Larissa Gonçalves Cunha Rios

Avaliação dos efeitos da cirurgia ortognática e da prótese de ATM a curto e médio prazos.

Evaluation of the effects of orthognathic surgery and TMJ prosthesis in medium and short term.

Tese apresentada à Faculdade de Odontologia da Universidade de Uberlândia, para obtenção do Título de Doutor em Odontologia na Área de Clínica Odontológica Integrada.

Uberlândia, 2022

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Projeto de Pesquisa de vinculação:	Tratamento das Deformidades e dor Oro-facial e das disfunções temporomandibulares				

Reuniu-se em Web Conferência pela plataforma Zoom, em conformidade com a PORTARIA Nº 36, DE 19 DE MARÇO DE 2020 da COORDENAÇÃO DE APERFEIÇOAMENTO DE PESSOAL DE NÍVEL SUPERIOR - CAPES, pela Universidade Federal de Uberlândia, a Banca Examinadora, designada pelo Colegiado do Programa de Pós-graduação em Odontologia, assim composta: Professores Doutores: Luiz Renato Paranhos (UFU); Flaviana Soares Rocha (UnB); João Roberto Gonçalves UNESP-ARARAQUARA); Jonas Bianchi (UNIVERSITY OF PACIFIC); Darceny Zanetta Barbosa (UFU); orientador(a) do(a) candidato(a).

Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Darceny Zanetta Barbosa, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

Aprovada.

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DEDICATÓRIA

Dedico este trabalho ao meu
marido Felipe, minha mãe
Elizabeth, minha irmã
Mariana e meus sobrinho Ana
Laura e Miguel.

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À Deus por ter me abençoado sempre em minha vida, me dando saúde, me ajudando a superar obstáculos e colocando pessoas especiais em minha vida.

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SUMÁRIO

RESUMO

Deformidades dentofaciais e desarranjos internos da articulação temporomandibular (ATM) são problemas que podem ter um grande impacto na vida do paciente, e frequentemente estas duas alterações podem estar correlacionadas. A elaboração do plano de tratamento das deformidades dentofaciais, deve envolver uma avaliação clínica minuciosa, facial, oclusal e das articulações temporomandibulares. Articulações temporomandibulares que apresentem alguma disfunção, devem ser avaliadas cautelosamente, e se necessário tratadas antes ou durante a cirurgia ortognática. O tratamento destas disfunções dependerá do grau de acometimento, podendo ser indicado desde o tratamento mais conservador à substituição da articulação por uma prótese total. Os objetivos deste trabalho foram avaliar o impacto da cirurgia ortognática com avanço e rotação anti-horária do complexo maxilo-mandibular na via aérea e coluna cervical, avaliar as principais complicações associadas a cirurgia para instalação de prótese total de ATM, e relatar um caso de uma paciente que foi submetida a diversos tratamentos para desarranjo interno da articulação temporomandibular, sendo por fim tratada com a prótese total de ATM. Os resultados demonstraram que tanto a cirurgia ortognática como o procedimento cirúrgico para instalação da prótese de ATM são seguros e estáveis, sendo capazes de melhorar a capacidade funcional dos pacientes.

PALAVRAS-CHAVE: Cirurgia ortognática, coluna cervical, via aérea, desordens temporomandibulares, instalação de prótese mandibular

ABSTRACT

Dentofacial deformities and internal disorders of the temporomandibular joint (TMJ) are problems that can have a great impact on the patient's life, and often these two alterations can be correlated. The elaboration of a treatment plan for dentofacial deformities must involve a meticulous clinical evaluation of face, occlusion, and temporomandibular joints. Dysfunctional temporomandibular joints should be carefully evaluated and, if necessary, treated before or concomitant with orthognathic surgery, when this one is indicated. The treatment of these dysfunctions is based on the degree of involvement and vary from conservative treatment to replacement of the joint by a total prosthesis. The objectives of this study were to evaluate the impact of orthognathic surgery with advancement and counterclockwise rotation of the maxillomandibular complex on the airway and cervical spine, to evaluate the main complications associated with surgery for the installation of a TMJ total prosthesis, and to report a case of a patient submitted to several treatments for internal derangement of the temporomandibular joint, being finally treated with the TMJ total prosthesis. The results showed that both orthognathic surgery and the surgical procedure for installing the TMJ prosthesis are safe and stable, being able to improve the functional capacity of patients.

KEY-WORDS: Orthognathic Surgery, cervical Vertebrae, airway management temporomandibular Joint Disorders, Mandibular Prosthesis Implantation

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

As deformidades dentofaciais e os desarranjos internos da articulação temporomandibular (ATM) são alterações que podem acarretar grandes prejuízos funcionais. As deformidades podem estar ou não associadas a disfunções articulares, e isso deve ser observado para a elaboração do plano de tratamento do paciente.

As principais queixas funcionais das deformidades dentofaciais são problemas oclusais, dificuldades na mastigação, dores musculares, e até mesmo dificuldade respiratória, como apnéia do sono. Esta quando diagnosticada como apnéia obstrutiva, está frequentemente relacionada com o retrognatismo mandibular e angulações aumentadas do plano oclusal e do plano mandibular (Coleta *et al.,* 2009).

A maioria dessas deformidades pode ser corrigida através da cirurgia ortognática, procedimento que visa estabelecer um equilíbrio anatômico e funcional dos ossos da face, a partir de osteotomias maxilares e mandibulares, devolvendo ao indivíduo equilíbrio funcional dos maxilares. Pacientes que apresentam retrognatismo mandibular e plano oclusal aumentado têm indicação de cirurgia ortognática com avanço e rotação anti-horária do plano oclusal. Este movimento além da correção da deformidade facial e relação oclusal também promove um aumento significativo da via aérea superior, devido ao estiramento da musculatura supra-hióide e velofaríngea (Hernández-Alfaro *et al.,* 2011).

Alguns autores avaliaram bidimensionalmente os efeitos da cirurgia ortognática com rotação do plano oclusal e os correlacionaram com o volume de via aérea, coluna cervical e osso hióide. Estes estudos concluíram que pacientes que foram submetidos a cirurgia ortognática tiveram mudanças na posição da coluna cervical e do osso hióide, e um aumento no volume de via aérea superior (Mehra *et al.,* 2001; Gonçalves *et al.,* 2006).

Além dos objetivos estéticos e funcionais relacionados à cirurgia ortognática, um grande desafio durante o procedimento cirúrgico, além de estabelecer a oclusão ideal e harmonia facial, é o adequado posicionamento das articulações temporomandibulares (ATMs) numa posição o mais fisiológica possível (Gaggl *et al.,* 1999).

Em um estudo realizado por Gomes *et al*., em 2017 com 79 pacientes submetidos a procedimento de rotação anti-horária do complexo maxilo-mandibular, os autores constataram que existe estabilidade na cirurgia ortognática quando há saúde da

articulação temporomandibular ou quando se faz a plicatura do disco articular nos casos de desordens articulares diagnosticadas previamente à cirurgia ortognática.

As patologias articulares mais frequentes incluem hiperplasia condilar, osteocondroma, deslocamento do disco articular, artrite reativa, reabsorção condilar interna do adolescente, e patologias da ATM em estágio final (por exemplo, doenças autoimunes, artrite reativa avançada ou osteoartrite, múltiplas operações nas articulações, lesões traumáticas e anquilose). Sendo que estas condições estão frequentemente associadas com deformidades dentofaciais e má oclusão.

O tratamento destas patologias dependerá do grau de acometimento dos componentes articulares. Os tratamentos incluem terapias conservadoras como medicamentosa, fisioterapia e placas oclusais, tratamentos menos invasivos como administração medicamentosa intra-articular, e procedimentos cirúrgicos desde os menos invasivos como artroscopia, aos mais invasivos como discopexia, condilectomias e prótese total de ATM (Al-Moraissi *et al.,* 2020, Santos *et al.,* 2021). O plano de tratamento deve sempre que possível iniciar com as terapias mais conservadoras até as mais invasivas quando necessários (Al-Baghdadi *et al*., 2014). As patologias proliferativas como as hiperplasias condilares quando ativas são comumente tratadas por condilectomia alta e discopexia, e dependendo do grau deformidade dentofacial gerado pelo crescimento condilar, a cirurgia ortognática também pode ser indicada. O tratamento dos osteocondromas é similar, porém por se tratar de um crescimento que altera a anatomia condilar tanto verticalmente quanto horizontalmente faz-se necessário a realização de condilectomia baixa.

O deslocamento anterior e/ou medial do disco articular é um dos causadores mais comuns das disfunções articulares (Mehra & Wolford, 2001). Este pode ou não estar associado a queixas álgicas, comprometimento funcional e a reabsorções condilares. A avaliação da necessidade de cirurgia para reposicionamento do disco articular deve considerar as queixas apresentadas pelo paciente, os tratamentos já realizados, os achados imaginológicos e o comprometimento articular.

O tratamento de articulações que apresentam maior comprometimento articular, como inviabilidade de plicatura discal, reaborções severas, tumores extensos, é realizado através da substituição articular por prótese total de ATM (Morey-Mas *et al.,* 2011), associada ou não a cirurgia ortognática.

Há dois tipos de próteses de ATM disponíveis no mercado, as chamadas próteses de estoque que são próteses pré-fabricadas que variam de tamanho em uma escala padrão, e as próteses customizadas que são fabricadas para cada paciente utilizando um planejamento individual baseado em tomografias computadorizadas e tecnologia CAD/CAM, sendo estas as que devolvem um melhor equilíbrio entre os componentes do aparelho estomatognático (Ettinger *et al.,* 2016).

Vários estudos relatam que essa modalidade de tratamento é eficaz e segura em acompanhamento a longo prazo e indicado para tratamento em diversas situações. Em comparação com outras modalidades, são mais previsíveis, não requerem um segundo sítio cirúrgico doador, tendem a não ser suscetíveis a recidivas de doenças degenerativas e promovem um retorno mais precoce da função (Wolford *et al.,* 2015; Balon *et al.,* 2019; Mamid *et al.,* 2019). Porém, como todo procedimento cirúrgico, neste também pode haver complicações.

2. PROPOSIÇÃO

O objetivo geral deste trabalho foi avaliar os efeitos da cirurgia ortognática e da prótese de ATM a curto e médio prazo.

Os objetivos específicos foram:

- Avaliar ~~retrospectivamente~~ o impacto da cirurgia ortognática bimaxilar com rotação anti-horária do plano oclusal no aumento da via aérea faríngea e na coluna cervical.
- Avaliar as principais complicações pré e pós-operatórias relacionadas à instalação de prótese total de ATM por meio de revisão sistemática
- Relatar um caso clínico de tratamento de desarranjo interno da ATM, exemplificando as diversas modalidades de tratamento, desde as menos invasivas à prótese total de ATM.

3. CAPÍTULOS

3.1. Capítulo 1

Three-dimensional assessment of the pharyngeal airway and cervical spine after orthognathic surgery with counterclockwise rotation of the maxillomandibular complex.

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Short title: Head position and orthognathic surgery

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Abstract

Purpose: The aim of this study was to evaluate changes in airway morphology and cervical vertebra posture of patients submitted to bimaxillary orthognathic surgery with counterclockwise rotation of the maxillo-mandibular complex. Materials and Methods: This retrospective cohort study evaluated cone-beam computed tomography scans of patients with high occlusal plane angle facial profiles that underwent orthognathic surgery with counterclockwise rotation of maxillo-mandibular complex, for post-surgery airway and cervical postural changes. Airway and cephalometric measurements were obtained before surgery (T1), immediately after surgery (T2), and at least 9 months after surgery (T3) using Dolphin Imaging® 11.95. Results: The airway parameters, such as area, minimum axial area, and volume, were significantly increased after surgery ($P \leq 0.001$). Statistical significant head/cervical posture change was observed at longest follow-up (T3-T1), based on changes of OPT-SN angle (mean value 2.9°) and of CVT-SN angle (mean value 3.5°). Statistical significant correlations between upper airway increase, surgical movements, and changes in head posture were found ($P \leq 0.05$). Conclusions: According to these results, orthognathic surgery with counterclockwise rotation of the maxillomandibular complex might increase the upper airway dimensions and improve cervical posture.

Introduction

Respiratory and sleep disorders constitute a public health problem, leading to a biopsychosocial impact in quality of life. Patients with significant obstructive respiratory disorders such as Obstructive Sleep Apnea (OSA) can develop hypertension, arrhythmia, inability to concentrate, memory and judgment impairment, irritability, stroke, heart attack and even death[1].

OSA is often related to mandibular retrognathism and high occlusal plane angle (HOP) facial morphology[2]. Studies have shown that maxillo-mandibular advancement (MMA) significantly improves the pharyngeal airway space, confirming the application of this technique for the treatment of pharyngeal airway space obstruction[3,4,5]. This improvement occurs by protraction of the supra-hyoid and velopharyngeal muscles[6] that

displace the tongue and soft palate forward, opening the pharyngeal airway and alter the head and neck posture[7,8,9].

The aims of this study are to determine the effect of MMA surgery and counterclockwise rotation (CCWR) of the maxillomandibular complex (MMC) on the pharyngeal airway space, hyoid bone position, and cervical spine posture. The hypothesis is that the surgical skeletal changes will improve the pharyngeal airway dimensions as well as cervical spine and hyoid positions. The correlation between these variables was evaluated.

Materials and Methods

Study population

This retrospective cohort study evaluated cone-beam computed tomography (CBCT) scans of patients who underwent orthognathic surgery with MMA and CCWR of the MMC, that were operated in two centers (Araraquara, Brazil; Dalla, USA). The patient inclusion criteria for the study: 1) HOP facial morphologies; 2) Orthognathic surgery with bilateral mandibular ramus sagittal split osteotomies and Le Fort I osteotomies for CCWR of the MMC; 3) Osteotomies stabilized with rigid fixation; 4) Minimum of 9 months follow-up, and 5) Adequate records for assessment. The exclusion criteria were: 1) Craniofacial syndromes; 2) Previous surgical intervention in the craniofacial, cervical, or oropharyngeal regions, and 3) Inadequate or poor-quality records. The Research Ethics Committee of the Federal University of Uberlandia, Brazil, approved this project, with protocol number 2.250.020.

Images acquisition

CBCT scans were performed at three-time intervals: one day before surgery (T1), immediate (within one week) post-surgery (T2), and the longest post-surgery follow-up (at least 12 months after surgery) (T3). ICAT^{TM} Cone Beam 3D Imaging System (Imaging Science International, Hatfield, PA, USA) was used, and a standardized protocol on each subject was obtained as follows: 1) Patient seated upright with the Frankfort horizontal plane (tragus-infraorbital rim line) parallel to the floor; 2) Not to swallow; 3) Jaw and

occlusion in centric relation, and 4) Gently breathe through the nose during acquisition. An extended field of view (FOV) with defined voxels of 0.30 mm^3 and an exposure time of 17.9 seconds were used. The CT images were converted into DICOM files and exported to Dolphin Imaging® 11.95 software (Dolphin Imaging and Management Solutions, Chatsworth, CA).

Image evaluation

The DICOM files were imported into the Dolphin Imaging® 11.95 software (Dolphin Imaging and Management Solutions, Chatsworth, CA), and 3D volume was oriented in virtual space to establish a pattern for further analysis of the images. The correct positioning of the head ensured that during the airway study, the axial plane was in the midline of the face, providing data reliability. The midsagittal plane was oriented to the patient's midline in the coronal view, considering crista Galli and anterior nasal spine alignment. In the sagittal view, the Frankfort horizontal plane (FH) was parallel to the axial plane[5] (Fig. 1).

