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RESEARCH

Outcomes of bilateral temporomandibular joint arthroscopy: an international multicentric prospective study including 524 joints

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Abstract

Purpose This study aimed to evaluate the efficacy of bilateral TMJ arthroscopy in patients with different Wilkes stages, comparing the results obtained in different arthroscopic levels on a larger scale, unifying similar populations.

Methods A multicentric prospective clinical study was conducted in three TMJ departments performing temporomandibular joint surgery in Portugal and Brazil, with an enrolling window active from January 1, 2019, to December 1, 2022. The primary clinical outcome was TMJ pain evaluated through a visual analogue scale. The secondary clinical outcome was the maximum mouth opening (MMO). TMJ arthroscopy was performed with a 1.9-mm arthroscope, including a video system with a 2.8-mm outer protective cannula.

Results 262 patients, representing a total of 524 operated joints were enrolled. The mean age was 35.3 years. A significant decrease postoperatively in VAS pain was observed for all Wilkes stages. The lowest value of VAS pain was observed in Wilkes II compared to Wilkes III and IV. In the secondary outcome, MMO was observed to have a significant improvement in all Wilkes stages.

Conclusion In this multicentric study, bilateral TMJ arthroscopy was shown to be an effective procedure to reduce pain and increase maximum mouth opening in patients with different Wilkes stages, representing a valid minimally invasive solution.

Keywords Temporomandibular joint · Temporomandibular disorders · TMJ arthroscopy · Minimally invasive surgery · Multicentric study

Introduction

Temporomandibular joint (TMJ) arthroscopy is a minimally invasive surgical technique used to treat arthrogenous temporomandibular disorders (TMD) under direct visualization, embracing both a diagnostic and a therapeutic role [1, 2]. It was first introduced by Onishi at 1975 [3], as a pioneering technique to treat painful temporomandibular joints, reducing the number of TMJ open surgeries [4]. The arthroscopic approach allows direct observation of the TMJ compartments with reduced invasiveness, respecting the integrity of the joint's capsule. This ensures greater tolerance and a lighter postoperative recovery for patients if compared to open surgery [5, 6].

The operating field is mainly confined to the upper temporomandibular joint compartment, which can be divided into two recesses, the anterior and the posterior, separated by the articular eminence. In a posterior to anterior way, the most important structures are represented by medial

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synovial drape, retrodiscal synovium and retrodiscal ligament, posterior slope of the articular eminence and glenoid fossa, articular disk, intermediate zone, lateral pterygoid muscle shadow [7].

TMJ arthroscopy allows joint adherence lysis, joint lavage, and intra-articular surgical procedures. To classify the type of procedure, arthroscopy is divided into three levels depending on the operative procedures: level 1 includes basic diagnostic arthroscopy with lysis and lavage, level 2 is defined as operative arthroscopy with intra-articular coblation and other articular surgical techniques, and level 3 arthroscopy implicates a discopexy of the articular disc [8, 9]. The intra-articular surgical procedures include: myotomy of the lateral pterygoid muscle, cutting adhesions, coblation of synovitis spots and neo-vessels, tissue remodeling, retrodiscal ligament scarring, disc manipulation, and infiltration of substances [1, 8, 10].

TMJ arthroscopy seems to be long-term effective for relieving TMJ symptoms [1]. Recent studies have shown that TMJ arthroscopy promotes a reduction in pain and inflammatory processes, restoring the articular function with low morbidity [2, 11–13]. According to several studies, the clinical success of this technique varies between 50 and 92% [4, 5, 10, 14–20]. Many studies evaluated various arthroscopic procedures ranging from lysis and lavage to advanced operative arthroscopy, and results are not always in agreement with the effectiveness and outcomes [21]. This variability could be due to the fact that TMJ arthroscopy is performed widely and without a unified protocol. Several differences can be among surgeons, and protocol may vary.

A multicentric study analyzing outcomes in TMJ arthroscopy could support the development of a rigorous study protocol, ensure uniform data collection among different centers, and give a clearer response to the effectiveness of arthroscopy on a wider population. This multicentric prospective study aimed to evaluate the efficacy of bilateral TMJ arthroscopy in patients with different Wilkes stages, comparing the results obtained in different arthroscopic levels on a larger scale, unifying similar populations.

Materials and methods

Study design

A multicentric prospective clinical study was conducted in three TMJ departments performing temporomandibular joint surgery in Portugal and Brazil, with an enrolling window active from January 1, 2019, to December 1, 2022. The included departments were: (1) Instituto Português da Face, Lisbon, Portugal; (2) Hospital Sirio-Libanês, São Paulo, Brazil and (3) - Hospital Municipal Carminio Carrichio, Tatuape, Sao Paulo, SP, Brazil.

