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Minimally invasive techniques on TMJ disorders in the pediatric population: a retrospective study.

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Resumo

Introdução: A disfunção da articulação temporomandibular (ATM) é um diagnóstico cada vez mais prevalente nos dias de hoje, não só em idade adulta, mas também pediátrica. A escolha do tratamento continua a ser controversa, havendo, no entanto, um crescente interesse nos procedimentos cirúrgicos minimamente invasivos (artrocentese e artroscopia da ATM). Atualmente, a literatura disponível apresenta múltiplos estudos com resultados destes tratamentos em adultos, mas poucos avaliam os mesmos em crianças e adolescentes.

Métodos: Este estudo retrospectivo incluiu doentes com idade inferior a 18 anos submetidos a artrocentese e artroscopia da ATM, entre 2019 e 2021, no *Instituto Português da Face*. Todos os doentes foram tratados pelo mesmo médico. Foram avaliados a dor (avaliada pela VAS), a abertura máxima oral (em milímetros), a tensão muscular (numa escala de 0-3), e a presença de estalidos articulares.

Resultados: Foram incluídos neste estudo onze doentes (idade média $15,91 \pm 0,94$), seis (55%) mulheres e cinco (45%) homens. Seis doentes realizaram artrocentese e seis realizaram artroscopia. Independentemente do diagnóstico e do tratamento, a taxa de sucesso foi de 82%. Após *follow-up* médio de $334,1 \pm 248,4$ dias, houve uma melhoria estatisticamente significativa a nível da dor, abertura máxima oral e tensão muscular observadas, com valores pós-operatórios médios de 0.15 ± 0.67 (média \pm DP), 40.70 ± 6.08 mm (média \pm DP) e 0.20 ± 0.52 (média \pm DP), respetivamente. Os estalidos articulares permaneceram em apenas 10% das articulações tratadas.

Conclusões: Dentro das suas limitações, o nosso estudo sugere que a artrocentese e artroscopia da ATM são seguras e eficazes em idade pediátrica. Este estudo sugere a necessidade de mais investigação sobre estes tratamentos neste grupo etário.

Palavras-chave: Articulação Temporomandibular; Tratamentos minimamente invasivos da articulação temporomandibular; Artroscopia da ATM; Artrocentese da ATM

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Abstract

Introduction: Temporomandibular joint (TMJ) disorders have become an increasingly prevalent diagnosis, not only in adults, but also in the pediatric population. The treatment of choice remains controversial, but there has been a growing interest in minimally invasive surgical procedures (TMJ arthrocentesis and arthroscopy). Currently, the available literature presents multiple studies and outcomes on these treatments in adults, yet, few evaluate these outcomes in children and adolescents.

Methods: This retrospective study included patients younger than 18 years submitted to arthrocentesis and arthroscopy of the TMJ, between 2019 and 2021, in *Instituto Português da Face*. All patients were treated by the same doctor. Pain (evaluated through VAS), maximal mouth opening (MMO) (in millimeters), muscle tenderness (MT) (in a scale of 0-3) and joint clicks were evaluated.

Results: Eleven patients (mean age $15,91 \pm 0,94$) were enrolled in this study, six (55%) women and five (45%) men. Six patients underwent arthrocentesis and six patients underwent arthroscopy. Regardless of the diagnosis and treatment, the success rate was 82%. After a mean follow-up of $334.1 \pm 248,4$ days, a statistically significant improvement in pain, MMO and MT were observed, showing mean postoperatively results of 0.15 ± 0.67 (mean \pm SD), 40.70 ± 6.08 mm (mean \pm SD) e 0.20 ± 0.52 (mean \pm SD), respectively. Clicks remained in 10% of joints.

Conclusions: Within its limitations, our study suggests that arthrocentesis and arthroscopy are safe and effective in the pediatric population. This study calls for further investigation of these treatments in this group of patients.

Keywords: Temporomandibular joint; Minimally invasive temporomandibular joint treatments; TMJ Arthroscopy; TMJ Arthrocentesis

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Abbreviations and acronyms

TMJ - Temporomandibular Joint

TMD - Temporomandibular Disorder

MMO - Maximal Mouth Opening

MT - Muscle Tenderness

DC/TMD - Diagnostic Criteria for Temporomandibular Disorders

RDC/TMD - Research Diagnostic Criteria for Temporomandibular Disorders

MRI - Magnetic Resonance Imaging

CT - Computed Tomography

US - Ultrasound

DDwoR - Disc Displacement without Reduction

DDwR - Disc Displacement with Reduction

OA - Osteoarthritis

BTX - Botulinum Toxin

VAS - Visual Analog Scale

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Introduction

Epidemiology and Etiology

Temporomandibular joint disorders (TMD) are a group of disorders that affect primarily women, with the highest symptoms incidence between 20 and 40 years of age (Grossi, Lipton, & Bigal, 2009). Despite lacking extensive data on the matter, it is still not an uncommon diagnosis in the pediatric population, increasing in prevalence during adolescence. The prevalence of TMD diagnosis varies extensively in the literature, ranging from 7.3 to 30.4% (Christidis et al., 2018). This variation can be attributed to multiple methodological differences, such as differences in the population investigated and assessment methodology, in diagnostic criteria, and variations among examiners. Some studies have reported that up to 34% (Scrivani, Khawaja, & Bavia, 2018) of children with primary dentition may have at least 1 sign or symptom associated with TMD, while in adolescents with permanent dentition the numbers vary from 5% to 32.5% (Scrivani, Khawaja, & Bavia, 2018). In early childhood, the gender prevalence is less prominent, becoming more accentuated between 15 and 50 years of age, showing a female preponderance (Howard, 2013).