Cephalograms were created, and a customized analysis consisting of linear and angular measurements was performed to evaluate the surgical movements as well as hyoid and cervical vertebrae positional changes. The horizontal reference plane (HRP) was constructed at 7º to the SN plane, and the vertical reference plane (VRP) was built perpendicular to HRP through Sella (S). There were 14 linear and 01 angular measurements used to evaluate the dento-skeletal surgical changes and stability. Two linear and 03 angular measurements were used to assess hyoid bone and cervical spine position (Fig.2). Table 1 shows all measurements and abbreviations used.

A software airway analysis tool was used to determine the pharyngeal airway volume (AV), surface area (SA), and minimum axial area (MAA). References were identified to establish the limits of the oropharynx. In the sagittal view, the upper limit was determined by a line parallel to the Frankfort horizontal plane tangent to the basion point and extended to the posterior nasal spine. A line tangent to the tip of the epiglottis parallel to the Frankfort plane defined the lower boundary[3] (Fig. 3). The lateral pharyngeal walls determine the lateral boundaries. The anterior boundary was the posterior border of the tongue and soft palate. The posterior boundary was the posterior

pharyngeal wall. The software automatically calculated the pharyngeal AV (mm^3), SA (mm^2), and MAA (mm) of the upper airway (Fig.4).

Statistical methods

All data were imported into SPSS software® (SPSS 25.0, Chicago, IL, USA) for statistical analysis. The data were submitted to Kurtosis and Asymmetry analysis to confirm the normality of the variables sample. Repeated Measures ANOVA was used to evaluate the hypothesis of equality of the variables three-time intervals: surgical-changes (T2 - T1), long-term changes (T3 - T1), and post-surgical stability (T3 – T2). The Pearson's correlation test was applied to determine the relationship of skeletal surgical changes relative to airway variables, cervical spine and hyoid bone positions.

Results

This retrospective cohort study evaluated post-surgical changes in airway dimensions and cervical posture in HOP patients receiving orthognathic surgery for CCWR of the MMC. Repeatability and reproducibility tests were done to evaluate the reliability of measurements, which showed adequate values for all variables tested.

Forty-four patients were included, 22 women and 22 men, with a mean age of 26.8 years. Table 2 shows the descriptive measures of age and follow-up by group and gender. The cephalometric values are presented in Table 3. The mean pre-surgical value of VRP-A was 64.5 mm, VRP-B 54.6 mm, VRP-Pog 55.1 mm, VRP-Me 50.5 mm, and the occlusal plane angle (HRP-OP) was 11.5°, characterizing the morphological facial pattern of the subjects studied.

The surgical movements were assessed using T2-T1 values (Table3). Mean maxillary surgical changes were 1.01 mm upward (HRP-A) and 3.96 mm forward (VRP-A), while mean mandibular movements were 1.70 mm upward (HRP-B) and 10.93 mm forward (VRP-B), and the chin movements were forward 14.14 mm (VRP-Me) and 13.53 mm (VRP-Pog). The occlusal plane angle decreased 7.04° (HRP-OP). These changes characterize the CCWR of the MMC.

The differences between T3 and T1 showed long-term changes. Based on VRP-B, VRP-Pog, and VRP-Me, and the long-term mean mandibular advancement was 10.76 mm, 13.22 mm, and 13.88 mm, respectively. The long-term mean maxillary advancement at point A was 3.79 mm (VRP-A) and upward movement of 0.71 mm (HRP-A). There was also a decrease of the occlusal plane angle (HRP-OP) of 6.75°. There was a statistically significant difference in all horizontal movements and occlusal plane changes from T1 to T2 and T1 to T3.

Post-operative stability was assessed through changes between T3 and T2 (T3-T2). There was a statistically significant difference concerning surgical movements only in the position of the upper and lower incisors in the measurements HRP-U1, VRP-U1, and VRP-L1. All other changes showed no statistically significant difference between the immediate and the late post-surgery period.

Cervical spine angles changed on the longest follow-up (T3-T1) based on OPT-SN angle (mean value 2.9°, range 1.4°-4.4°) and CVT-SN angle (mean value 3.5°, range 1.9°-5.1°). The hyoid bone moved anterior (Hy-C3) 0.7 mm (range -0.2 to 1.7) and superior (MP-Hy) 1.8 mm (range 0.7-3.0) on the longest follow-up, presenting a significant difference. All surgical movements (T2-T1) remained stable during the follow-up period (T3-T2).

Table 4 presents the changes in pharyngeal airway space parameters. In the immediate post-operative period (T2-T1), there was a mean increase in the pharyngeal AV of 3203.48 mm^3, SA of 200.13 mm^2 and MAA of 56.48 mm. All these changes were statistically significant. Regarding late post-operative changes (T3-T1), there was also an increase in all parameters, with an AV of 5688.52 mm^3, SA of 164.68 mm^2 and MAA of 82.73 mm. Only the AV had a statistically significant difference between T2 and T3 with an increase of 2485.04 mm^3.

Pearson correlation coefficients demonstrated that the post-surgical changes were significantly associated with some surgical movements (Table 5). Post-surgical increase AV was significantly associated with the forward movement of the chin (VRP-Pog and VRP-Me). The post-surgical area increased significantly in correlation to the forward movement of point A (VRP-A), and the decreased OPT-SN angle, which was also significantly correlated to the increase of MAA. Cervical spine angle changes were

correlated with the decrease of OPT-SN, with the reduction of CVT-SN and HRP-OP angles. The cervical spine angle changes were also associated with the forward movement of the mandible and chin (VRP-B, VRP-Pog, and VRP-Me). The decrease of the distance of the mandibular plane to the hyoid bone (MP-Hy) was significantly correlated to the reduction of the occlusal plane (HRP-OP) and the increase of VRP-B.

Discussion

This study analyzed the effect of orthognathic surgery on the pharyngeal airway dimensions, hyoid and cervical spine positions in patients submitted to the advancement and CCWR of the MMC. Pre-surgery, these patients presented with HOP facial morphology including mandibular retrognathism, which can contribute with a decreased volume of the pharyngeal airway and sleep apnea symptoms. Because these patients may require surgical intervention for correction, it is necessary to study the stability of the surgical changes, as well as the effects in the airway dimensions, hyoid and cervical spine positions.

Patients with HOP facial morphology commonly have a narrow pharyngeal airway with associated airway obstruction issues. These patients may also present with increased head extension, as a result of an attempt to increase airway space through abnormal head posture, including a head-postured-forward neck position with mandibular projection[10]. This fact agrees with the sample presented in this paper, in which the data documents retruded maxilla and mandible, increased occlusal plane angle, increased cervical spine angles, and decreased AV. The increase of cervical spine angles is likely associated with the individual's attempt to project the mandible and improve the dimensions of the pharyngeal airway as demonstrated by other authors[7].

All patients in this study were operated by two experienced surgeons (L.M.W and J.R.G) who used the same surgical technique, which is of paramount importance for the standardization of the technique and sample studied. In addition, the patients were submitted to CBCT exams with the same standardization of time and technique, and there were no significant differences between the two centers studied.

The image acquisition for the study was Cone-Beam Computed Tomography. Other studies evaluated the same factors as this study, but with two-dimensional images,

which may significantly compromise the results, considering that factors such as minimal axial area and pharyngeal airway volume cannot be accurately measured[3,11,12].

Muto et al., 2002[9] demonstrated the influence of head extension on the airway measurement in 2-D cephalometric assessments and showed that the OPT-SN angle is the main angle correlated to airway changes. OPT-SN decrease of 10º could represent a 4 mm increase in the dimensions of the pharyngeal airway. OPT-SN and CVT-SN angle represent cervical posture and these angles tend to increase in retrognathic patients[13]. After orthognathic surgery with CCWR of the MMC, the pharyngeal air space tends to increase, and there is a decrease in the OPT-SN and CVT-SN angles. In the current study there was a mean change in longest follow-up of -2.9 ° of the OPT-SN angle and -3.5 ° of the CVT-SN angle, showing statistically significant change ($p \leq 0.01$).

This study did not find strong correlations between airway changes and any variable. Although, there was a statistically significant correlation between the decrease of the OPT-SN angle and the increase of the pharyngeal SA and MAA post-surgery (T3-T1), demonstrating the relationship with an optimization of the respiratory function and the improvement of the cervical posture.

The literature shows significant increases in the dimensions of the pharyngeal airway after orthognathic surgery CCWR of the MMC, as well as the results of this study in which there was a statistically significant increase of the airway dimensions in the two post-surgery time-intervals ($p \leq 0.01$)[5,14]. This increase had a correlation between the CCWWR of the MMC and the increase of the dimensions of the airway, as with these movement, the supra-hyoid and velopharyngeal musculature are stretched[6]. This correlation was presented between the increase of area with the advancement of point A (VRP-A) and the increase of volume with the advancement of the chin (VRP-Me and VRP-Pog).

Although protraction of the supra-hyoid muscles, an antero-superior movement of the hyoid bone was observed by other authors[15], these movements did not correlate with the changes in the pharyngeal airway dimensions. One of the factors that could influence this result is that the patients who were not submitted to advancement of the mentum may have contributed to a non-significant alteration of the position of the hyoid bone, influencing its correlation with the increase of the upper airway.

Another measure that did not present a statistically significant difference was the OPT-CVT angle that represents the cervical spine angular change. Because it is a very small angle and has a small average change (-0.3 °), a statistically significant change did not occur. Other studies that evaluated this angle also did not obtain statistically significant differences, but in the other variables that also represent the cervical spine angular changes as OPT-SN and CVT-SN, these results were statistically significant[3,9].

The OPT-SN angle represents an accurate and reproducible association with craniocervical morphology[16]. This angle tends to increase in patients presenting mandibular retrognathism, which was also observed in our sample and can be related to an attempt to compensate the pharyngeal airway space[13,17]. After the CCWR of the MMC, there is an increase in airway dimensions, and a decrease in cranio-cervical angle (OPT.SN). Muto et al.,[9] showed that this is one of the main angles correlated to alterations of the pharyngeal airway. They also showed that the decrease of 10º of this angle can represent an increase of 4 mm of pharyngeal airway dimensions. This agrees with the results of this study, considering that a statistically significant correlation was obtained between the reduction of the OPT-SN and CVT-SN angles and the increase of the pharyngeal airway area ($p \leq 0.05$). A possible effect of improved cervical posture is a decrease in the head-postured-forward neck position and mandibular projection, that may have a negative consequence of a slight decrease in the post-surgical pharyngeal airway dimension. This would be the reverse change compared to Muto's study showing increased airway with head extension. However, the overall pharyngeal airway improvement should negate any potential adverse effect of the slight decrease in dimension.

Some authors reported a significant post-surgery movement of the hyoid bone up and forward[3,11,13,15]. This movement was also observed in this study, and the superior movement of the hyoid bone was strongly significant in both post-surgery periods (T2-T1 and T3-T1).

All dento-skeletal surgical movements remained stable on the post-surgery period (T3-T2), showing no statistically significant difference in all measurements, except some related to dental position (HRP-U1, VRP-U1 and VRP-L1), which can be explained by the post-surgical orthodontic movement to complete this treatment. Thus, there was no statistically significant difference in the longest follow-up related to occlusal plane (HRP-

OP), maxilla position (HRP-A and VRP-A), mandible position (HRP-B, HRP-Go), chin position (HRP-Me, VRP-Me, HRP-Pog and VRP-Pog). The population evaluated in this study consisted of HOP pattern patients, who commonly have joint problems and are more prone to post-surgical relapses if TMJ pathology is not previously treated[18]. In this study, all patients with pre-existing TMJ pathologies were surgically treated, either before or during orthognathic surgery, which contributed to the post-surgical stability of the surgical movements.

CBCT airway measurements are prone to error as was demonstrated by our group in a test-retest study[18]. Although it's possible that we have included random errors in the present study, the increase of oropharyngeal airway observed was 42% that is much larger than the error observed in the previous study (17%)[19].

We conclude that CCWR of the MMC is a stable procedure that increases the AV, SA, and MAA dimensions, improves cervical posture, and may be indicated for HOP patients with decreased-pharyngeal airway dimensions.

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Tables

Table 1- List of abbreviations of landmarks and variables.

Abbreviation	Landmarks/ variables
HRP	Horizontal reference plane constructed at 7º to the SN plane
VRP	Vertical reference plane built perpendicular to HRP through Sella
HRP-A	Vertical measurement HRP to point A (mm)
HRP-B	Vertical measurement HRP to point B (mm)
HRP-Pog	Vertical measurement HRP to point Pog (mm)
HRP-Me	Vertical measurement HRP to point Me (mm)
HRP-Go	Vertical measurement HRP to point Go (mm)
HRP-U1	Vertical measurement HRP to point upper incisal tip (mm)
HRP-L1	Vertical measurement HRP to point lower incisal tip (mm)
VRP-A	Horizontal measurement HRP to point A (mm)
VRP-B	Horizontal measurement HRP to point B (mm)
VRP-Pog	Horizontal measurement HRP to point Pog (mm)
VRP-Me	Horizontal measurement HRP to point Me (mm)
VRP-Go	Horizontal measurement HRP to point Go (mm)
VRP-U1	Horizontal measurement HRP to point upper incisal tip (mm)
VRP-L1	Horizontal measurement HRP to point lower incisal tip (mm)
HY-C3	distance between hyoid bone and vertebra C3 (mm)
MP-HY	distance between mandibular plane and hyoid bone (mm)
OPT-SN	angle formed by the intersection of the tangent line to the odontoid process and the sella-nasal line (º)
CVT-SN	angle formed by the intersection of the tangent line to the cervical vertebra and the sella-nasal line (º)
OPT-CVT	angle formed by the intersection of the tangent line to the odontoid process and the tangent line to the cervical vertebra, it represents the degree of cervical curvature (º)
HRP-OP	occlusal plane angle (º)
AV	Airway volume (mm^3)
SA	Airway surface area (mm^2)
MAA	Minimum axial area (mm)

Table 2 – Descriptive measures of age and follow-up by gender

	Age (years)				Follow-up (months)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Female (22)	26.7	14.2	14.8	58.6	12.7	2.9	9.0	14.0
Male (22)	26.8	11.5	15.9	46.8	13.3	3.2	9.0	18.0
Both (44)	26.8	12.9	14.8	58.6	13.0	3.0	9.0	18.0

SD – Standard deviation, Min – Minimum, Max – Maximum

Table 3. Descriptive statistics and repeated measures ANOVA test for comparing follow-up changes.