This study was approved by the ethics committee of the organizing center (Instituto Português da Face - PT/IPFace/RCT/1901/02). The protocol was designed in accordance with the involved institutions to uniform the development of the study among involved centers. Patient enrollment was organized to obtain similar populations between the institutions to reduce the risk of bias and inter-institutional variability. Two populations were individuated, “the Portuguese population (PT)” and “The Brazilian population (BR).” Outcome assessment and surgical treatment were developed, shared, and uniformed to be repeatable in both centers. A minor variable component related to personal preference and surgical experience was contemplated.

Patients

The inclusion criteria included: (1) age > 18 years; (2) clinical diagnosis of bilateral arthrogenous disorder; (3) magnetic resonance imaging (MRI) supporting the diagnosis of arthrogenous TMD; (4) patients referred for a TMJ surgical opinion after the failure of non-surgical treatments (anti-inflammatory, muscle relaxant drugs, occlusal splints, and physiotherapy) after at least 3 months; (5) clinical-radiological criteria for bilateral TMJ arthroscopy. The exclusion criteria included: (1) a history of facial trauma or previous TMJ surgery; (2) severe previous medical problems or impaired cognitive capacity; (3) pregnant or breastfeeding women. All the outcomes were assessed before and after surgery (1 month, 3 months, 6 months, 1 year, then every year after 1 year follow up). The final diagnosis was confirmed with magnetic resonance imaging (MRI). The clinical severity of each joint was classified according to Wilkes’s classification for internal derangement [20]. Wilkes’s classification is divided into 5 stages from I to V (early, early/intermediate, intermediate, intermediate/late, late gross), based on clinical and radiological features. All patients gave their written informed consent in accordance with the current legislation and the guidelines of the Declaration of Helsinki.

Outcome assessment

The primary clinical outcome was TMJ pain (arthralgia) and was accessed through a Visual Analogue Scale (VAS). This scale varies between 0 (no pain) and 10 (maximum insupportable pain). Arthralgia was reported if it was verified: (1) history of pain in the TMJ area and (2) pain on palpation of the lateral pole *or* around the lateral pole or pain on maximum unassisted or assisted opening, right or left lateral movements, or protrusive movements [22]. The secondary clinical outcome was the maximum mouth opening (MMO,

in mm). MMO was measured using a certified ruler between the incisor's teeth. To define the success criteria, authors used 2 categories to classify the TMJ pain: good if VAS ≤ 2, and failure if VAS > 2. In MMO, the authors defined the cut-off of success for MMO > 35 mm (good ≥ 35 mm and acceptable between ≥ 30 mm and < 35 mm) and failure for MMO < 30 mm in the postoperative evaluation. The outcomes were graded together as good, acceptable and failure in accordingly with Table 1 as described by Eriksson and Westesson [21].

Surgical treatment protocol

The TMJ arthroscopy procedure involved the use of a 1.9-mm arthroscope equipped with a video system (Stryker, San Jose, CA, USA) and a 2.8-mm outer protective cannula. The initial step, level 1 TMJ arthroscopy, utilized a classic puncture technique with an entry point 10 mm anterior and 2 mm below the Holmlund–Hellsing (H-H) line. Subsequently, the arthroscope was inserted into the superior joint space. Another puncture, using a 21G needle, was made 30 mm anterior and 7 mm below the H-H line to irrigate the joint with Ringer solution. In level 2 TMJ arthroscopy, the second puncture was replaced by inserting a 2.8-mm outer protective cannula with a sharp trocar until reaching the joint. This cannula served as a passage for instruments, including a coblator device (Coblator II ENT, Arthrocare, USA), utilized for various procedures such as adhesion removal, synovitis management, anterior disc release, and posterior ligament coagulation. Additionally, this portal facilitated the injection of sub-synovial medication using a 22G long spinal needle. Level 3 TMJ arthroscopy employed a 3/0 polydioxanone (PDS) suture for arthroscopic discopexy. Supplementary injection with 1.5 ml of low molecular weighthyaluronic acid (Suplasyn®, 20 mg/ml) were administered. Before surgery, a prophylactic antibiotic protocol with either amoxicillin/clavulanic acid or clarithromycin was prescribed. Postoperatively, analgesic therapy was prescribed if necessary.

Statistical analysis

Data were analyzed using the IBM SPSS (v26) software. The variables were expressed as the mean (± standard deviation (SD)). Descriptive data for patients' characteristics was obtained. For the whole group of patients, the student's paired t-test was used for variables with normal distribution (MMO), and the signed ranks test was used for variables without normal distribution (VAS pain). A Fisher-T test was used to analyze the success of the arthroscopy. In comparison of Wilkes stages and arthroscopic level, two independent groups were established. Subsequently, Mann-Whitney test and Student t-test for unpaired data were applied for VAS pain and MMO and outcomes. To eliminate possible bias in comparation of Wilkes and arthroscopic level, the analysis relative to MMO only considered bilateral involvement with similar Wilkes and arthroscopic level performed. $P < 0.05$ was considered statistically significant.