The cause of temporomandibular disorders is considered multifactorial, embracing biologic, behavioral, environmental, social, emotional and cognitive factors, that, alone or in combination, contribute to the development of typical signs and symptoms of TMD (de Leeuw & Klasser, 2013).

Anatomy

Temporomandibular joint (TMJ) is the most used joint in the body, and one of the most complex, both morphologically and functionally. Each joint is formed between the condyle of the mandible and the glenoid fossa of the temporal bone, filled with synovial fluid.

The mandibular condyle of a child is flatter (Fig. 1) and is composed of thinner cortical bone, which contributes to more intracapsular fractures in the pediatric population (Allori et al., 2010).



Fig 1. 3D Computed Tomography of a 2 years old child. Note the flatter articular eminence. Image is a courtesy of Prof. Dr. David Ângelo.

Opposed to most synovial joints, whose articular surfaces are covered with hyaline cartilage, the articular surfaces are covered by non-hyaline cartilage, articulated through a fibrous disc interposed between these surfaces (Wadhmwa & Kapila, 2008) (Standring et al., 2016). This disc divides the articular space into superior and inferior compartments, having an important functional role. First, it functions as a shock absorber and acts like a surface between the condyle and articular tubercle. The hinge and sliding movements of the TMJ are promoted by the rotation and translation of the disc over the condylar head. (Howard, 2013).

The TMJ is surrounded by a fibrous capsule that encompass TMJ structures and the associated temporomandibular, sphenomandibular, and stylomandibular ligaments, and mainly mobilized by four muscles (masseter, temporalis, lateral pterygoid, and medial pterygoid), that will keep the articular surfaces in constant contact. Besides the masticatory muscles, the facial muscles and the muscles in the anterior part of the neck are also involved with the TMJ function. Opposed to that, the ligaments do not actively participate in normal function of the TMJ. Rather, they protect and stabilize the joint by restricting certain joint movements, and since they do not

stretch, they can become elongated and compromise normal joint function (Standring et al., 2016).

Both joints work together bilaterally, enabling and facilitating the freedom of mandibular movement, characterized by opening and closing, protrusion and retrusion, and lateral excursive movements (Baskan & Zengingul, 2006). In combination, that allows the process of mastication, swallowing, speech, respiration and yawning, essential for survival and propagation.

Types of Disorders

TMD is a collective term for a group of musculoskeletal and neuromuscular conditions involving the TMJ, the muscles of mastication and related structures. While it has been associated with functional disturbances of the masticatory system, some researchers and clinicians extend the definition of TMD to masticatory muscle disorders, degenerative and inflammatory TMD, and TMJ disc displacements (Scrivani, Khawaja, & Bavia, 2018). This disorder is mostly found in adults, but, through the course of the years, it has become a finding in the pediatric population, increasing in prevalence during adolescence. Unfortunately, TMD research specific to the pediatric population is still scarce, and that is the reason why we end up basing the diagnosis and management mostly on adult studies. Early detection and appropriate intervention are important to reduce the dysfunction and prevent progression, lessening the possible negative impact. Therefore, pediatric providers must take an adequate history and physical examination that incorporates the TMJ and muscles of mastication, since children and adolescents are growing individuals and one should be alert to any potential negative effects on the normal orofacial growth. (Christidis et al., 2018). During childhood, the transition from deciduous to permanent dentition takes place, inducing changes of the craniofacial complex, evoking a number of adaptive physiological changes in TMJ. However, most observed deviations might be temporary, as a reflection of growth and joint remodeling. (Mesquita et al., 2013)

According to DC/TMD and RDC/TMD, patients with TMD most commonly present with TMJ noise during mandibular movements, limitation and restriction of mandibular movement and asymmetric motion, and pain (arthralgia, myalgia, myofascial pain, myofascial pain with referral and headache) (Chen et al., 2020). Chewing and other jaw functions tend to aggravate pain, which is often described as muscle fatigue and tightness (Christidis et al., 2018).

TMD pain alone has recently been identified as a problem among adolescents. Children and adolescents with orofacial pain are reported to experience psychological distress, impaired

social relationships, chronic fatigue syndrome, and recurrent sick leave/absence from school. It is also well known that children and adolescents who suffer from chronic pain have serious consequences in their daily lives. In comparison to adults, physical abilities, social relationships, and learning abilities are negatively impacted. Also, lack of sleep can affect normal growth and development, resulting in more pain, fatigue, and a high frequency of illness, having a negative impact on one's quality of life (Chen et al., 2020).