	T2-T1					T3-T1					T3-T2				
			95% Confidence Interval					95% Confidence Interval					95% Confidence Interval		
Variable	Mean	SD	Lower limit	Upper limit	Sig.	Mean	SD	Lower limit	Upper limit	Sig.	Mean	SD	Lower limit	Upper limit	Sig.
HRP-A	-1,01	0,46	-2,14	0,13	0,09	-0,71	0,44	-1,81	0,39	0,31	0,30	0,12	-0,01	0,61	0,06
HRP-B	-1,70	0,76	-3,58	0,18	0,08	-1,67	0,77	-3,57	0,24	0,10	0,03	0,08	-0,16	0,22	0,97
HRP-Me	0,59	0,96	-1,80	2,98	0,90	0,77	0,94	-1,57	3,10	0,80	0,18	0,10	-0,08	0,43	0,25
HRP-Pog	-0,61	0,60	-2,12	0.90	0,69	-0,49	0,60	-1,99	1,02	0,81	0,13	0,08	-0,08	0,33	0,37
HRP-Go	-0,02	0,49	-1,24	1,21	1,00	-0,14	0,46	-1,29	1,01	0,99	-0,12	12,00	-0,42	0,17	0,65
HRP-OP (º)	-7,04	0,56	-8,44	-5,63	0,00*	-6,75	0,54	-8,10	-5,41	0,00*	0,29	0,17	-0,13	0,71	0,26
HRP-U1	-2,18	0,41	-3,19	-1,16	0,00*	-1,70	0,41	-2,72	-0,68	0,00*	0,48	0,12	0,18	0,77	0,00*
HRP-L1	-1,72	0,41	-2,75	-0,69	0,00*	-1,55	0,41	-2,56	-0,54	0,00*	0,17	0,14	-0,02	0,53	0,56
VRP-A	3,96	0,40	2,97	4,95	0,00*	3,79	0,39	2,81	4,77	0,00*	-0,17	0,10	-0,42	0,08	0,25
VRP-B	10,93	1,14	8,09	13,77	0,00*	10,76	1,15	7,90	13,61	0,00*	-0,17	0,13	-0,50	0,16	0,52
VRP-Me	14,14	1,01	11,64	16,65	0,00*	13,88	0,99	11,41	16,34	0,00*	-0,27	0,11	-0,54	0,01	0,06
VRP-Pog	13,53	0,90	11.30	15,75	0,00*	13,22	0,86	11,08	15,37	0,00*	-0,30	0,17	-0,72	0,12	0,23
VRP-Go	3,93	0,66	1,76	5,02	0,00*	3,42	0,66	1,77	5,06	0,00*	0,02	0,09	-0,21	0,25	0,99
VRP-U1	5,62	0,43	4,54	6,69	0,00*	5,22	0,41	4,19	6,24	0,00*	-0,40	0,14	-0,74	-0,06	0,02*
VRP-L1	7,09	0,55	5,74	8,45	0,00*	6,68	0,51	5,40	7,95	0,00*	-0,42	0,14	-0,77	-0,06	0,02*
OPT-SN (º)	-0,73	0,90	-2,97	1,51	0,81	-2,92	0,74	-4,76	-1,09	0,00*	-2,19	0,79	-4,16	-0,23	0,03*
CVT-SN(º)	-0,31	0,91	-2,60	1,97	0,98	-3,45	0,79	-5,43	-1,48	0,00*	-3,14	0,81	-5,14	-1,13	0,00*
OPT-CVT(º)	0,71	0,33	-0,12	1,54	0,11	-0,34	0,33	-1,16	0,48	0,67	-1,05	0,29	-1,76	-0,34	0,00*
MP-Hy	2,27	0,74	0,42	4,11	0,01*	-1,84	0,59	-3,31	-0,38	0,01*	-4,11	0,67	-5,77	-2,45	0,00*
Hy-C3	2,33	0,65	0,72	3,94	0,00*	2,29	0,52	1,01	3,57	0,00*	-0,04	0,40	-1,02	0,94	1,00

* p<0,05 **p<0,01 Sig -- Significance SD – Standard Deviation T1 – Presurgery T2 – Immediate post-surgery T3 – Longest follow-up

Table 4. Descriptive statistics and repeated measures ANOVA test for comparing pharyngeal airway changes

	T2-T1					T3-T1					T3-T2				
	95% Confidence Interval					95% Confidence Interval					95% Confidence Interval				
Variable	Mean	SD	Lower limit	Upper limit	Sig.	Mean	SD	Lower limit	Upper limit	Sig.	Mean	SD	Lower limit	Upper limit	Sig.
AV	3203,48	650,25	1588,05	4818,92	0,00*	5688,52	716,85	3907,64	7469,40	0,00*	2485,04	630,78	917,98	4052,09	0,00*
SA	200,13	21,49	146,75	253,51	0,00*	164,68	18,11	119,70	209,66	0,00*	-35,45	18,21	-80,69	9,79	0,16
MAA	56,48	9,66	32,49	80,47	0,00*	82,73	11,42	54,36	111,09	0,00*	26,24	10,67	-0,26	52,75	0,05

* p<0,05 **p<0,01 Sig -- Significance SD – Standard Deviation T1 – Presurgery T2 – Immediate post-surgery T3 – Longest follow-up

AV -- Airway Volume SA – Surface area MAA -- Minimum axial area

Table 5. Pearson Correlation between the variables

		T3-T1 AV	T3-T1 SA	T3-T1 MAA	T3-T1 OPT-NS	T3-T1 CVT-NS	T3-T1 OPT-CVT	T3-T1 MP-HY	T3-T1 HY-C3	T3-T1 VRP-Pog	T3-T1 VRP-B	T3-T1 VRP-Me	T3-T1 HRP-OP	T3-T1 HRP-A
T3-T1 AV	Pearson cor. Coef.	1	,791**	,542**	0,258	0,251	0,04	0,049	-0,032	-,299*	-0,246	-,308*	0,011	0,292
	Sig.		0	0	0,091	0,1	0,795	0,752	0,837	0,048	0,107	0,042	0,944	0,054
T3-T1 SA	Pearson cor. Coef.	,791**	1	,435**	,308*	0,262	0,016	0,123	0,062	-0,245	-0,263	-0,273	-0,044	,369*
	Sig.	0		0,003	0,042	0,086	0,918	0,428	0,69	0,108	0,084	0,073	0,776	0,014
T3-T1 MAA	Pearson cor. Coef.	,542**	,435**	1	,379*	0,274	-0,223	-0,02	-0,1	0,053	-0,052	0,007	-0,062	0,187
	Sig.	0	0,003		0,011	0,072	0,146	0,896	0,517	0,731	0,739	0,964	0,691	0,225
T3-T1 OPT-NS	Pearson cor. Coef.	0,258	,308*	,379*	1	,906**	0,183	0,132	0,064	,408**	0,133	,326*	-,434**	0,165
	Sig.	0,091	0,042	0,011		0	0,234	0,392	0,681	0,006	0,389	0,031	0,003	0,284
T3-T1 CVT-NS	Pearson cor. Coef.	0,251	0,262	0,274	,906**	1	,513**	0,242	0,085	,334*	0,118	0,286	-,389**	0,104
	Sig.	0,1	0,086	0,072	0		0	0,113	0,584	0,027	0,444	0,06	0,009	0,500
T3-T1 OPT-CVT	Pearson cor. Coef.	0,04	0,016	-0,223	0,183	,513**	1	0,236	0,167	-0,034	0,043	0,003	-0,017	-0,157
	Sig.	0,795	0,918	0,146	0,234	0		0,123	0,279	0,828	0,78	0,985	0,915	0,309
T3-T1 MP-HY	Pearson cor. Coef.	0,049	0,123	-0,02	0,132	0,242	0,236	1	0,018	0,211	,410**	0,187	-,371*	-0,071
	Sig.	0,752	0,428	0,896	0,392	0,113	0,123		0,907	0,169	0,006	0,225	0,013	0,647
T3-T1 HY-C3	Pearson cor. Coef.	-0,032	0,062	-0,1	0,064	0,085	0,167	0,018	1	-0,012	0,123	-0,056	-0,152	0,107
	Sig.	0,837	0,69	0,517	0,681	0,584	0,279	0,907		0,938	0,425	0,719	0,326	0,488
T3-T1 VRP-Pog	Pearson cor. Coef.	-,299*	-0,245	0,053	,408**	,334*	-0,034	0,211	-0,012	1	,397**	,932**	-,489**	-0,192
	Sig.	0,048	0,108	0,731	0,006	0,027	0,828	0,169	0,938		0,008	0	0,001	0,212
T3-T1 VRP-B	Pearson cor. Coef.	-0,246	-0,263	-0,052	0,133	0,118	0,043	,410**	0,123	,397**	1	,363*	-0,147	-,445**
	Sig.	0,107	0,084	0,739	0,389	0,444	0,78	0,006	0,425	0,008		0,015	0,342	0,002
T3-T1 VRP-Me	Pearson cor. Coef.	-,308*	-0,273	0,007	,326*	0,286	0,003	0,187	-0,056	,932**	,363*	1	-,402**	-0,230
	Sig.	0,042	0,073	0,964	0,031	0,06	0,985	0,225	0,719	0	0,015		0,007	0,133
T3-T1 HRP-Pog	Pearson cor. Coef.	0,011	-0,044	-0,062	-,434**	-,389**	-0,017	-,371*	-0,152	-,489**	-0,147	-,402**	1	-0,002
	Sig.	0,944	0,776	0,691	0,003	0,009	0,915	0,013	0,326	0,001	0,342	0,007		0,988
T3-T1 VRP-A	Pearson cor. Coef.	0,292	,369*	0,187	0,165	0,104	-0,157	-0,071	0,107	-0,192	-,445**	-0,230	-0,002	1
	Sig.	0,054	0,014	0,225	0,284	0,500	0,309	0,647	0,488	0,212	0,002	0,133	0,988	

**. The correlation is significant at the 0.01 level (2 extremities).

*. The correlation is significant at the 0.05 level (2 extremities).

Captions to illustrations

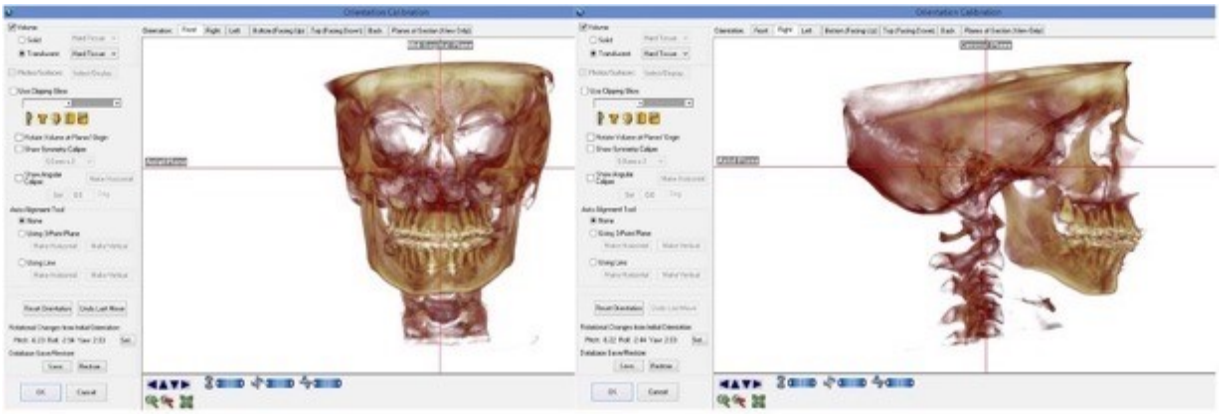

Fig. 1 Orientation of patient head in coronal and sagittal view.

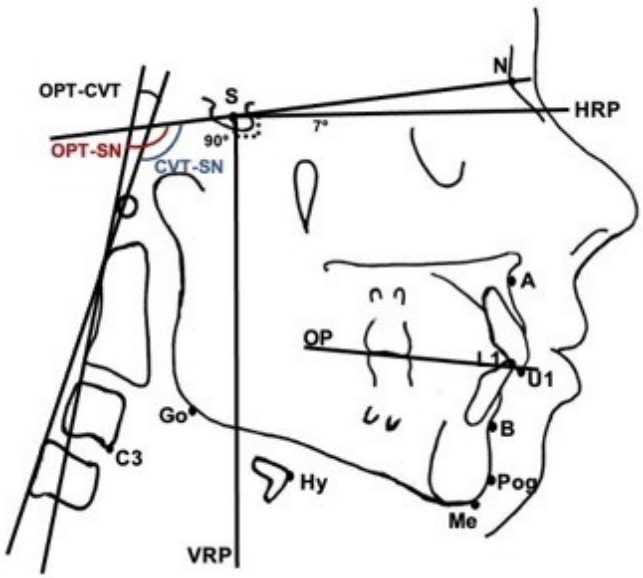

Fig 2. HRP, horizontal reference plane constructed at 7º to the SN plane; VRP, vertical reference plane constructed perpendicular to HRP, through Sella (S). 16 linear measurements: HRP-A, vertical measurement HRP to point A; HRP-B, vertical measurement HRP to point B; HRP-Pog, vertical measurement HRP to point Pog; HRP-Me, vertical measurement HRP to point Me; HRP-Go, vertical measurement HRP to point Go, HRP-U1, vertical measurement HRP to point upper incisal tip; HRP-L1 vertical measurement HRP to point lower incisal tip. All these points were also measured in relation to the VRP plane for horizontal evaluation. Also, the linear measurements performed to evaluate hyoid bone position were: Hy-C3, distance between hyoid bone and C3; MP-HY, distance between mandibular plane and hyoid bone. 04 angular measurements: OPT-SN, angle formed by the intersection of the tangent line to the odontoid process and the sella-nasal line; CVT-SN, angle formed by the intersection of the tangent line to the cervical vertebra and the sella-nasal line; OPT-CVT, angle formed by the intersection of the tangent line to the odontoid process and the tangent line to the cervical vertebra, it represents the degree of cervical curvature; HRP-OP, occlusal plane angle.

Fig. 3. Delimitation of the upper airway

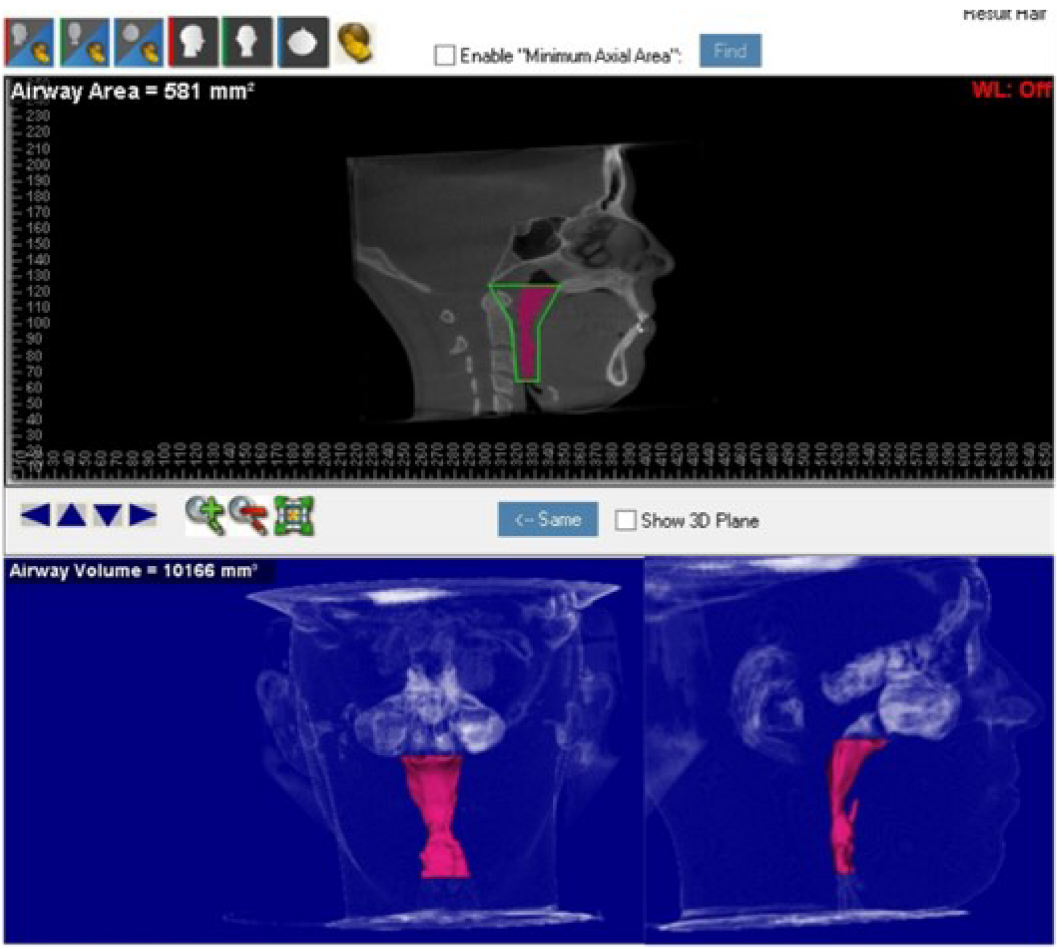

Fig. 4. Delimitation of minimum axial area, airway volume and airway surface area.