Table 1 Criteria for classification of three postoperative outcomes

Good	No pain or only mild pain level (VAS ≤ 2 on a 0–10 scale) and MMO ≥ 35 mm
Acceptable	No pain or only mild pain level (VAS ≤ 2 on a 0–10 scale) and MMO ≥ 30 mm and < 35 mm
Failure	Pain constantly or moderate (VAS > 2 on a 0–10 scale) and/or MMO < 30 mm

Results

In the present multicentric study, 262 patients (61 Portuguese patients, 201 Brazilian patients) representing 524 operated joints, were enrolled. The mean age of the entire population was 35.30 ± 12.45 years. Of the 262 evaluated patients, 220 (83.97%) were female and 42 (16.03%) were male, with an equal M: F ratio of 1:4 for each population. Variables for each population are reported in Table 1. Globally, the most common arthrogenous diagnosis were: (1) dislocated disc with reduction (DDwR) (54.77%, $n = 287$ joints); (2) dislocated disc without reduction (DDwoR) (41.99%; $n = 220$ joints); (3) arthralgia (1.91%; $n = 10$ joints). Percentages of distribution of preoperative intra-articular diagnosis were almost superimposable among centers.

The mean preoperative VAS pain was 4.89 ± 2.62 (0–10, mean ± SD), the two populations, and the mean MMO was 34.58 ± 6.62 mm (mean ± SD). Both variables were almost identical among the two populations.

Arthroscopic levels

Arthroscopy level I was performed in 56 joints (10.7%), whereas level II and III were performed in 319 (60.9%) and 148 (28.2%) joints, respectively. Level I was mainly conducted in Portugal (43, 35.25% vs. 13, 3.23% joints), while level III mainly was adopted in Brazil (143, 35,57%, vs. 6, 4.91%). Both centers performed mostly level II arthroscopy, adopting this technique in 60% of each population. An interpersonal surgical difference was noted in the technique of discopexy: in the Portuguese population, the surgeon preferred a level II arthroscopy, with indirect discopexy through treatment of the peri-discal structures, while in the Brazilian population, a direct discopexy approach through level III was preferred. The distribution of Wilkes Classification among the two populations is shown in Table 2. Considering the enrollment of similar patients with similar

Table 2 Baseline characteristics of the patients in the study. The Portuguese and Brazilian populations were compared

Variables		*n* (%), or mean ± SD		
		Portuguese population	Brazilian population	*p*-value
Number of patients		61	201	–
Sex		Number of patients(%)	Number of patients (%)	0.072
	Female	56 (79.6%)	164 (81.6%)	
	Male	5 (20.4%)	37 (18.4%)	
Age (mean ± SD)		32.61 ± 10.94	36.35 ± 12.57	0.1356
Number of joints		122	402	–
Follow-up period (days)		639.3 ± 445.5 (31-1236 days)	454.7 ± 235.9 (90–730 days)	0.0009***
Preoperative intra-articular diagnosis		Number of joints (%)	Number of joints (%)	–
	DDwR	58 (48.33%)	229 (56.68%)	
	DDwoR	48 (40.00%)	172 (42.57%)	
	Arthralgia	7 (5.83%)	3 (0.74%)	
	Disc Perforation	4 (3.33%)	0 (0.00%)	
	Osteoarthrosis (OA)	3 (2.50%)	0 (0.00%)	
Wilkes Classification		Number of joints (%)	Number of joints (%)	0.6878
	2	66 (54.10%)	210 (52.24%)	
	3	37 (30.33%)	115 (28.61%)	
	4	19 (15.57%)	77 (19.15%)	
Arthroscopy Surgery Level		Number of joints (%)	Number of joints (%)	< 0.0001
	I	43 (35.25%)	13 (3.23%)	
	II	73 (59.83%)	246 (61.19%)	
	III	6 (4.91%)	143 (35.57%)	
Preoperative VAS pain (0–10)		4.89 ± 3.02	4.89 ± 2.49	0.5327
Preoperative MMO (mm)		32.56 ± 8.06	34.48 ± 6.57	0.0578
Postoperative VAS pain (0–10)		0.53 ± 1.53	0.81 ± 1.44	0.0549
Postoperative MMO (mm)		40.19 ± 4.75	38.87 ± 4.69	0.0600

preoperative values between the two populations, outcomes were measured directly on the general population, unifying the two groups.