The American Academy of Orofacial Pain classified TMD into: (1) TMJ articular disorders, associated with joint pain, joint disorders, joint diseases, fractures and congenital disorders; (2) masticatory muscle disorders, like muscle pain, contracture, hypertrophy, neoplasm, movement disorders and masticatory muscle pain; (3) headache disorders (Scrivani, Khawaja, & Bavia, 2018) (Urukalan et al., 2021).

There are multiple classifications for TMD present in the literature: (1) Wilkes Staging Classification for Internal Derangement of the TMJ; (2) the Bronstein and Merrill Clinical Staging Classification for TMJ Internal Derangement; (3) the Research Diagnostic Criteria for Temporomandibular Disorders, and (4) Dimitroulis Classification. This last classification propose a more detailed diagnostic classification and can even assist the therapeutic approach.

A detailed history of the patient is the most important initial step to approach the patient. After that, clinical and physical examination can follow three main steps:

1. Firm bilateral pressure and palpation applied to the masseter muscles and cervical muscles, looking for tenderness, pain, or pain referral patterns, and muscle atrophy or hypertrophy (Wright, 2010);

2. Palpation of the lateral capsule of the TMJ is also important, and it is performed having the patient open their mouth halfway while the clinician firmly presses the index fingers in the depression created behind each condyle. TMJ palpation searches for the presence of discomfort or pain, and also allows the feeling of asynchronous or irregular movements and sounds. TMJ sounds are categorized as clicking, soft-tissue crepitus and hard-tissue grating (Dmd, 2012). Noise should be measured during jaw opening, closing, and excursion. TMJ sounds are most commonly caused by disc displacement or internal derangement, but they can also be caused by altered synovial lubrication, intracapsular adhesions, disc, condyle, or tubercle shape deviations, and disc and condyle incoordination during movement. Internal TMJ derangements may not progress, and clicking may not change over time. TMJ noise can naturally decrease in

frequency and intensity. However, the absence of joint sounds does not always imply that a pathologic condition has resolved or is no longer present (Wright, 2010).

3. Evaluation of mandibular range of motion. Examining jaw movements, including mandibular range of motion (i.e., maximum unassisted opening, maximum assisted opening, maximum lateral excursion, maximum protrusive excursion) and mandibular opening pattern may aid in the diagnosis of TMD. TMD can also cause both limited and excessive mandibular range of motion. The normal range of mandibular openings go from 35 to 50 mm. The average excursive mandibular movement to each side is 8 to 10 mm. During these movements, pain, mandibular deviation, end-point deflection, catching, or locking should be considered (Wright, 2010).

The clinical examination is the most important step in the diagnosis of TMJ pathology, for it provides a lot of useful information to explore the patient. However, special imaging techniques are sometimes needed, due to the complexity of the anatomy of this joint and its associated pathologies. After proper evaluation, the clinician should decide which patients would need special imaging techniques to help determine the status of the joint, depending on clinical signs and symptoms (Talmaceanu et al., 2018). One of the goals for imaging the TMJ is to determine the underlying disease and associated pathology, since the treatment can be adapted to different disorders of the TMJ. Magnetic resonance imaging (MRI) is the examination of choice to characterize the disc position and TMJ internal derangement, imaging the soft tissue structures of the TMJ, being the gold standard imaging modality in diagnosing disc displacements (Vilanova et al., 2007) (Bag, 2014). MRI could also detect the early signs of TMD, like thickening of anterior or posterior band, rupture of retrodiscal tissue, changes in shape of the disc and joint effusion (Talmaceanu et al., 2018). CT scan is also used, and provides information concerning bone assessment of trauma, infection, congenital abnormalities, or bony invasion of tumor. Ultrasound (US) has also been evaluated as a screening technique in recent years to evaluate disc displacement of the TMJ (Vilanova et al., 2007). Mandibular condyles are prone to significant changes in size and shape during childhood growth. As the condyles develop and increase in size, their shape turns from a round into an oval configuration, and the angle decreases and, therefore, the position of the condyle within the fossa changes (Howard, 2013). These age-related changes should be taken into consideration when imaging the TMJ in children.

The primary goals of TMD management are to alleviate pain, restore normal jaw function, and allow patients to resume normal daily activities. These goals are achievable if a program is in place that addresses both the physical disorders and the other factors that contribute to TMD

(de Leew & Klasser, 2013), which impair a person's quality of life and necessitate treatment (Zhang et al., 2020). Treatment options for TMD can be divided into three main categories: non-invasive, minimally invasive, and invasive. Occlusal splints, pharmacotherapy, and physical therapy are examples of non-invasive approaches; minimally invasive approaches include TMJ arthrocentesis and arthroscopy; and, at last, invasive approaches are related to arthroplasty and TMJ replacement (Zhang et al., 2020).