3.2. Capítulo 2

Complications of temporomandibular total joint prosthesis: a systematic review and meta-analysis

Artigo enviado para Revista Internacional Journal of Oral & Maxilofacial Surgery

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Keywords: temporomandibular total joint prosthesis, complications, temporomandibular joint disorders

Short title: Complications of TMJ total replacement

ABSTRACT

This systematic review and metanalysis aimed to determine the most prevalent complications resulting from total temporomandibular joint (TMJ) replacement. An electronic search was performed using EMBASE, LILACS, MEDLINE (*via* PubMed), SciELO, Scopus, and Web of Science up to November 2020. Prospective or retrospective clinical studies on patients who underwent total TMJ replacement were included. Two reviewers performed the study selection, data extraction, and individual risk of bias assessment using the Joanna Briggs Institute critical appraisal tools. The pooled prevalence of each complication was calculated through a proportion meta-analysis using the random-effects model and 95% confidence interval. A total of 34 studies met the eligibility criteria and were included in the qualitative analysis, and 29 studies were included in the quantitative synthesis. All the eligible studies had a low risk of bias. The results of the meta-analysis revealed that the most prevalent complications were paresis or paralysis of the facial nerve branches (10%; 95% confidence interval [CI]: 5–19%), followed by sensory alteration (4%; 95% CI: 2–6%), and infection (3%; 95% CI: 2–4%). In conclusion, Total TMJ replacement has a low prevalence of complications, and most of them can be managed successfully.

INTRODUCTION

Temporomandibular joint (TMJ) dysfunction is a well-known disorder that generally affects 5% of the population and can be divided into intra-articular and extra-articular disorders [1,2]. Extra-articular disorders are related to muscle problems, whereas intra-articular disorders are related to inflammatory arthropathies, articular disc dislocation, idiopathic degenerative processes, ankylosis, tumors, trauma, and infections [3,4,5,6]. These pathological conditions interfere with the function, shape, and stability of the stomatognathic system. The Wilkes classification is based on the staging of intra-articular disorders by relating clinical signs and symptoms to imaging and surgical findings, where stage 5 demonstrates degenerative signs of the joints characterized by crackling, severe pain, restricted movement, and functional difficulty [4].

Over the past few years, different treatments have been proposed to restore joint shape and function, especially in severe cases. These treatments comprise affected joint component removal, use of different materials for joint interposition, reconstructions with autogenous bone, osteogenic distractions, and total substitution with alloplastic implants [7,8,9]. TMJ prostheses comprise two components, one temporal, fixed to the glenoid fossa,

and one mandibular, mimicking the condyle/fossa function. The prosthesis materials and designs differ depending on the manufacturing company [10]. In addition, these prostheses can be stocked or customized, another factor that influences the choice of treatment [10,11].

Several studies have reported that this treatment modality is effective and safe, with long-term monitoring and use in various situations. Compared with other modalities, they are more predictable, do not require a second donor surgical site, tend not to be susceptible to degenerative disease relapses, and promote an earlier return of function. Among its disadvantages are the high cost and the loss of laterality and protrusive mandibular movements [7,10,11].

Failures and complications can occur in all types of treatment and may be related to the surgery itself. This study aimed to assess the prevalence of major transoperative and postoperative complications resulting from total TMJ prosthesis installation.

MATERIALS AND METHODS

Protocol and registration

The study protocol was reported following the Preferred Items for Reporting Systematic Reviews and Meta-analyses (PRISMA) Protocols [12] and was registered in the International Prospective Register of Systematic Reviews database (CRD42020218873). This systematic review was conducted following the PRISMA statements [12], with guidance from the Joanna Briggs Institute (JBI) [13].

Focused question

The present systematic review aimed to answer the following question: “What is the global prevalence of complications resulting from the installation of total TMJ prosthesis?” The research question was based on the CoCoPop strategy, where the population (Pop) corresponds to the adult patients who underwent total TMJ replacement, conditions (Co) corresponded to complications during or after surgery, and context (Co) corresponds to the global prevalence.

Eligibility criteria

The inclusion criteria were studies that treated healthy patients (American Society of Anesthesiology I or II), females or males, who were subjected to total TMJ replacement. The studies selected were prospective randomized or non-randomized trials

or retrospective or prospective observational clinical studies that mentioned the number of patients who underwent the procedure and the presence or absence of complications during or after total TMJ replacement (any postsurgical period). There were no restrictions on the language or year of publication.

The exclusion criteria were as follows: 1) partial TMJ prostheses; 2) prostheses that are not currently used; 3) articles that evaluated only one type of complication and its treatment; and 4) literature review articles, letters to the editor and/or editorials, case reports, case series, abstracts, books, book chapters, and studies that did not report the data of interest (presence or absence of surgical and postsurgical complications).

Sources of information, search, and study selection

The search was performed until November 2020, and the databases searched were EMBASE, LILACS, MEDLINE (*via* PubMed), SciELO, Scopus, and Web of Science. Gray literature was partially captured by searching the OpenThesis and OpenGrey databases. The Boolean operators OR/AND were used to combine descriptor terms for the search strategy (Table 1), selected in the databases (Medical Subject Headings, Eemtry, and Health Sciences Descriptors), obeying the syntax of each database.
The results were exported to EndNote Web®, where duplicate articles were automatically excluded. Following this, duplicate articles that had not been previously detected were manually eliminated.

The initial selection was the analysis of the titles and abstracts based on eligibility by two examiners (L.G.C.R and F.G.G.P.L) who were blinded to the names of the journals and authors. Whenever the title or abstract did not provide sufficient information or the abstract was not available, the full text was analyzed to decide on their eligibility. The full texts of the selected articles were downloaded and read to verify the inclusion criteria. All excluded articles were registered separately with a justification of exclusion. The articles selected after this stage were reanalyzed, and data were extracted in a standard manner. The data extracted included the year of publication, number of patients, sample characteristics, prosthesis system used, follow-up time, the presence or absence of complications, complications found, complication assessment method, treatment of complications, conflict of interest, and funding.

Risk of individual bias of the studies

The checklist of the JBI critical appraisal tools for use in JBI Systematic Reviews was used to assess the risk of bias of the selected articles [13]. The study quality and individual risk of bias were assessed in accordance with the PRISMA guidelines, and these procedures were performed by two reviewers (L.G.C.R and F.G.G.P.L). Using this tool, the risk was assessed as follows: high, up to 49% "yes" scores; moderate, between 50% and 69% "yes" scores; low, more than 70% "yes" scores.

Summary measures and syntheses of results

To summarize the data, a descriptive analysis of the findings was performed, focusing on the prevalence of the main complications related to TMJ prostheses. It was calculated the summarized effect of the prevalence of complications with the greatest impact on prosthesis prognosis, including infection, sensory alteration, prosthesis displacement, paresis or paralysis of the facial nerve branches, and heterotopic bone formation.

The individual studies were combined in the meta-analysis using the random-effects model proposed by Dersimonian-Laird, logit transformation and the inverse-variance method. The between-study variance was analyzed using tau-square (τ^2) statistics, and the heterogeneity magnitude was estimated using I-square (I^2) statistics. For each analysis, the data were grouped into subgroups based on the prospective or retrospective study design.

All analyses were performed using R-program (version 4.0, for Windows using the meta package) and were reported with 95% confidence intervals (CIs) and a p-value of 0.05, which was used as the level of statistical significance.

RESULTS

Study selection

During the first phase of study selection, 2954 studies were identified by a systematic search performed within nine electronic databases, including gray literature. After eliminating duplicate studies, 2371 records were analyzed by the title and abstract, of which 2295 records were excluded. The remaining 76 studies were selected for full-text analysis, and only 34 studies met the eligibility criteria [15-48] and were included in the qualitative analysis. The details of the selection process are shown in Figure 1.

Study characteristics

The main characteristics of the study are presented in Table 2. The studies were published between 1994 and 2020 and they were performed in 12 different countries, with 17 studies [21,23-27,31,32,35-38,40,41,43,46,48] in Europe, 14 studies [15-20,28,30,33,34,39,44,45,47] in North America and three studies [22,29,42] in Oceania. The total sample included 2231 patients who received total TMJ prostheses (2942 prostheses), although two studies did not mention the total number of prostheses installed. The average age of the sample ranged from 18 to 55.7 years, with female predilection in all eligible studies.

All studies evaluated the patients before and after surgery, including 24 retrospective [15-22,24-26,29,30,34,35,39-47] and 10 prospective studies [23,27,28,31-33,36-38,48]. Three TMJ prosthesis brands were reported in the studies: Biomet, TMJ Concepts/TechMedica, and Christensen, and only one study did not mention the brand of the prosthesis used [32].

Risk of individual bias of the studies

Table 3 shows detailed information on the individual risk of bias of the studies included in the qualitative analysis regarding quasi-experimental studies. All eligible studies presented a low risk of bias. Item 4 was considered "Not applicable" for all eligible studies because they were preoperative and postoperative studies without comparison to any control group. Item 6 was considered "No" in two studies [16,29], as they reported that patients with incomplete follow-up, and this was not statistically evaluated. Item 9 was considered "Uncertain" in five studies [23,34-37] because they did not mention the method used for statistical analyses.

Synthesis of results and meta-analysis

All eligible studies described the complications during and after surgery for TMJ total prosthesis. The main complications described were infection [15,20,23,25,27,28,30-32,34,39-45], sensory alteration [22,25,27,29,36,40,42,43,48], prosthesis displacement [22,26,27,31,38,42], paresis or paralysis of the facial nerve branches [23-27,31,35,36,38,40,42,43,45-48], occlusal changes [25,36,37,40,41,48], removal of the prosthesis [15,16,18-20,23,28,30-32,36,37,39,41,42,45,48], bleeding [21,24,25,27,35,41], and heterotopic bone formation [15,18,20,30,36,37,39,41,45,48]. Other complications, albeit fewer, were also observed. All the complications are presented in Appendix 1.

Only three of the eligible articles did not present the exact number of complications found; therefore, for analyzing the proportion of each complication, the number of patients in those studies was not included in the meta-analysis [17,33,47]. Moreover, two other studies [29,40] were excluded from the meta-analysis because they did not perform clinical

examinations to evaluate complications. Therefore, only 29 studies were included in the quantitative analysis.

The most prevalent complication was paresis or paralysis of the facial nerve branches (10%; 95% CI: 5–19%, I^2 = 82%) (Figure 2), followed by sensory alteration (4%; 95% CI: 2–6%, I^2 = 66%) (Figure 3), infection (3%; 95% CI: 2–4%, I^2 = 0%) (Figure 4), heterotopic bone formation (2%; 95% CI: 2–4%, I^2 = 68%) (Figure 5), and prosthesis displacement (2%; 95% CI: 1 – 4%, I^2 = 45%) (Figure 6).

DISCUSSION

This systematic review aimed to investigate the main complications during and after total TMJ replacement surgery. Several studies have indicated that total TMJ reconstruction with alloplastic materials is an effective and safe treatment method [29,50]; however, some authors have reported that the rate of complications related to this reconstruction is directly linked to the number of previous TMJ procedures [51]. Meta-analysis results showed that the most prevalent complication was paresis or paralysis of the facial nerve branches, followed by sensory alteration, infection, heterotopic bone formation, and prosthesis displacement.

Damage to the facial nerve resulting in paresis or paralysis was observed in 15 studies [23-27,31,35,36,38,40,42,43,45,46,48], and its high prevalence can be explained by the region that is accessed for TMJ prosthesis installation, which is in proximity to vital structures. Therefore, in addition to motor damage, sensory alterations are very common and are the second most prevalent complication found in our research. The treatment of neuronal damage should be initiated as soon as possible, and several treatment modalities can be indicated according to the damage experienced. Low-intensity laser therapy has shown good results, especially when combined with drug therapy of vitamin complexes. Surgeries for direct repair or using autogenous or alloplastic grafts can be performed depending on the section or discontinuation caused [52].

Postsurgical infection was found in 17 studies, and some caused prosthesis loss [15,20,23,25,27,28,30,31,32,34,39,40,41-45]. Contamination of the prosthesis can occur during and after the surgical procedure via a hematogenous or localized route [53]. A study developed by Riegel et al. [54] showed that 53% of explanted prosthetic devices presented *Staphylococcus aureus* as the predominant organism responsible for prosthesis infection, followed by *Propionibacterium acnes* in 33% of patients. The authors also observed that 66% of

infected prostheses had multi-organism cultures, 33% had single-organism cultures, and most organisms were resistant to penicillin (46% of isolated organisms showed resistance) [54].

Wolford et al. [53] suggested a treatment protocol based on the duration of the infection. According to these authors, the protocol for managing acute infection, preferably within 5 days of the onset of infection, should start with broad-spectrum antibiotics, infectious disease consultation, surgical intervention with drainage, debridement, cleaning of the prosthesis and culture and sensitivity test, catheter irrigation with a double antibiotic solution every 4 h for 4–5 days, removal of the infection after 5 days, and intravenous antibiotic therapy based on culture and sensitivity results. Outpatient intravenous antibiotic therapy should be maintained for 4–6 weeks. Regarding the treatment for chronic infection, 1 month after the onset of infection, the protocol suggested was similar to that for acute infection; however, the prosthesis must be removed in the first surgical intervention, and an acrylic spacer must be placed. Reconstruction with a new prosthesis with the placement of an autogenous fat graft around the prosthesis should be done after 8–10 weeks, and oral antibiotic therapy should be maintained for 10 days as outpatient care [53].

The formation of heterotopic bone around the prosthesis can lead to pain and limitation of mandibular function [55], which was reported in 10 studies in our research [15,18,20,30,36,37,39,41,45,48]. The most indicated treatment for this complication is surgical exploration, debridement of heterotopic bone, and the use of autologous fat grafts around the TMJ prosthesis [19,55]. It is extremely important to perform outpatient follow-up with physical therapy to stimulate mandibular movement.

Displacement of the prosthesis was observed in six studies [22,26,27,31,38,42]. The mandibular component is prone to dislocation, especially in the first week after surgery [56]. Several factors such as muscular stability, poor adaptation of the prosthetic components, sectioning of the pterygomasseteric sling, and removal of the coronoid bone can contribute to dislocation of the prosthesis, which could reduce the vertical anchorage of the mandible to the temporal bone and malocclusion [56]. When dislocation occurs in the operative room, immediate repositioning is performed; however, when this occurs later, it is necessary to perform physiotherapy and use intermaxillary elastics, with some cases requiring relocation under general anesthesia or light sedation [22,42].

Other less frequent but extremely important complications such as hypersensitivity reactions and severe bleeding were also observed. Hypersensitive reactions can occur mainly when nickel, cobalt, or chromium are part of a metal alloy, while they are the most common sensitizing agents in humans. The hypersensitivity occurrence is also greater in cases of metal-metal prostheses, wherein particles resulting from their wear can lead to this complication [22]. One way to prevent this complication is to perform an allergy test before the surgical procedure; some authors perform cobalt-chrome patch tests in all patients for 3 consecutive days preoperatively [23], and in cases where hypersensitivity is reported, the joint component that causes allergy it is replaced with a component free of the causative agent, with titanium alloy components being one of the indicated replacements [20].

One of the most serious complications during TMJ prosthesis installation surgery is severe bleeding, which was reported by six authors in this review [22,24,25,27,35,41]. The most common cause of bleeding is damage to the carotid artery or its branch, the internal maxillary artery, which often must be ligated or embolized [24]. Other hemorrhages may result from smaller branches, in which local measures may be effective, with or without blood transfusions. Prevention can be performed by the correct use of retractors to protect against vascular damage, use of safer bone-cutting tools (i.e., piezosurgery), and use of preoperative angiography, especially in cases of ankylosis [24].

