

According to Sharma et al. (2020), combined orthodontic and orthognathic movement will have no effect on preexisting anterior disc displacement without reduction, restricted condylar translation, and joint effusion. Definitive operative and nonoperative procedures, whether open or closed, are required to correct these aspects of TMJ dysfunction in conjunction with orthognathic surgery for a healthy TMJ in patients with skeletal Class II malocclusion.

We also found other aspects related to the repercussions of orthognathic surgery on the TMJ, such as in the study by Fang et al. (2009). The authors reported that there was no significant difference before and after orthognathic surgery regarding maximum mouth opening, and patients without joint symptoms preoperatively remained asymptomatic postoperatively. Castro et al. (2020) found a reduction in TMJ sounds/noises in patients undergoing orthognathic surgery, corroborating with Ueki et al. (2002), who noted improvement in joint symptoms.

As for the rigid internal fixation, Ureturk & Apaydin (2018) evaluated the stress distribution on TMJs using different fixation methods. The authors concluded that the use of bicortical screws increases the stress on the condyle, and for the patients with a tendency toward temporomandibular disorders, miniplate fixation techniques should be used.

Correlating with biopsychosocial aspects, Bergamaschi et al. (2020) developed a longitudinal study to assess the impacts of orthognathic surgery in patients with skeletal class II malocclusion on oral health-related quality of life, temporomandibular disorders, and psychological symptoms. The findings revealed that although orthognathic surgery improves quality of life and some TMD conditions, poorer postoperative outcomes are observed when psychological conditions are present. While orthognathic surgery provides numerous benefits, the treatment for these patients should be multifactorial, requiring providers to be aware of the patients' full context, addressing not only physical aspects but also psychological changes caused by dentofacial deformity throughout life.

As limitations of the included studies, we can consider sample sizes and several other individual variables, such as analysis method, bias, presence and type of TMJ pathology, surgical technique, surgeon skill, and post-surgical

orthodontics. It is also worth noting the short follow-up time, as in short-term follow-up, such as in the study by Firoozei et al. (2017), who performed MRI 3 month postoperatively, patients are still in the healing process, and the results may differ in longer follow-up.

Therefore, further in-depth studies are required to address the topic with larger samples, relevant postoperative follow-up time, and three-dimensional analysis of the TMJ, also including the various types of facial deformities and the repercussions of orthognathic surgical movements on TMJ.

Conclusion

Although most articles included in this systematic review did not notice significant changes in the position of the articular disc after orthognathic surgery, there are studies that revealed changes in the articular disc position, especially in cases of articular disc displacement with reduction, besides the improvement in painful symptoms and changes in joint sounds/noises.

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Supplementary Table 1 - Studies excluded after complete reading

	Excluded studies	Reasons for exclusion of articles
1	Aghabeig et al., 2001	On MRI
2	Almashraqi et al., 2020	Off topic
3	Alder et al., 1999	On MRI
4	Abrahamsson et al., 2012	On MRI
5	Aslanidou et al., 2020	On MRI
6	Bergamaschi et al., 2020	On MRI
7	Bianchi et al., 2018	On MRI
8	Enami et al., 2012	On MRI
9	Farella et al. 2007	On MRI
10	Gonçalves et al., 2008	Off topic
11	Goncalves et al., 2013	Off topic
12	Gokalp et al., 2000	Off topic
13	Gomes et al 2018	On MRI
14	Han et al. 2017	On MRI
15	Miao et al., 2017	On MRI
16	Ueki et al. 2015	On MRI

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STATEMENTS

Conflicts of interest: All authors certify that they have no affiliations or involvement with any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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