Few studies have documented the long-term success or failure of specific treatment modalities for TMD in the pediatric population. Simple, conservative, and reversible types of therapy have been suggested as effective in reducing most TMD symptoms. However, in some patients, a conservative approach might not be effective. Given the impact that these disorders might have on this group of patients, it's important to expand the studies on other treatments that are shown to have favorable results in adults. Over the last few decades, minimally invasive surgery has grown in popularity and become an option for patients who have failed conservative management and where open treatment may be considered excessive (Monje, 2020). Arthrocentesis and arthroscopy have filled a significant gap by providing a safe and effective alternative for TMJ disorders, which is less invasive, and has fewer complications than open surgery. In this particular case, careful attention should be given regarding the pediatric TMJ, since one of the major goals should be avoiding unwanted iatrogenic injury to the cartilage and articular disc, which can evolve to a state of osteoarthritis or harm the normal development of the joint.

The main goal of TMJ arthrocentesis is to remove intra-articular adhesions and inflammatory mediators from the upper joint compartment using hydraulic pressure, by inserting two catheters into the upper joint space, generally under local anesthesia, and irrigating with saline solution (Kim et al., 2019). This procedure reduces pain and friction between intra-articular surfaces (Gallo & Colombo, 2019). It has proven to be very effective for disc displacement without reduction with limited mouth opening. Compared with other surgical procedures, TMJ arthrocentesis has been reported to be effective in reducing pain and increasing mouth opening (Jun et al., 2019) (Soni, 2019).

Instead, TMJ arthroscopy enables direct visualization of joint pathology, which allows the biopsy of pathologic tissues, visualization and lysis of adhesions, directly instillation of steroids into inflamed synovial tissues, and, most importantly of all, it has the advantage of enabling correlation of the clinical/imaging findings with the actual joint pathology (Wright, 2010). TMJ arthroscopy requires a small diameter telescopic system with light source and

monitor, so continuous practice is required and recommended to master the technique. It is an intervention that may help diagnose pathological inflammatory conditions, pause a progressive osteoarthritic process and possibly prevent the need for open joint surgery (Choi et al., 2017).

There are several arthrocentesis-arthroscopic surgery comparative studies, concerning pain reduction and increased jaw opening, in the adult population. In a 1996 RCT, an 82 % success rate was reported for TMJ arthroscopy and 75 % for arthrocentesis. Goudot et al. in a retrospective study of 62 patients who underwent these interventions reported that despite showing similar pain control results, arthroscopy showed better results related to function. Niztan et al. reported successful TMJ arthrocentesis for closed lock internal derangements, showing an over 81% success rate. These studies covered short and long-term follow-up, as well as a randomized control trial study. There were also studies on the use of arthrocentesis in the management of TMJ osteoarthritis, as well as studies on the analytical treatment outcomes (OA). Sembronio et al. stated that in closed lock patients the success rate was slightly lower, around 72.7 %, but higher in patients with acute symptoms (87.5 %), compared with patients with chronic disease (68.0 %). Concerning these interventions in children, few studies have been developed to explore the outcomes and results. From 2008 to 2016, a retrospective study was developed to estimate preliminary outcomes of TMJ arthroscopy in the pediatric population. The main purpose of the study was to determine the short and long-term changes in pain in pediatric patients subjected to TMJ arthroscopy. The results suggested the procedure to be safe and effective in reducing pain and improving jaw dysfunction in both groups. In terms of disease, patients with diagnosis of a noninflammatory disease process (especially Wilkes III) had better outcomes compared with those with inflammatory disease. Open TMJ surgery is indicated for the management of irreversible pathology, mostly related to advanced inflammatory/degenerative joint disease. Invasive and specific surgical procedures are performed based on the patient's pathology and abilities (Murakami, 2021).

The benefits of these first line interventions include the ability to undergo these procedures in an ambulatory setting, rapid pain reduction, immediate increase of jaw mobility, fast recovery, along with a documented long-term high success rate of over 80 %. The clinical impact of these minimally invasive procedures is comparable to open joint surgery, allowing the clinicians and patients to have other options with similar results. Both procedures have promoted research that has explained the importance of disc mobility, improved synovial fluid analysis, as well as amplifying the urgency of the diagnosis of intra-articular joint pathology (Soni, 2019). The frequency of complications mentioned in the literature ranges between 2% and 10%. Blood clots in the external auditory meatus, tympanic membrane perforation, partial hearing loss, ear

fullness, and vertigo are the most common complications. Neurologic damage to the fifth and seventh cranial nerves, as well as TMJ damage that could lead to osteoarthritis, were among the other common injuries (Wolf et al., 2011).

Objectives

This study aims to investigate the safety and effectiveness of TMJ arthroscopy and arthrocentesis in a pediatric population.

Material and Methods

1.1 Study Design

A retrospective study was carried out in *Instituto Português da Face* (IPF) in Lisbon, Portugal, including patients treated for TMD from April of 2019 to November of 2021. The study was approved by the ethics committee of *Instituto Português da Face* and all enrolled patients gave their informed consent in writing, following current legislation. Patient data was scrubbed of any personal identifying parameters and given a random ID number.

The inclusion criteria were: 1) Age < 18 years old; 2) Clinical indication for TMJ arthroscopy or arthrocentesis; Dimitroulis Classification in categories 2-4. Exclusion criteria: 1) Previous TMJ surgical intervention; 2) Age > 18 years old.