This study is not exempt from limitations, the main ones being the high heterogeneity, justified by different types of studies, different operators, different forms of assessment, and different periods assessed. There is also the absence of an overall estimate of the prevalence of complications owing to the absence of individual patient data and the fact that few studies have described the exact number of patients with complications. However, there was a wide search, including the gray literature, and the eligible articles had a low risk of bias.

We concluded, that total TMJ reconstruction is associated with a low prevalence of complications. The most prevalent reported complications were paresis or paralysis of the facial nerve branches, followed by sensory alteration, infection, heterotopic bone formation, and prosthesis displacement. Although some are irreversible, most complications can be successfully managed.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: All authors declare no conflict of interest.

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Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Informed consent: Formal consent was not required for this study.

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Tables

Table 1 - Strategies for database search.

Database	Search Strategy	Results
Embase http://www.embase.com	('temporomandibular joint disorders ankylosis' OR 'tmj ankylosis' OR 'temporomandibular joint disorders'/exp OR 'temporomandibular joint disorders' OR 'disorder, tmj' OR 'temporomandibular joint disease'/exp OR 'temporomandibular joint disease' OR 'tmj disease') AND ('prostheses and implants'/exp OR 'prostheses and implants' OR 'endoprostheses' OR 'prosthesis'/exp OR 'prosthesis' OR 'artificial implant'/exp OR 'artificial implant' OR 'maxillofacial prosthesis implantation'/exp OR 'maxillofacial prosthesis implantation' OR 'mandibular prosthesis implantation'/exp OR 'mandibular prosthesis implantation' OR 'total temporomandibular join replacement' OR 'temporomandibular total joint prosthesis') AND ('infection'/exp OR 'infection' OR 'ankilosis' OR 'hypersensitivity'/exp OR 'hypersensitivity' OR 'allergies' OR 'allergic reaction'/exp OR 'allergic reaction' OR 'allergy'/exp OR 'allergy' OR 'sprain'/exp OR 'sprain' OR 'prosthesis failure'/exp OR 'prosthesis failure' OR 'complications'/exp OR 'complications' OR 'postoperative complication'/exp OR 'postoperative complication' OR 'musculoskeletal pain'/exp OR 'musculoskeletal pain' OR 'nociceptive pain'/exp OR 'nociceptive pain' OR 'tissue pain' OR 'pain'/exp OR 'pain')	867
LILACS http://lilacs.bvsalud.org/	(“Temporomandibular Joint Disorders Ankylosis” OR “Temporomandibular Joint Disorders”) AND (“Prostheses and Implants” OR “Endoprostheses”)	29
	(“TMJ Ankylosis” OR “Temporomandibular Joint Disease”) AND (“Prosthesis” OR “Artificial Implant” OR “Mandibular Prosthesis Implantation”)	4
	(“Disorder, TMJ” OR “TMJ Disease”) AND (“Total Temporomandibular Joint Replacement” OR “Temporomandibular Total Joint Prosthesis”)	8
PubMed http://www.ncbi.nlm.nih.gov/pubmed	((“Temporomandibular Joint Disorders Ankylosis” OR “TMJ Ankylosis” OR “Temporomandibular Joint Disorders” OR “Disorder, TMJ” OR “Temporomandibular Joint Disease” OR “TMJ Disease”) AND (“Prostheses and Implants” OR “Endoprostheses” OR “Prosthesis” OR “Artificial Implant” OR “Maxillofacial Prosthesis Implantation” OR “Mandibular Prosthesis Implantation” OR “Total Temporomandibular Join Replacement” OR “Temporomandibular Total Joint Prosthesis”) AND (“Infection” OR "Ankilosis" OR "Hypersensitivity" OR “Allergies” OR “Allergic Reaction” OR “Allergy” OR "Sprain" OR "Prosthesis Failure” OR “Complications” OR “Postoperative Complication” OR “Musculoskeletal	311

	Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain"))	
SciELO http://www.scielo.org/	("Temporomandibular Joint Disorders Ankylosis" OR "Temporomandibular Joint Disorders") AND ("Prostheses and Implants" OR "Endoprostheses")	6
	("TMJ Ankylosis" OR "Temporomandibular Joint Disease") AND ("Prosthesis" OR "Artificial Implant" OR "Mandibular Prosthesis Implantation")	0
	("Disorder, TMJ" OR "TMJ Disease") AND ("Total Temporomandibular Joint Replacement" OR "Temporomandibular Total Joint Prosthesis")	0
Scopus	(("Temporomandibular Joint Disorders Ankylosis" OR "TMJ Ankylosis" OR "Temporomandibular Joint Disorders" OR "Disorder, TMJ" OR "Temporomandibular Joint Disease" OR "TMJ Disease") AND ("Prostheses and Implants" OR "Prosthesis" OR "Artificial Implant" OR "Maxillofacial Prosthesis Implantation" OR "Mandibular Prosthesis Implantation" OR "Total Temporomandibular Join Replacement" OR "Temporomandibular Total Joint Prosthesis") AND ("Infection" OR "Ankilosis" OR "Hypersensitivity" OR "Allergies" OR "Allergic Reaction" OR "Allergy" OR "Sprain" OR "Prosthesis Failure" OR "Complications" OR "Postoperative Complication" OR "Musculoskeletal Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain"))	372
Web of Science http://apps.webofknowledge.com/	(("Temporomandibular Joint Disorders Ankylosis" OR "TMJ Ankylosis" OR "Temporomandibular Joint Disorders" OR "Disorder, TMJ" OR "Temporomandibular Joint Disease" OR "TMJ Disease") AND ("Prostheses and Implants" OR "Endoprostheses" OR "Prosthesis" OR "Artificial Implant" OR "Maxillofacial Prosthesis Implantation" OR "Mandibular Prosthesis Implantation" OR "Total Temporomandibular Join Replacement" OR "Temporomandibular Total Joint Prosthesis") AND ("Infection" OR "Ankilosis" OR "Hypersensitivity" OR "Allergies" OR "Allergic Reaction" OR "Allergy" OR "Sprain" OR "Prosthesis Failure" OR "Complications" OR "Postoperative Complication" OR "Musculoskeletal Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain"))	27
OATD https://oatd.org/	**("Prostheses and Implants" OR "Endoprostheses" OR "Prosthesis" OR "Artificial Implant" OR "Maxillofacial Prosthesis Implantation" OR "Mandibular Prosthesis Implantation" OR "Total Temporomandibular Join Replacement" OR "Temporomandibular Total Joint Prosthesis") AND ("Infection" OR "Ankilosis" OR**	440

	"Hypersensitivity" OR "Allergies" OR "Allergic Reaction" OR "Allergy" OR "Sprain" OR "Prosthesis Failure" OR "Complications" OR "Postoperative Complication" OR "Musculoskeletal Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain")	
OpenGrey http://www.opengrey.eu/	("Temporomandibular Joint Disorders Ankylosis" OR "TMJ Ankylosis" OR "Temporomandibular Joint Disorders" OR "Disorder, TMJ" OR "Temporomandibular Joint Disease" OR "TMJ Disease") AND ("Prostheses and Implants" OR "Endoprostheses" OR "Prosthesis" OR "Artificial Implant" OR "Maxillofacial Prosthesis Implantation" OR "Mandibular Prosthesis Implantation" OR "Total Temporomandibular Join Replacement" OR "Temporomandibular Total Joint Prosthesis") AND ("Infection" OR "Ankilosis" OR "Hypersensitivity" OR "Allergies" OR "Allergic Reaction" OR "Allergy" OR "Sprain" OR "Prosthesis Failure" OR "Complications" OR "Postoperative Complication" OR "Musculoskeletal Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain")	0
OpenThesis http://www.openthesis.org/	**("Prostheses and Implants" OR "Endoprostheses" OR "Prosthesis" OR "Artificial Implant" OR "Maxillofacial Prosthesis Implantation" OR "Mandibular Prosthesis Implantation" OR "Total Temporomandibular Join Replacement" OR "Temporomandibular Total Joint Prosthesis") AND ("Infection" OR "Ankilosis" OR "Hypersensitivity" OR "Allergies" OR "Allergic Reaction" OR "Allergy" OR "Sprain" OR "Prosthesis Failure" OR "Complications" OR "Postoperative Complication" OR "Musculoskeletal Pain" OR "Nociceptive Pain" OR "Tissue Pain" OR "Pain")**	890
TOTAL		2954

Table 2. Summary of the main characteristics of the eligible studies.

Author, year	Follow-up (mean)	Sample (n)	Participants	Average age ± SD (years)	Number of prostheses installed
Wolford *et al.,*1994[15]	Mean of 30 months	56	55♀/1♂	39	100
Mercuri *et al.,* 1995[16]	Mean of 13.6 months	215	202♀/13♂	40.9	363
Wolford *et al.,* 2003[17]	20.8-33 months	45	40♀/5♂	38.8	78
Wolford *et al.,* 2003[18]	73.5 months	38	37♀/1♂	36	69
Wolford *et al.,* 2008[19]	At least 12 months	115	110♀/5♂	Not available	203
Pinto *et al.,* 2009[20]	Mean of 3.4 years	47	47♀/0♂	34.5	90
Westermark, 2010[21]	2-8 years	12	9♀/3♂	29	19
Jones, 2011[22]	06 months-03 years	7	Not available	55.7	12
Kanatas *et al.,* 2012[23]	12 months	31	22♀/9♂	45	44
Machon *et al.,* 2012[24]	Mean of 02 years	27	21♀/6♂	33.8	38
Idle *et al.,* 2013[25]	Mean of 12 months	402	332♀/70♂	44	577
Mommers *et al.,* 2013[26]	Mean of 18.5 months	8	5♀/3♂	49.2	12
Sidebottom & Gruber, 2013[27]	12 months	74	65♀/9♂	47	103
Aagaard & Thygesen, 2014[28]	Mean of 14.2 months	61	74 ♀/7♂ (prosthesis)	41	81
Burgess *et al.,* 2014[29]	Mean of 46 months	52	44♀/ 8♂	52.4	72
Sanovich *et al.,* 2014[30]	06-83 months	36	36♀/0♂	49.4	62
Gruber *et al.,* 2015[31]	03-05 years	58	52♀/6♂	47	84
Hussain *et al.,* 2015[32]	12 months	55	49♀/6♂	39	77
Wolford *et al.,* 2015[33]	Mean of 21 years	56	52♀/4♂	38.6	99
Ettinger *et al.,* 2016[34]	Mean of 1.4 years	45	39♀/ 6♂	49.1	64
Gerbino *et al.,*2016[35]	Mean of 46 months	12	6♀/6♂	44.3	22
Gonzalez-Perez *et al.,* 2016[36]	03 years	57	38♀/19♂	52.6	75
Gonzalez-Perez *et al.,* 2016[37]	02 years	52	35♀/17♂	52.6	68
O'Connor *et al.,* 2016[38]	12 months	26	22♀/4♂	40	46
Wolford *et al.,*2016[39]	Mean of 68 months	32	22♀/10♂	39	48
Elledge *et al.,*2017[40]	12 months	233	05:01♀: ♂	45	Not available
Gerbino *et al.,* 2017[41]	At least 12 months	38	29♀/9♂	45.1	55
Kanatsios *et al.,* 2018[42]	Mean of 5.2 years	60	58♀/2♂	53.5	67
Balon *et al.,* 2019[43]	15-68 months	12	10♀/ 2♂	49.2	12
Chowdhury *et al.,*2019[44]	At least 12 months	8	Not available	27.5	8
Sahdev *et al.,* 2019[45]	Mean of 4.4 years	95	85♀/10♂	44.3	175
Siegmund *et al.,* 2019[46]	06 months	28	20♀/8♂	45	28
Brown *et al.,* 2020[47]	Mean of 19 months	13	Not available	18	Not available
Gonzalez-Perez *et al.,* 2020[48]	05 years	70	46♀/24♂	51	91

Table 3 - Risk of bias assessed by the Joanna Briggs Institute Critical Appraisal Tools[49]

Authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	
Quasi-experimental studies										
Wolford *et al.,*1994[15]	√	√	√	N/A	√	√	√	√	√	100%
Mercuri *et al.,* 1995[16]	√	√	√	N/A	√	-	√	√	√	88,8%
Wolford *et al.,* 2003[17]	√	√	√	N/A	√	√	√	√	√	100%
Wolford *et al.,* 2003[18]	√	√	√	N/A	√	√	√	√	√	100%
Wolford *et al.,* 2008[19]	√	√	√	N/A	√	√	√	√	√	100%
Pinto *et al.,* 2009[20]	√	√	√	N/A	√	√	√	√	√	100%
Westermark, 2010[21]	√	√	√	N/A	√	√	√	√	√	100%
Jones, 2011[22]	√	√	√	N/A	√	√	√	√	√	100%
Kanatas *et al.,* 2012[23]	√	√	√	N/A	√	√	√	√	U	88,8%
Machon *et al.,* 2012[24]	√	√	√	N/A	√	√	√	√	√	100%
Idle *et al.,* 2013[25]	√	√	√	N/A	√	√	√	√	√	100%
Mommers *et al.,* 2013[26]	√	√	√	N/A	√	√	√	√	√	100%
Sidebottom & Gruber, 2013[27]	√	√	√	N/A	√	√	√	√	√	100%
Aagaard & Thygesen, 2014[28]	√	√	√	N/A	√	√	√	√	√	100%
Burgess *et al.,* 2014[29]	√	√	√	N/A	√	-	√	√	√	88,8%
Sanovich *et al.,* 2014[30]	√	√	√	N/A	√	√	√	√	√	100%
Gruber *et al.,* 2015[31]	√	√	√	N/A	√	√	√	√	√	100%
Hussain *et al.,* 2015[32]	√	√	√	N/A	√	√	√	√	√	100%
Wolford *et al.,* 2015[33]	√	√	√	N/A	√	√	√	√	√	100%
Ettinger *et al.,* 2016[34]	√	√	√	N/A	√	√	√	√	U	88,8%
Gerbino *et al.,*2016[35]	√	√	√	N/A	√	√	√	√	U	88,8%
Gonzalez-Perez *et al.,* 2016[36]	√	√	√	N/A	√	√	√	√	U	88,8%
Gonzalez-Perez *et al.,* 2016[37]	√	√	√	N/A	√	√	√	√	U	88,8%
O'Connor *et al.,* 2016[38]	√	√	√	N/A	√	√	√	√	√	100%
Wolford *et al.,*2016[39]	√	√	√	N/A	√	√	√	√	√	100%
Elledge *et al.,*2017[40]	√	√	√	N/A	√	√	√	√	√	100%
Gerbino *et al.,* 2017[41]	√	√	√	N/A	√	√	√	√	√	100%
Kanatsios *et al.,* 2018[42]	√	√	√	N/A	√	√	√	√	√	100%
Balon *et al.,* 2019[43]	√	√	√	N/A	√	√	√	√	√	100%
Chowdhury *et al.,*2019[44]	√	√	√	N/A	√	√	√	√	√	100%
Sahdev *et al.,* 2019[45]	√	√	√	N/A	√	√	√	√	√	100%
Siegmund *et al.,* 2019[46]	√	√	√	N/A	√	√	√	√	√	100%
Brown *et al.,* 2020[47]	√	√	√	N/A	√	√	√	√	√	100%
Gonzalez-Perez *et al.,* 2020[48]	√	√	√	N/A	√	√	√	√	√	100%

√ - yes; - - no; U – Unclear; N/A – Not applicable. Risk of bias domains for Quasi-experimental studies – Q.1) "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)?" Q.2) "Were the participants included in any comparisons similar?" Q.3) "Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?" Q.4) "Was there a control group?" Q.5) "Were there multiple measurements of the outcome both pre and post the intervention/exposure?" Q.6) "Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?" Q.7) "Were the outcomes of participants included in any comparisons measured in the same way?" Q.8) "Were outcomes measured in a reliable way?" Q.9) "Was appropriate statistical analysis used?"