Prior to treatment, all patients were examined by the same surgeon (David Ângelo, Ph.D., MD.). The variables measured throughout the study were TMJ pain, through a Visual Analog Scale (VAS, 0-10, with 0 being no pain and 10 having maximum insupportable pain), MMO (mm) using a certified ruler between the incisor’s teeth, muscle tenderness (MT) through palpation in masseter and temporalis muscle, and presence of joint clicks. For MT, the authors used a 0-3 classification as defined in RDC/TMD (E. Schiffman et al., 2014; E. L. Schiffman et al., 2010). Patients’ VAS score, MMO and MT were registered pre- and postoperatively according to the following timeline: T0 (preoperative); and T1 (postoperative maximum follow up). The success rate of surgery was graded as good, acceptable and failure in accordance with table 1 as described by Eriksson and Westesson (2001).

Table 1. Criteria for classification of success rate

Good	No pain or only mild pain level (0-2 on a 0-10 VAS scale) and MMO \geq 35mm
Acceptable	No pain or only mild pain level (0-2 on a 0-10 VAS scale) and MMO \geq 30 mm and \leq 35 mm
Failure	Constant or moderate to severe pain (2-10 on a 0-10 VAS scale) and/or MMO \leq 30 mm

1.2. Treatment protocol

1.2.1. TMJ arthrocentesis

Asepsis with betadine and sterile drape. Local anaesthesia with lidocaine and adrenaline, blocking the auriculotemporal nerve. No landmarks were used, palpation with the finger of the anatomic structures was appropriate, considering the experience of the main surgeon. To perform the first puncture in the upper compartment using a dilution with local anesthetic (1cc) + ringer lactate solution (2cc) and a 21G needle. The confirmation of the correct position with the joint was performed observing pumping with the inflow and outflow. Without this confirmation, we do not progress for the second access. For the authors, the pumping sign is an essential sign of successful joint puncture. The second puncture was performed anteriorly with a 21G, again without any specific landmark. When the outflow was detected a lavage with 60-100ml of ringer lactate solution was performed. After the lavage, the joint was supplemented with hyaluronic acid (1-2ml). If the imaging analysis demonstrated signs of osteoarthritis, we injected hyaluronic acid (1ml) and Platelet-rich plasma (PRP) (2ml) (SUPER PRP).

1.2.2. TMJ arthroscopy

The TMJ arthroscopy was performed with a 1.9-mm arthroscope including a video system (Stryker, San Jose, CA, USA), with a 2.8-mm outer protective cannula. Additional equipment has been previously described (Ângelo et al., 2021a). Briefly, for TMJ arthroscopy level 1, the authors used the classic puncture with an entry point 10 mm anterior and 2 mm below the Holmlund–Hellsing (H-H) line. The arthroscope was inserted into the superior joint space. A second puncture with a 21-G needle was performed 30 mm anterior and 7 mm below

the H-H line to wash the joint with 250–300 ml Ringer solution. After washing the joint, 1.5–2 cc of hyaluronic acid was injected into it. For level 2 TMJ arthroscopy, the second puncture was substituted by a 2.8-mm outer protective cannula with a sharp trocar until the joint was reached. The 2.8-mm cannula was used as an instrumental passageway for (1) a ReFlex Ultra 45 Plasma Wand system for intra-articular coblation and/or (2) intrasynovial medication through a 22-G long spinal needle. Antibiotic protocol (amoxicillin/clavulanic-acid or clarithromycin) and non-steroidal anti-inflammatory drugs (ibuprofen) were routinely prescribed following surgery. Patients were instructed to follow a soft diet for 3 days after surgery and 5 physiotherapy and 3 speech therapy exercise sessions started 3-5 days after intervention.

1.2.3. Masticatory muscle botox

If the patient was diagnosed with muscle tenderness G2-3, 195U of Incobotulinum toxin A Xeomin® (Merz) distributed in masseter, temporalis and cervical muscles. The treatment was performed 12-15 days before the TMJ arthrocentesis or arthroscopy.

1.2.4. Physiotherapy and speech therapy

After the TMJ arthrocentesis or arthroscopy, all patients have performed 5-8 sessions of physiotherapy and 2-3 sessions of speech therapy.

1.3 Statistical Analysis

Data were analyzed using SPSS (v26) and GraphPad Prism (v9) software. The variables were expressed as the mean \pm standard deviation (SD). The normality of data was verified for all tests. Student's paired *t*-test was used for variables with normal distribution and Signed Ranks Test for variables without normal distribution. $P < 0.05$ was considered statistically significant.

Results

A total of 11 patients were included in this study. Patients had a mean age of $15,91 \pm 0,94$ (mean \pm SD) years (6 female and 5 male). 5 patients presented additional oral risk factors

for TMD: 3 (27%) patients had undergone orthodontic treatment, 1 (9%) was subjected to wisdom teeth removal, and 1 (9%) suffered facial trauma.