Table 4. Complications presented in the elegible studies

	Sample	Infection	Sensory alteration	Dislocation of prosthesis	Paresis or paralysis of facial nerve	Frey's Syndrome	Hearing alteration	Mouth opening limitation	Occlusal alteration	Haematoma	Screw removal	Hypersensitivity	Prosthesis removal	Severe bleending	Heterotopic bone formation	Parotid fistula	Chronic pain	Contralateral condyle pain
Wolford *et al.,*1994[15]	56	1	0	0	0	0	0	0	0	0	3	0	2	0	17	0	1	0
Mercuri *et al.,* 1995[16]	215	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0
Wolford *et al.,* 2003[18]	38	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0
Wolford *et al.,* 2008[19]	115	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0
Pinto *et al.,* 2009[20]	47	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
Westermark, 2010[21]	12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Jones, 2011[22]	7	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kanatas *et al.,* 2012[23]	31	1	0	0	5	0	0	2	0	0	0	1	2	0	0	0	0	0
Machon *et al.,* 2012[24]	27	0	0	0	9	0	0	0	0	0	0	0	0	3	0	0	0	0
Idle *et al.,* 2013[25]	402	5	41	0	98	0	0	0	12	0	0	0	0	5	0	0	0	0
Mommers *et al.,* 2013[26]	8	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Sidebottom & Gruber, 2013[27]	74	2	3	5	35	0	0	0	0	0	0	0	0	2	0	0	0	0
Aagaard & Thygesen, 2014[28]	61	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
Burgess *et al.,* 2014[29]	52	0	13	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0
Sanovich *et al.,* 2014[30]	36	1	0	0	0	0	0	0	0	0	1	0	4	0	2	0	0	0
Gruber *et al.,* 2015[31]	58	2	0	2	1	0	0	0	0	0	0	0	2	0	0	0	0	0
Hussain *et al.,* 2015[32]	55	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ettinger *et al.,* 2016[34]	45	4	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Gerbino *et al.,*2016[35]	12	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	0

	Sample	Infection	Sensory alteration	Dislocation of prosthesis	Paresis or paralysis of facial nerve	Frey's Syndrome	Hearing alteration	Mouth opening limitation	Occlusal alteration	Haematoma	Screw removal	Hypersensitivity	Prosthesis removal	Severe bleending	Heterotopic bone formation	Parotid fistula	Chronic pain	Contralateral condyle pain
Gonzalez-Perez *et al.*, 2016[36]	57	0	3	0	2	0	0	0	3	0	0	1	1	0	1	0	0	0
Gonzalez-Perez *et al.*, 2016[37]	52	0	0	0	0	0	0	0	2	0	0	0	2	0	1	0	0	0
O'Connor *et al.*, 2016[38]	26	0	0	5	8	1	0	0	0	1	0	0	0	0	0	0	0	0
Wolford *et al.*,2016[39]	32	1	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0
Elledge *et al.*,2017[40]	233	7	55	0	102	0	0	0	3	0	0	0	0	0	0	0	0	0
Gerbino *et al.*, 2017[41]	38	1	0	0	0	0	0	0	1	0	0	0	1	2	1	0	0	1
Kanatsios *et al.*, 2018[42]	60	1	9	1	25	0	0	0	0	1	0	0	1	0	0	0	0	0
Balon *et al.*, 2019[43]	12	1	10	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Chowdhury *et al.*,2019[44]	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sahdev *et al.*, 2019[45]	95	3	0	0	27	0	0	16	0	0	0	1	2	0	3	0	0	0
Siegmund *et al.*, 2019[46]	28	0	0	0	8	0	0	0	0	0	0	0	0	0	0	1	0	0
Gonzalez-Perez *et al.*, 2020[48]	70	0	7	0	2	0	0	0	3	0	0	3	5	0	1	0	0	0
Total	2062	34	142	16	336	3	2	19	24	3	5	8	76	14	34	1	1	1

Figure 1. Flowchart of the process of literature search and selection, adapted from the PRISMA statement.

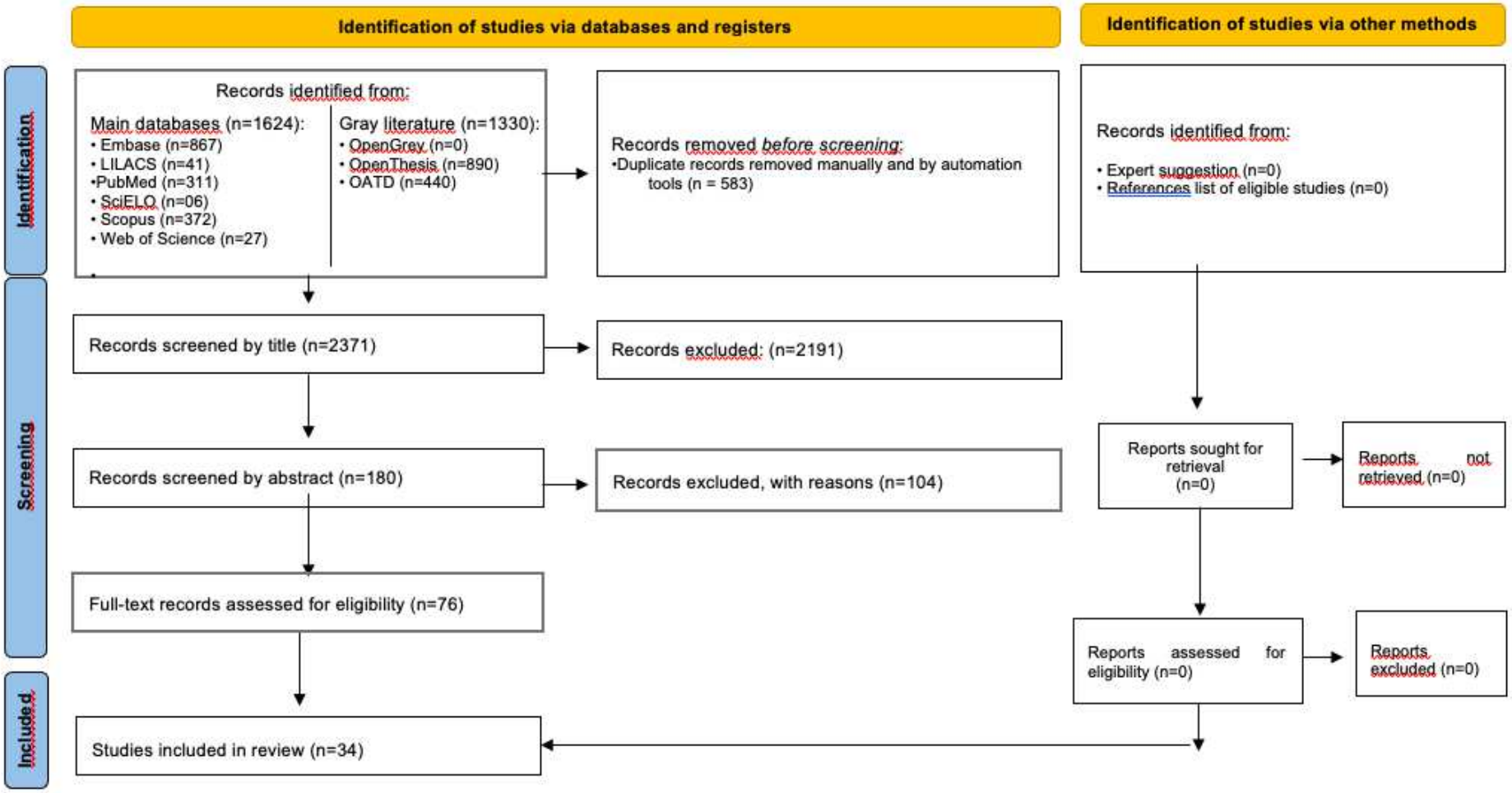


Figure 2. Forest plot of the prevalence of paresis or paralysis prevalence.

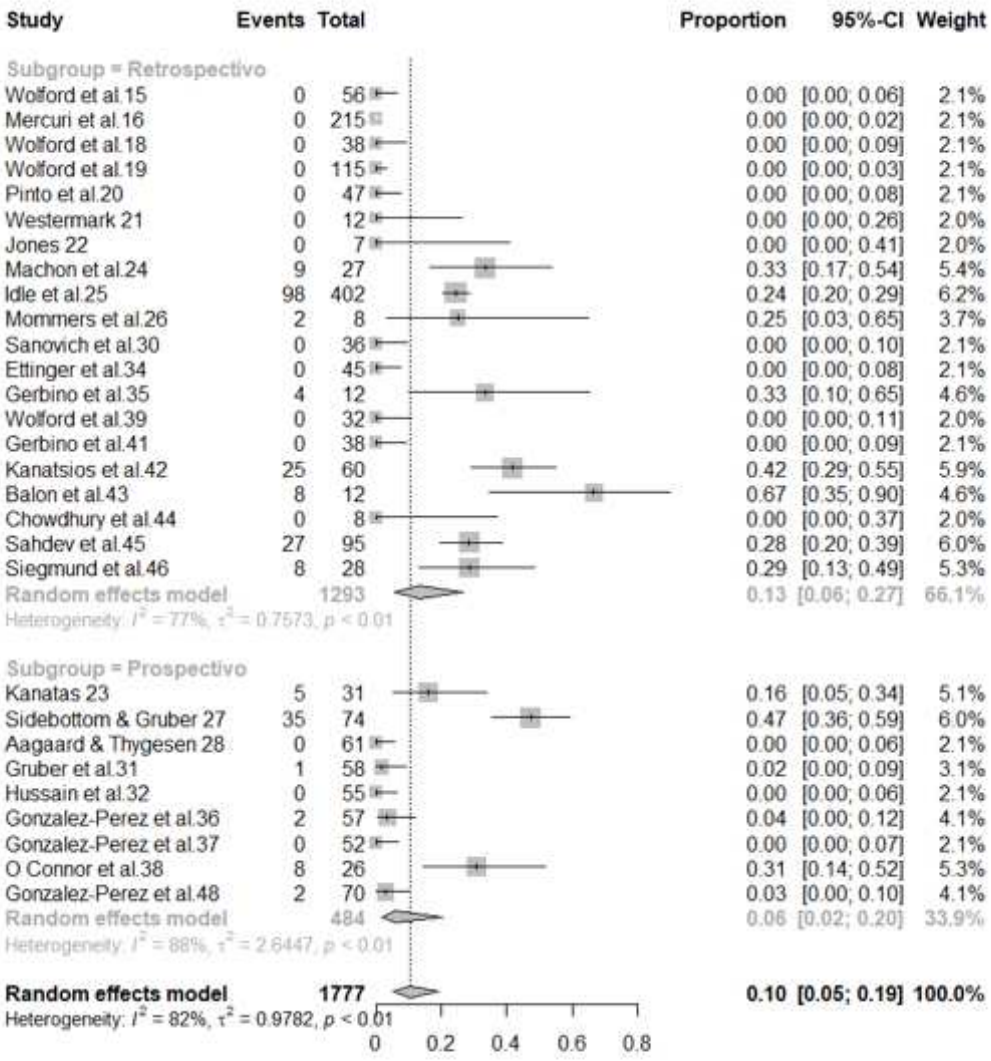


Figure 3. Forest plot of the prevalence of sensory alteration.

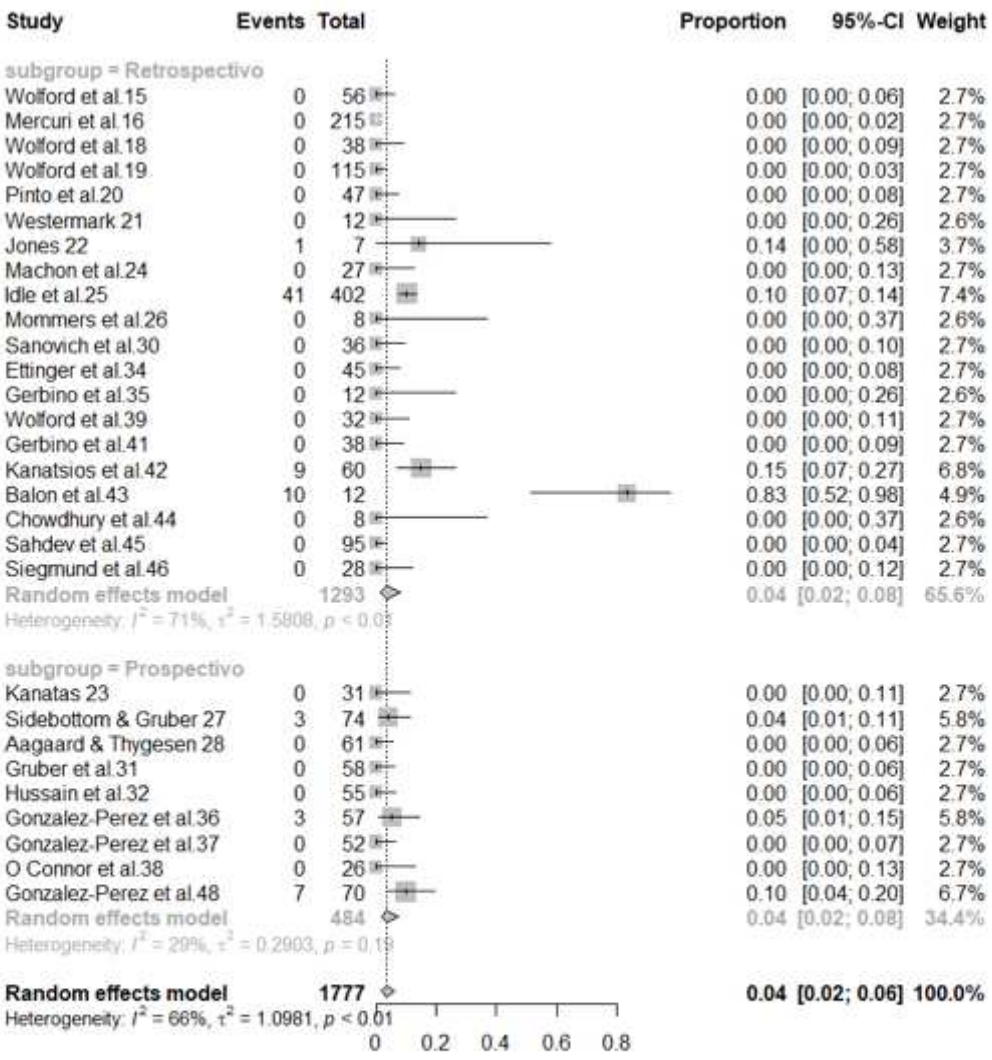


Figure 4. Forest plot of the prevalence of infection.

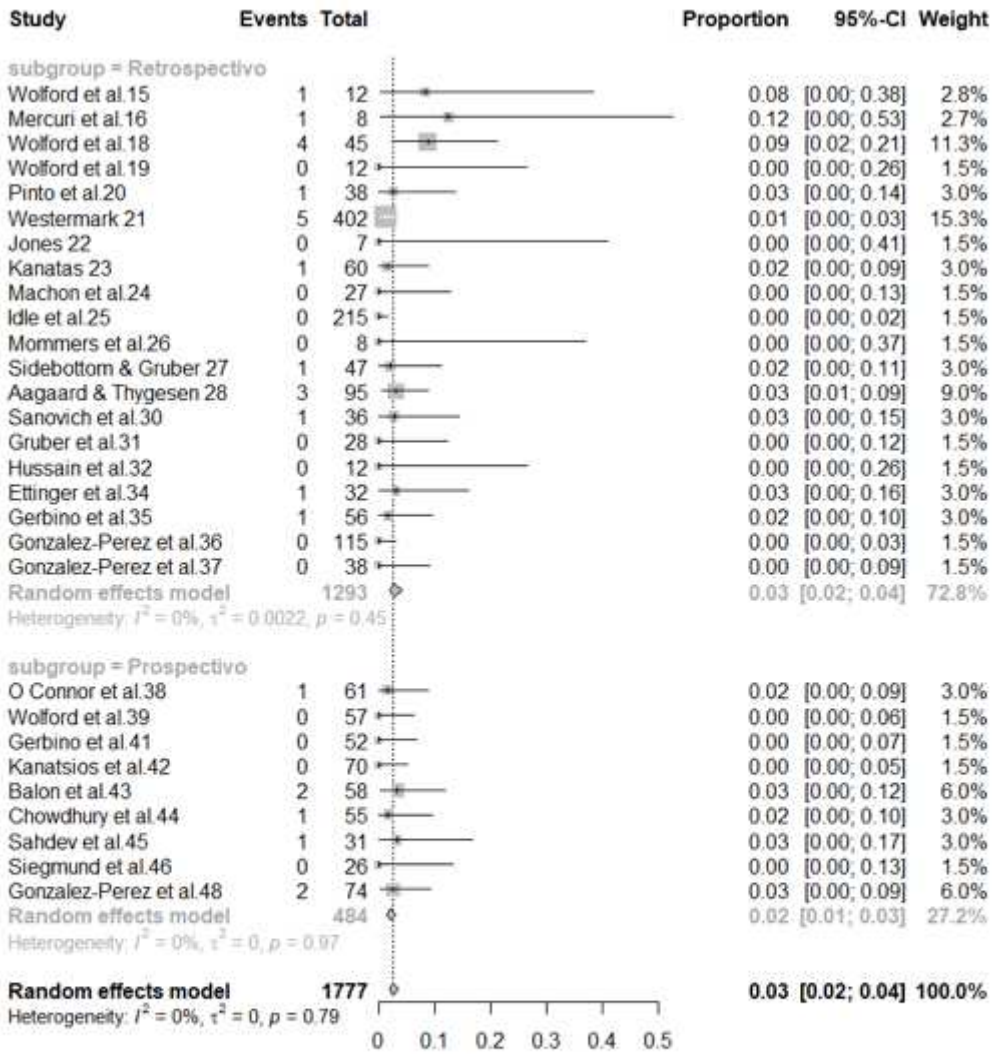


Figure 5. Forest plot of the prevalence of heterotopic bone formation.

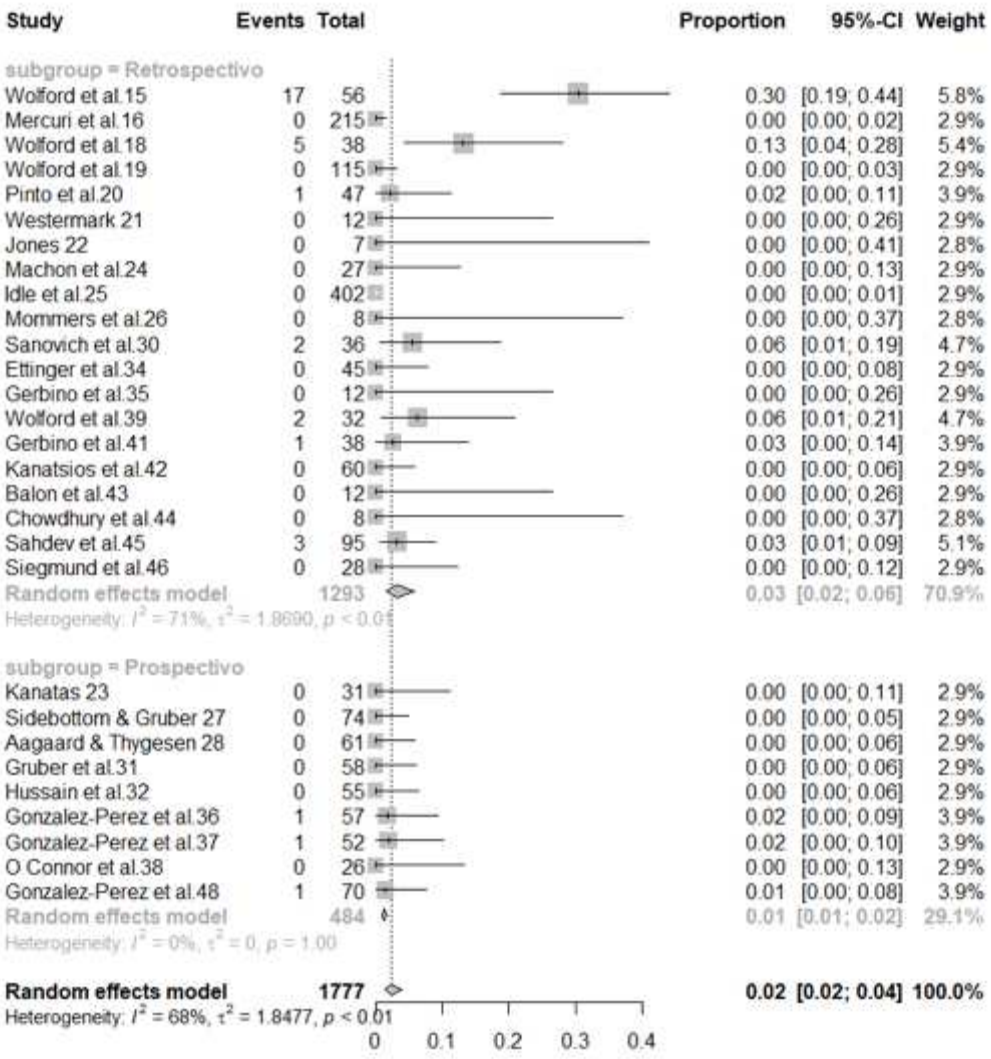
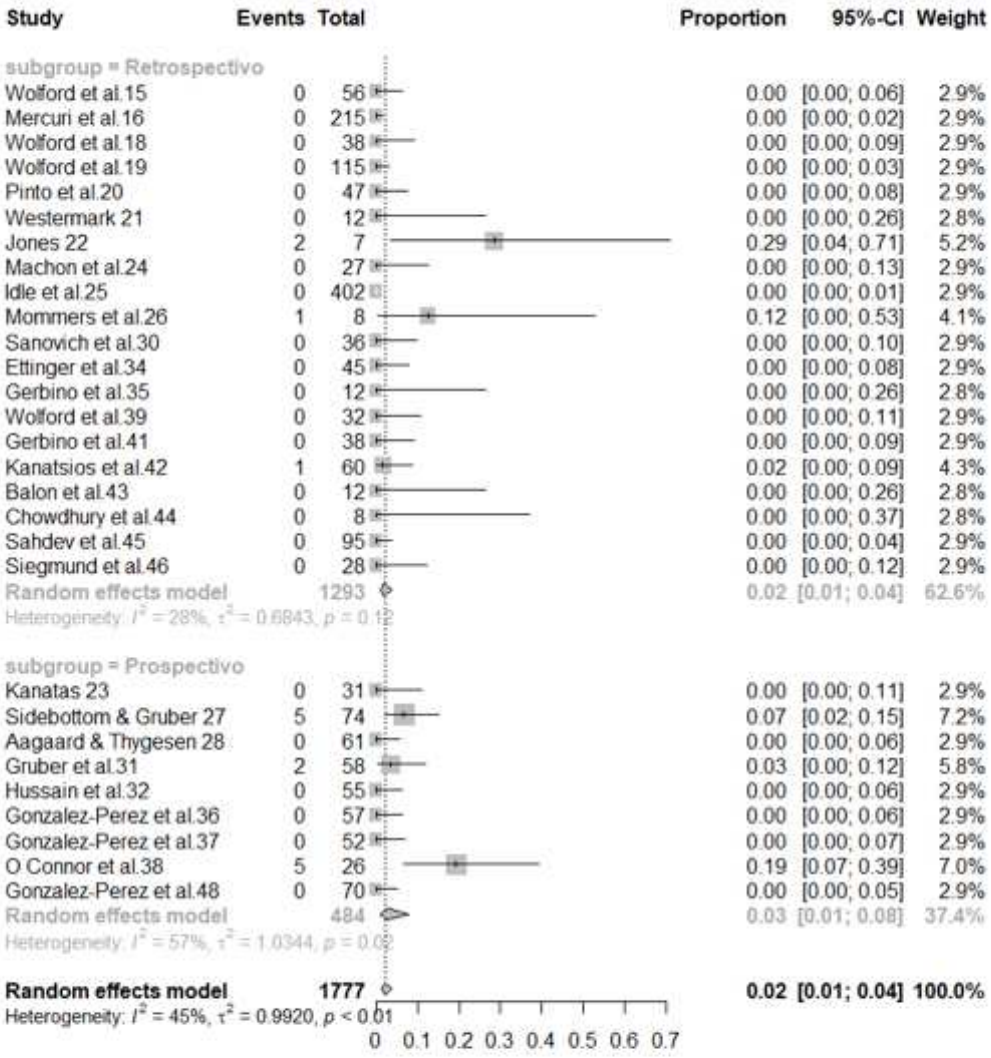


Figure 6. Forest plot of the prevalence of prosthesis displacement.



3.3. CAPÍTULO 3

Management of temporomandibular disorders, from conservative treatments to total TMJ prosthesis: a case report.

Artigo a ser enviado para Revista Internacional Journal of Case Reports and Images

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ABSTRACT

Introduction: Temporomandibular disorders can cause a great impact in patient life. It is important to establish a diagnosis and a correct treatment plan. This must be based on the in the symptomatology and in the degree of involvement of the joint components, performing whenever possible, less invasive treatments. However, in some conditions conservative treatments may not be effective, and the surgeon must then review the treatment plan.

Case report: Patient with temporomandibular dysfunction, severe left TMJ pain and loss of mandibular function was submitted to several treatments, such as pharmacological and physical therapy, TMJ disc replacement, and finally TMJ total prosthesis with improvement of the symptoms and restoration of the stomatognathic system.

Conclusion: The treatment of temporomandibular disorders, especially internal derangements, is a challenge, thus the surgeon must define a diagnosis and develop a correct treatment plan according to the evolution of the patient's symptoms.

Keywords: Temporomandibular Joint Disorders; Temporomandibular Joint Disc; Joint Prosthesis

INTRODUCTION

Temporomandibular disorders can cause a great impact on the lives of patients and can generate functional limitations such as limited mouth opening, pain, and chewing difficulty. The three most common temporomandibular disorders are myofascial dysfunction, disc displacement, and temporomandibular joint (TMJ) degenerative or proliferative diseases [Dimitroulis, 2018].

Myofascial dysfunction is a muscle disorder mostly related to oral parafunctional habits and sometimes with psychogenic disorders, examples of these dysfunctions are myositis, fibromyalgia, neuropathic pain, and chronic pain syndrome. The internal derangements are characterized by the internal malfunction of the temporomandibular joint, either by hypo or hypermobility, or abnormal position of the articular disc [Dimitroulis, 2018]. Examples of TMJ degenerative diseases are osteoarthrosis,

idiopathic condylar resorption, and juvenile arthritis, and of TMJ proliferative disease are condylar hyperplasia and osteochondroma. Often internal derangements such as joint disc displacement can lead to a degenerative disorder, specially when it is without reduction [Bo-Yeon *et al.,* 2021].

The treatment of the internal derangements is based on the is based on the cause, severity and change in the patient's quality of life. In terms of disc displacement, a staggered treatment is usually recommended, starting with occlusal splint, pharmacal and physical therapy, then less invasive surgical techniques such as arthrocentesis or arthroscopy, followed by surgical open procedures such as discopexy and finally TMJ total prosthesis, based on whether the patient has improved [Dolwick, 2007].

The aim of this work is to report a case of a patient who underwent all phases of this treatment, obtaining a satisfactory result with the TMJ total prosthesis.

Case report

A 38 years-old woman was referred for evaluation of severe left TMJ pain, trismus, limited range of motion and loss of mandibular function. During the clinical evaluation, the patient presented diffuse pain during palpation of the left temporomandibular joint region with increased intensity when performing full mouth opening, with sounds/noises. Due to joint complaints, a TMJ MRI was requested and an anterior displacement of the articular disc without reduction was found (Figure 1 and 2). The patient was submitted to pharmacological, psychological and physical therapy and arthrocentesis, however there was no improvement in symptoms. Thus, it was proposal the replacement of left temporomandibular joint disc.

The TMJ discopexy was developed using the endaural approach to access the left temporomandibular joint. During this procedure degenerative signs were observed, the retrodiscal tissue was removed, and a 1.7mm mini anchor was inserted 8 mm below the condyle head and sutured to the disc. The patient related improvement of the symptoms at the immediate postoperative.

However, after 05 months of the procedure the patient reported pain and limited range of mandibular function. The computed tomography showed resorption of left condyle (Figure 3). Due to these finds, a TMJ total prosthesis was indicated.

The patient was submitted to a total temporomandibular joint replacement using a customized TMJ total prosthesis (TMJ Concepts®). The endaural and the submandibular

approach was performed, the condyle segment was removed, and the prosthesis components were inserted (Figures 4 and 5), the procedure occurred without complications. The patient was discharged with the post-operative recommendations, antibiotic prescription of ceftriaxone and metronidazole, and weekly outpatient return.

After one month of this procedure the patient returned complaining pain in left TMJ, swelling and a purulent collection drainage was observed in the left periauricular region. Thus, a broad-spectrum endovenous antibiotics was started and the patient was submitted to a surgical intervention with drainage, debridement, and cleaning of the prosthesis. The patient evolved with improvement of symptoms and total regression of the condition within 15 days. In the follow-up of 03 years, the patient presented good mouth opening, absence of pain, satisfactory mandibular excursion movements and CT images showing stability and absence of prosthetic failure (Figure 6).

DISCUSSION

There are several treatments for TMJ disorders, and it is important to establish the treatment plan of each patient. This plan must considerer the clinical and symptomatologic signs, and whenever possible, it is advisable to carry out a staggered treatment, starting with non-surgical procedures and if necessary, performing surgical treatments.

The nonsurgical treatment should include medications, such as nonsteroidal anti-inflammatory drugs and muscle relaxant, patient orientation about nonchewer soft diet, physical and psychological therapy, homecare procedures and occlusal appliance. When these approaches do not improve the clinical condition, surgical procedures (ie, arthrocentesis, astroscopic and disc replacement) may be indicated [Molinari *et al*., 2007]. The patient presented in this study was submitted to all the nonsurgical procedures, however there was no improvement in pain and function limitation in the long-term, thus the patient was submitted to arthrocentesis.

The arthrocentesis, consists in a lavage of TMJ superior space, removing adhesions and inflammatory content, and placement of medications into joint [Dolwick, 2007, Dimitroulis, 2018]. This procedure could be performed under local anesthesia with or without sedation. In this case, after this procedure the patient evolved with the improvement of the symptoms for just few weeks, then she reported worsening of them.

One of most common TMJ derangement is the disc displacement, which can even be observed in asymptomatic individuals. This displacement can lead to damage of TMJ

tissues, generating inflammatory and degenerative disorders [Dolwick, 2007; Mehra & Wolford, 2001]. The disc repositioning is indicated for the patients that have a disc displacement and the nonsurgical treatment was not effective or present an active condylar degeneration. It consists in removing the inflammatory adhesions and the retro discal tissue, repositioning the disc in the appropriate position, and stabilizing it with sutures attached in a mini anchor [Gonçalves *et al.,* 2015]. Zhu *et al.*, 2021 carried out a study with 84 adolescent patients who were submitted to disc repositioning to treat anterior disc displacement and they concluded that this procedure could promote condylar regeneration in juvenile patients. The bone remodeling after the disc replacement was also observed by Gonçalves *et al.,* 2013, that reported a facilitated bone apposition in localized condylar regions in patients that had anterior disc displacement and were submitted to orthognathic surgery combined to this procedure.