In total, 20 joints were diagnosed with TMD disorders (Table 3). The most frequent intra-articular diagnosis was disc dislocation without reduction (DDwoR) plus synovitis, (5 joints, 25%), followed by disc displacement with reduction (DDwR) (4 joints, 20%). TMJ synovitis was observed in 4 joints (20%). Two joints (10%) had a diagnosis of DDwoR. 1 joint (5%) was diagnosed with DdwoR plus osteoarthritis (OA). 1 joint (5%) was diagnosed with DDwR plus synovitis. Three joints (15%) had 3 concomitant diagnosis: 1 joint (5%) was diagnosed with DdwoR + OA + Synovitis, 1 joint (5%) with DDwR + OA + Synovitis and 1 joint (5%) with DDwR + OA + Disc perforation. Seven patients presented with muscle tenderness, of which 1 (9,1%) had a grade I muscle contraction, 2 (18,2%) had a grade II muscle contraction, and 4 (36,3%) had a grade III muscle contraction.

Of the 11 patients, 5 patients (45%) underwent BTX injections before the procedures. Six had an arthrocentesis performed, of whom 2 (16,7%) had a unilateral intervention, and 4 (33,3%) a bilateral one. 6 patients underwent arthroscopy, 2 (16,7%) having a unilateral intervention, and 4 (33,3%) a bilateral one (Table 4).

There were no surgical or wound healing complications. None of the patients required reintervention.

Table 2. Demographic data

Data information	n (%), or mean \pm SD	
Number of patients	11	
Sex	Female	6 (55%)
	Male	5 (45%)
Age Mean (years)	15.91 \pm 0.94	
Oral Risk factors		
	Orthodontic treatment	3 (27%)
	Wisdom teeth removal	1 (9%)
	Facial Trauma	1 (9%)

Table 3. Study variables

Variables	n (%), or mean \pm SD	
Number of joints diagnosed	20	
Affected Joint		
	Right (only)	0 (0%)
	Left (only)	2 (10%)
	Bilateral	18 (90%)
Preoperative Intra-articular Diagnosis		
	DDwoR	2 (10%)
	DDwoR + Synovitis	5 (25%)
	DDwoR + OA	1 (5%)
	DDwoR + OA + Synovitis	1 (5%)
	DDwR	4 (20%)
	DDwR + Synovitis	1 (5%)
	DDwR + OA + Synovitis	1 (5%)
	DDwR + OA + Disc perforation	1 (5%)
	Synovitis	4 (20%)
Preoperative Muscular Diagnosis		

	Muscle Tenderness	7 (63.6%)
	III	4 (36.3%)
	II	2 (18.2%)
	I	1 (9.1%)
Follow-up period (days)	334.1 ± 248.4	

Table 4. Treatments performed

Treatments Performed	N (%)
Unilateral Arthrocentesis	2 (16.7%)
Bilateral Arthrocentesis	4 (33.3%)
Unilateral Arthroscopy	2 (16.7%)
Bilateral Arthroscopy	4 (33.3%)

A comparison between preoperative and postoperative outcomes was performed (Table 5). The mean preoperative pain was 3.10 ± 2.36 (mean \pm SD), MMO was 32.70 ± 7.73 mm (mean \pm SD),

MT was 1.65 ± 1.31 (mean \pm SD) and 11 (55%) joints presented clicks. After a mean of 334.1 ± 248.4 days of follow up, a statistically remarkable improvement of pain, MMO and MT was observed, showing results of a mean postoperative pain of 0.15 ± 0.67 (mean \pm SD), MMO of 40.70 ± 6.08 mm (mean \pm SD), and MT was 0.20 ± 0.52 (mean \pm SD). Joint clicks remained in 2 (10%) joints.

Table 5. Statistical test results for VAS, MMO and MT and comparison between preoperative and postoperative results. *** $p < 0.005$; **** $p < 0.0001$ when compared to preoperative results.

	PreOp	PostOp	P-value
	n (%), or mean \pm SD	n (%), or mean \pm SD	
VAS (0-10)	3.10 ± 2.36	0.15 ± 0.67	$p = 0.0002^{***}$
MMO (mm)	32.70 ± 7.73	40.70 ± 6.08	$p = 0.046^*$
MT (0-3)	1.65 ± 1.31	0.20 ± 0.52	$p = 0.001^{**}$
Joint Clicks	11 (55%)	2 (10%)	$p = 0.002^{**}$

The success rate of TMJ arthrocentesis and arthroscopy, according to the criteria mentioned in Table 1, was determined and is shown in Table 6. The proportion of the patients that showed a good (no pain or only mild pain level (0-2 on a 0-10 VAS scale) and $MMO \geq 35$ mm) and acceptable

(no pain or only mild pain level (0-2 on a 0-10 VAS scale) and MMO \geq 30 mm and \leq 35 mm) outcome was 82% and 9%, respectively. 9% was classified as a failure (pain constantly or moderate (2-10 on a 0-10 VAS scale) and/or MMO \leq 30 mm).