In the reported case, the patient did not present improvement of the symptoms after conservative treatment and arthrocentesis, so the disc repositioning was performed. However, 05 months after this procedure the patient still presented limited mandibular function, severe TMJ pain and progress left TMJ resorption, thus, TMJ total prosthesis was indicated.

The temporomandibular total prosthesis is indicated in cases where there is severe impairment of one of the joint components, either by degenerative or proliferative processes [Wolford *et al.,* 2015]. There are two types of TMJ total prosthesis, customized that are manufactured based on a specific planning for each patient and the prefabricated prosthesis which are available in standard sizes.

Total TMJ reconstruction with alloplastic materials is an effective and safe treatment method [Burgess *et al.,* 2014; Giannakopoulos *et al*., 2011], however some complications are reported, and one of the most common is the infection. This contamination can occur during or after the surgical procedure via a hematogenous or localized route [Wolford, 2010]. Wolford *et al.,* suggested a treatment protocol for acute infection which should be started preferably in the first five days of the onset of infection. This protocol recommends a broad-spectrum antibiotic, infectious disease consultation, surgical intervention with drainage, debridement and cleaning of the prosthesis, catheter irrigation with a double antibiotic solution every 4 h for 4–5 days, and intravenous antibiotic therapy based on culture and sensitivity results. It also recommends that the outpatient intravenous antibiotic therapy should be maintained for 4–6 weeks. In the case reported, the patient developed the infection one month after the TMJ total prosthesis

implantation, and the surgical intervention for the infection treatment was developed two days after the onset of the symptoms, following this treatment protocol. The patient presented complete resolution of the infection in the postoperative period of one week and had total improvement of pain and mandibular function.

CONCLUSION

In conclusion, the treatment of temporomandibular disorders can be challenging and require several treatment modalities. Thus, knowledge of surgical and non-surgical treatments, as well as their indications, are essential.

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Figures

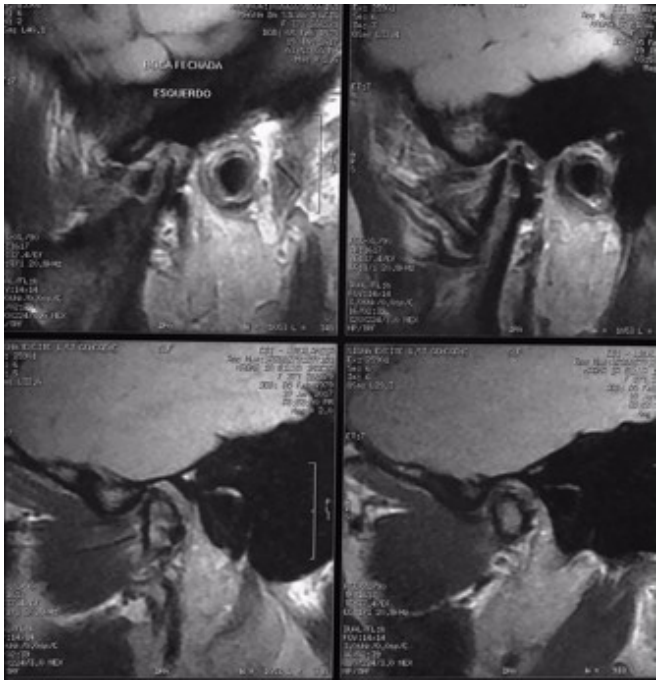

Figure 1. RMI images showing an anterior displacement of the left TMJ disc in closed mouth position.

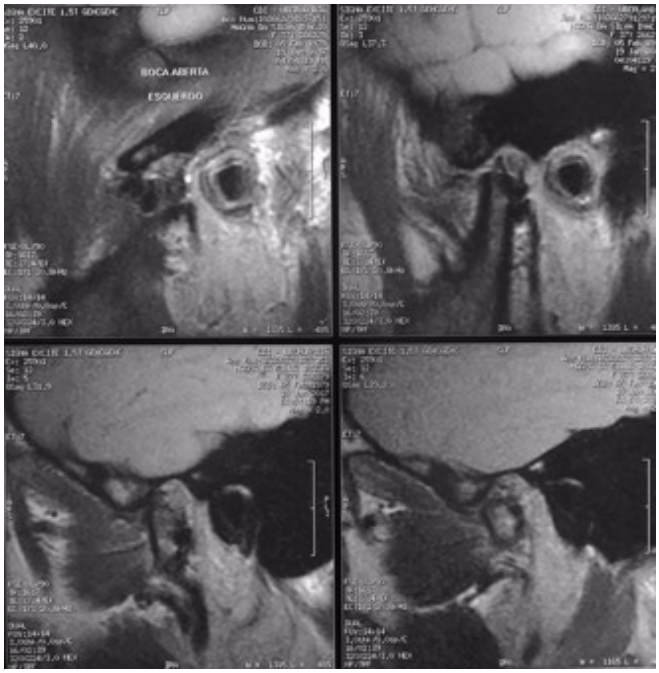

Figure 2. RMI images showing an anterior disc displacement without reduction in open mouth position.

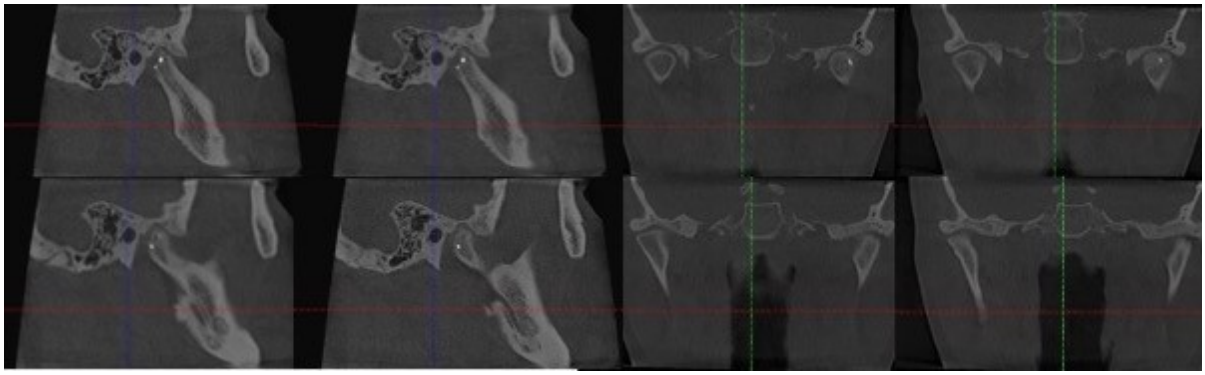

Figure 3. CT images post disc replacement procedure. Note the resorption of left condyle.

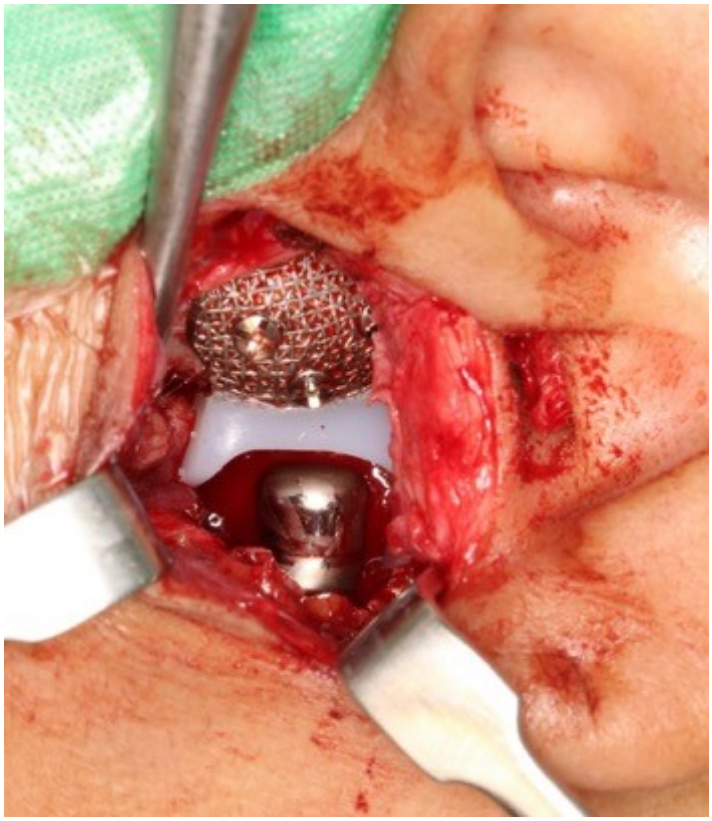

Figure 4. Articular component of TMJ total prosthesis.

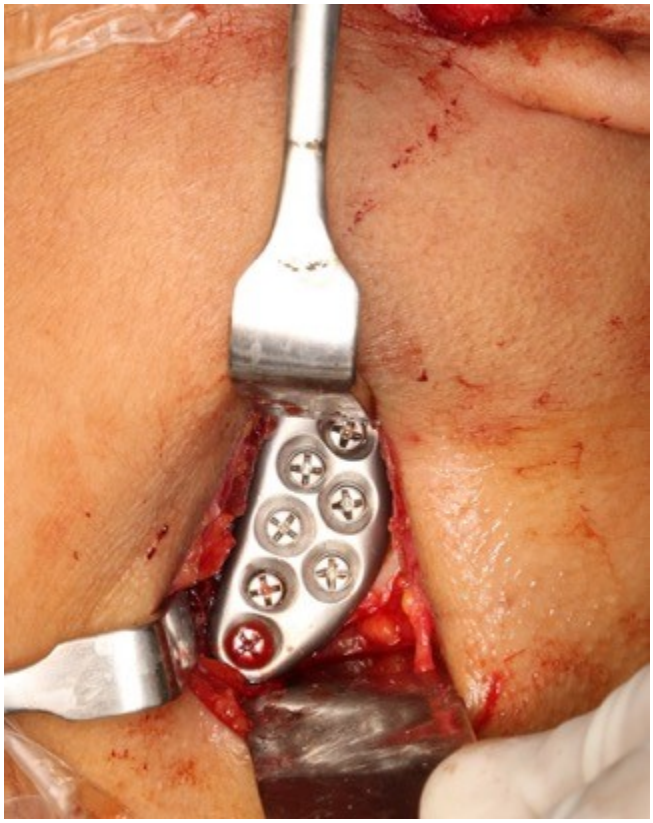

Figure 5. Mandibular component of TMJ total prosthesis.

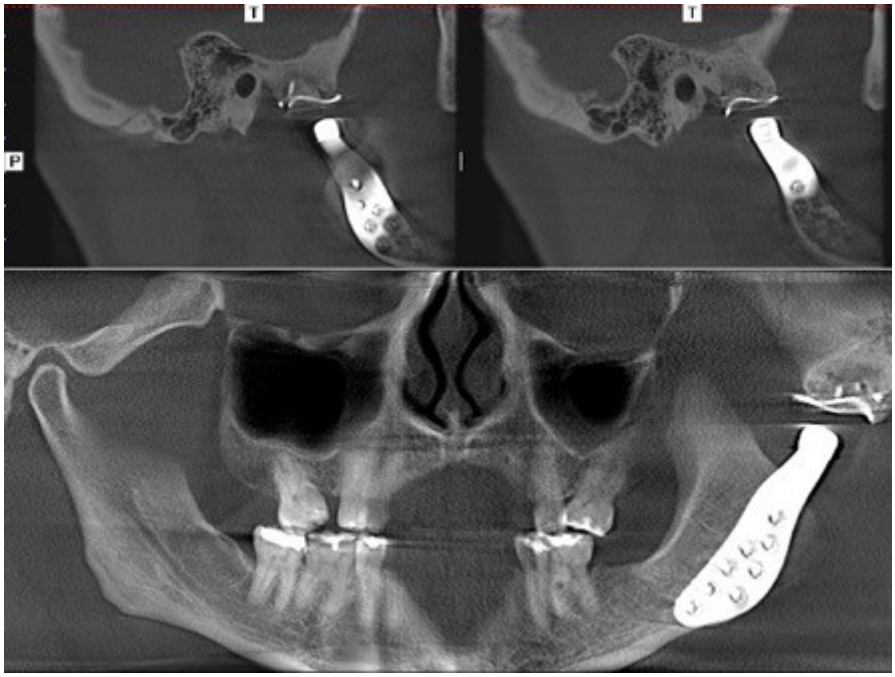

Figure 6. 3-year follow-up tomographic images.

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ANEXO

UNIVERSIDADE FEDERAL DE UBERLÂNDIA/MG

PARECER CONSUBSTANCIADO DO CEP

DADOS DA EMENDA

Título da Pesquisa: Análise tridimensional do volume de via aérea superior e da posição da coluna cervical após cirurgia ortognática com avanço e rotação anti-horária do complexo maxilo-mandibular

Pesquisador: Darceny Zanetta Barbosa

Área Temática:

Versão: 3

CAAE: 69339816.0.0000.5152

Instituição Proponente: Universidade Federal de Uberlândia/ UFU/ MG

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.814.913

Apresentação do Projeto:

Trata-se de emenda para ampliar a equipe executora e alterar cronograma.

Os pesquisadores encaminham a seguinte justificativa: "Devido a necessidade de continuarmos a avaliação dos pacientes descritos no projeto, e tendo em vista a entrada de mais uma pesquisadora na equipe (mestranda Karina Tostes Borsato) solicitamos apenas adição da mesma na equipe executora bem como a alteração do cronograma de execução. Ressaltamos que os objetivos e metodologia não foram alterados."

Objetivo da Pesquisa:

Permanecem os objetivos iniciais.

Avaliação dos Riscos e Benefícios:

Permanecem os riscos e benefícios iniciais.

Comentários e Considerações sobre a Pesquisa:

Pesquisa relevante.

Considerações sobre os Termos de apresentação obrigatória:

Todos devidamente apresentados, com renovação do termo da equipe executora.

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normal do estudo (Res. CNS 466/12). É papel de o pesquisador assegurar medidas imediatas adequadas frente a evento adverso grave ocorrido (mesmo que tenha sido em outro centro) e enviar notificação ao CEP e à Agência Nacional de Vigilância Sanitária – ANVISA – junto com seu posicionamento.

• Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP de forma clara e sucinta, identificando a parte do protocolo a ser modificada e suas justificativas. Em caso de projetos do Grupo I ou II apresentados anteriormente à ANVISA, o pesquisador ou patrocinador deve enviá-las também à mesma, junto com o parecer aprobatório do CEP, para serem juntadas ao protocolo inicial (Res.251/97, item III.2.e).

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_1195384_E1.pdf	07/08/2018 08:55:28		Aceito
Outros	lattes_pesquisador_adicionado.pdf	07/08/2018 08:13:38	Darceny Zanetta Barbosa	Aceito
Outros	Justificativa_Emeda_CEP.pdf	07/08/2018 08:12:49	Darceny Zanetta Barbosa	Aceito
Declaração de Pesquisadores	termo_de_compromisso_karina_borsato.pdf	07/08/2018 08:11:19	Darceny Zanetta Barbosa	Aceito
Projeto Detalhado / Brochura Investigador	PROJETO.pdf	07/08/2018 08:03:17	Darceny Zanetta Barbosa	Aceito
Outros	Respostas_as_pendencias.doc	14/08/2017 20:06:11	Darceny Zanetta Barbosa	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_01pag.doc	14/08/2017 20:05:45	Darceny Zanetta Barbosa	Aceito
Declaração de Instituição e Infraestrutura	declaracao_instituicaocoparticipante.pdf	05/06/2017 14:37:32	Darceny Zanetta Barbosa	Aceito
Declaração de Pesquisadores	termocompromissoequipeexecutora.pdf	29/05/2017 10:43:01	Darceny Zanetta Barbosa	Aceito
Folha de Rosto	folha_de_rosto.pdf	29/05/2017 10:40:45	Darceny Zanetta Barbosa	Aceito

Situação do Parecer:
Aprovado

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