Table 6. Success rate of TMJ arthrocentesis and arthroscopy

Success rate	
Good	9 (82%)
Acceptable	1 (9%)
Failure	1 (9%)

Discussion

Over the last few years, minimally invasive TMJ surgery has been appointed not only as an alternative for conservative treatment failure, but also as an initial treatment that intends to

limit the progression of the disease to a more acute and symptomatic phase (Li et al., 2021). The main advantages of these techniques are: minimal pain and trauma to the patient, reduced risk of complications, faster recovery, minimal cosmetic deformity, low emotional impact, and, ultimately, improved quality of life. These treatment options, especially TMJ arthrocentesis and arthroscopy, showed faster and more efficient clinical results over conservative approaches in the management of TMD in terms of improving mouth opening and reducing pain (Wolf et al., 2011) (González-García, 2015).

TMJ arthrocentesis is a simple, office-based procedure performed most of the times under local anaesthesia. The main goals of this technique are: removal of inflammatory markers from the joint; lavage of the synovial fluid; and the breakdown of adhesions and adhesions. TMJ arthroscopy is performed under general anesthesia, but it is possible to visualize cavities and joint tissues, perform diagnosis, irrigations, biopsies, remove adhesions and correct traumas (Moses, 1989) (Cardoso et al., 2007). This intervention allows for lysis and lavage of the upper compartment (level 1 arthroscopy), as well as for intra-articular surgical procedures (level 2-3 arthroscopy). It is recognized to be effective in reducing pain and restoring mandibular function, with minimal morbidity.

The use of these techniques in adulthood is well validated in the literature. However, data on the efficacy and safety of minimally invasive TMJ surgery in pediatric patients is scarce. Thus, it is crucial to investigate the effectiveness of minimally invasive therapies in this age group to mitigate the degenerative impact on the joint. In children, the available data focuses on conservative treatments: patient education on the disease and its pathology; behavioral therapy, cognitive behavioral therapy [CBT]; physical therapy, that might include jaw exercises, transcutaneous electrical nerve stimulation [TENS], ultrasound, massage, TMJ distraction and mobilization, thermotherapy, coolant therapy; pharmacological therapy; and occlusal splints, to provide orthopedic stability to the TMJ. Clinicians seem reluctant to try minimally invasive approaches treatments in infants and adolescents, since there is not enough evidence to do these procedures safely and confidently. In the expectation to improve knowledge in the specific topic, this study tries to further investigate and expand the research of pre-existing studies on the efficacy of TMJ arthrocentesis and arthroscopy in the pediatric population. A thorough evaluation allows us to assess whether these methods should be used as a reference treatment for this age group instead of other conservative treatments.

In our study, arthrocentesis and arthroscopy appear to benefit pediatric patients with TMD, significantly lowering pain and improving MMO, without post-surgical complications or need for reintervention.

In the available literature, TMD are associated with a female preponderance, accounting for 70-80% (A. Howard, 2013). In our study, only 55% of subjects were females, a lower value that can be explained by the small sample size. In another study, a 90% predominance of females was demonstrated in patients under the age of 20 (American Academy of Pediatric Dentistry, 2021). It remains unclear in the literature whether female predominance is a fact that is accentuated in adolescence or adulthood. Over the years, authors have attempted to determine the reason behind these results, suggesting that females were more likely to seek treatment for their condition and, when affected, had higher levels of pain and dysfunction, while other authors tried to attribute it to biomechanical, physiological, genetic and hormonal factors (Isberg et al., 1998) (A. Howard, 2013).

In our study, age ranged from 14 to 16 years. Despite most TMD being diagnosed around the ages of 20-40 (Grossi, Lipton, & Bigal, 2009), a study of 4724 children aged 5 to 17 showed that 25% of them had symptoms compatible with TMD. (American Academy of Pediatric Dentistry, 2021). Some etiologic factors are mentioned as a reason for the TMD development in the pediatric population: macrotrauma, which occurs frequently in childhood (unilateral and bilateral intracapsular or subcondylar fractures are the most common mandibular fractures in children); microtrauma from parafunctional habits, which overload the joint and promote the development of changes within the joint; psychosocial factors, like somatization, anxiety and stress, obsessive-compulsive personality types; and systemic and pathologic factors, which include connective tissue diseases, joint hypermobility, genetic susceptibility and hormonal fluctuations (Horton et al., 2016). In our study, 3 (27%) patients had had orthodontic treatment, 1 (9%) had been submitted to wisdom teeth removal, and 1 (9%) had suffered facial trauma.

In our study, mean preoperative pain score was 3.10 ± 2.36 . After the procedure, pain score decreased to 0.15 ± 0.67 . Equally, in a retrospective study, including 23 pediatric patients who underwent arthroscopy, the VAS scores improved 25-26% in short and long-term (Murakami, 2022). In an sample of 50 adults (78 joints) submitted to arthroscopy, Indresano et al. verified a reduction in pain in 70% of patients. Arthrocentesis is also an effective technique for pain reduction in patients with internal derangements of the TMJ (de Riu et al., 2013). Alpaslan et al. had evaluated patients with ID of the TMJ for a follow-up period of 22 months (range: 3-60 months) after arthrocentesis, observing significantly reduced pain and dysfunction. A

retrospective study, which analyzed 20 patients, it was shown a reduction of pain of 4.56 ± 1.74 (VAS) for the arthrocentesis group, and 2.5 ± 2.2 (VAS) for the arthroscopy group (Tan & Krishnaswamy, 2012). All these results suggest that the application of these techniques is equally effective in pediatric and adult age.

In our study, significative improvement in MMO was observed. Mean preoperative MMO was 32.70 ± 7.73 mm. Postoperatively, MMO improved to 40.70 ± 6.08 mm. In another study covering 23 pediatric patients, results of mouth opening increased by 5.4 and 8.2 mm, in the short-term and long-term, respectively (Murakami, 2022). Perceived jaw dysfunction improved significantly as well, with an average improvement of 23.8% in the short term and 19.2% in the long term. Equally, in the adult population, a study following arthrocentesis revealed that patients had a significant increase in mouth opening, from 24.1 ± 5.6 mm to 42.7 ± 4 mm (Nitzan et al., 1991). A 6-year retrospective study in patients submitted to TMJ arthroscopy reveals that that 56% of patients experienced an excellent range of motion, which accounts for a vertical mouth opening of 40 mm, and in 7 of 12 centers, more than 70% of patients reported excellent results; in the 3 centers reporting less than 20% excellent results, nearly 80% of the results were reported as good (vertical mouth opening between 30 and 40mm) (McCain et al., 1992). In another retrospective study analyzing 20 patients, mean MMO was 26.56 ± 2.74 and 30.25 ± 3.73 mm before TMJ arthrocentesis and arthroscopy respectively. Postoperatively, MMO was 39.56 ± 3.36 mm in the arthrocentesis group and 36.88 ± 7.43 mm in the arthroscopy group (Tan & Krishnaswamy, 2012). Murakami et al. also described that arthrocentesis and arthroscopy were equally effective in the treatment of closed lock of the TMJ, but they concluded that arthrocentesis was a better option in acute closed lock. However, Goudot et al. stated that TMJ arthrocentesis and arthroscopy were both valid treatment options for TMD, but arthroscopy was more successful in improving mouth opening. The results obtained in this study in a pediatric age with improved mouth opening after arthrocentesis and arthroscopy are comparable to those obtained in previous studies in adults.

Regarding joint clicking, most pediatric patients became free of clicks and only 2 joints out of 11 (10%) still presented clicking. In a retrospective study performed by Choi et al, of the 23 pediatric joints that presented noise, 14 (56%) had resolved after arthroscopy. Similarly, in adults in a retrospective study, 13 patients who had TMJ clicks, 12 patients (92.3%) no longer have this symptom after 4 months following arthrocentesis (AbdulRazzak et al., 2020).

About muscle tenderness, this variable is evaluated on a scale of 0-3, considering 0 the minimal level of muscle tenderness, and 3 the maximum. Preoperatively, our patients showed

values of MT of 1.65 ± 1.31 . Postoperatively, it improved, resulting in values of 0.20 ± 0.52 . This variable is difficult to treat, as it is very susceptible to external factors, such as parafunctional activities with no resolution, psychological factors, stress and anxiety, or even associated with other diseases, like fibromyalgia.

In our study, the outcomes for TMJ arthrocentesis and arthroscopy were good, with a success rate of 82%, meaning no pain or only mild pain level (0-2 on a 0-10 VAS scale) and MMO ≥ 35 mm. In 9% (n=1 patient) results were considered acceptable; in another 9% (n=1 patient) treatment was considered a failure.

Several studies have demonstrated a success rate for TMJ arthrocentesis and arthroscopy around 70% and 90% (Alpaslan et al., 2003) (Ahmed et al., 2012). Nitzan et al. reported a success rate of more than 81% for TMJ arthrocentesis. Sembronio et al. disclosed an overall success rate of 72.7% in closed lock patients, reporting a higher rate, 87.5%, in patients with acute symptoms (Murakami, 2022). 50 patients with ID of the TMJ reported a 73% global success rate for arthroscopy, according to a study done by Indresano. Fridrich and Zeitler reported an 82 % success rate for TMJ arthroscopy and 75% for arthrocentesis. No significant difference was found between these interventions.

The present study's limitations include its retrospective nature, small sample size, and absence of a control group following conservative treatment. Without a control group, we cannot evaluate the possibility that this patient population would have improved with continued medical management and conservative treatments.

Future research should compare therapeutic outcomes of TMJ arthrocentesis, arthroscopy and continued medical management on a statistically significant level. Future studies should also look at longer-term data to evaluate if there are any negative or positive side effects from these minimally invasive treatments. Studies suggesting the best treatment option regarding diagnosis could also be valuable, as well as studies which evaluate satisfaction of treated patients and impact on their quality of life.

We believe this study is a valid contribution to demonstrate the effectiveness and safety of these techniques in the pediatric population. In general, minimally invasive treatments were highly effective and there were no reported complications. We hope this study sheds light on this topic of interest, leading to more valid research and therefore allowing clinicians to feel safer and more confident about performing these techniques in the pediatric population.

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