Clinical outcomes

A statistically significant reduction was observed in the primary outcome, TMJ pain, postoperatively (0.83 ± 1.63) ($p < 0.0001$, Fig. 1A). The proportion of patients that showed a good outcome reducing pain was 82% (Fig. 1B). A significant MMO improvement from 34.58 ± 6.62 preoperatively to 39.21 ± 4.74 postoperatively was observed ($p < 0.0001$; Fig. 2A). 218 (83%) patients presented after the surgery MMO ≥ 35 mm (Fig. 2B). 3 patients failed to open more than 30 mm postoperatively. Bilateral TMJ arthroscopy outcome was considered "successful" in 178 (68.32%) patients, "acceptable" in 33 (12.60%), and "failure" in 50 (19.08%) patients (Table 3).

VAS pain, MMO, and were also evaluated in relation to the success rate were also assessed concerning the severity of the disease using the Wilkes Classification (Tables 4 and 5). Of 524 joints, 276 (52.7%), 152 (29.0%), and 96 (18.3%) were respectively classified as Wilkes stages II, III, and IV. The mean preoperative VAS scores were 4.74 ± 2.69 for Wilkes II, 4.89 ± 2.51 for Wilkes III, and 5.23 ± 2.52 for Wilkes IV (Table 4). A significant decrease postoperatively in VAS pain was observed for all Wilkes stages ($p < 0.0001$). Significant differences were found in comparing the postoperative pain between the different Wilkes' stages when comparing the postoperative pain between the different Wilkes' stages (Fig. 3). The lowest value of VAS pain was observed in Wilkes II compared to Wilkes III and IV (II: 0.67 ± 1.69 vs. III: 0.92 ± 1.62 and IV: 1.14 ± 1.40, $p = 0.001$ and $p < 0.0001$). Wilkes III also observed a lower VAS pain compared to Wilkes IV (0.92 ± 1.62 vs. 1.14 ± 1.40, $p = 0.024$). In MMO, a significant improvement was observed in all Wilkes stages (Table 4). There were no differences in the MMO postoperatively comparing the Wilkes stages (Table 4). There were also no differences in the success rate considering the Wilkes Classification (Table 5).

Table 6 summarizes mean VAS and MMO values preoperatively and postoperatively for the different arthroscopy levels. A significant improvement postoperatively in VAS pain and MMO was observed for all arthroscopy levels ($p < 0.0001$, Table 6). Comparing the postoperative results between the different arthroscopy levels, a significant difference in pain was observed comparing level III with level I and II ($p < 0.0001$ and $p = 0.007$). No differences were found in the success rate when comparing the arthroscopy levels (Table 7).

Figure 4 showed mean VAS values preoperatively and postoperatively for the arthroscopy surgery levels and Wilkes stages. Preoperatively was verified statistically significant differences between surgery levels I and III in Wilkes II and IV ($p = 0.044$ and $p = 0.036$). However, postoperatively, in all Wilkes stages with different arthroscopy surgery levels, it is possible to confirm a similar decrease in VAS pain in all parameters without statistically significant results (Fig. 4). The authors had reversible complications, namely: oedema of the preauricular area (6.5%); paralysis associated with auriculotemporal or VII frontal branch or zygomatic branch

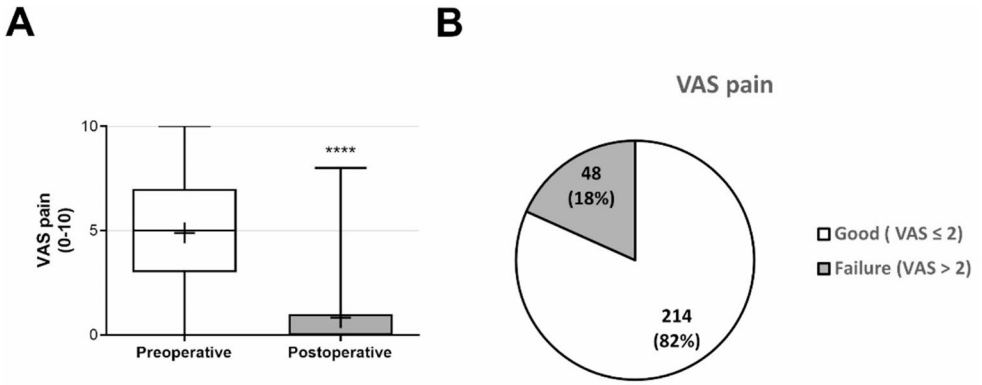

Fig. 1 Statistical test results (**A**) and outcomes (**B**) for VAS comparing preoperative and postoperative VAS results. Error bars indicate mean ± SD; **** $p < 0.0001$ compared to preoperative VAS pain

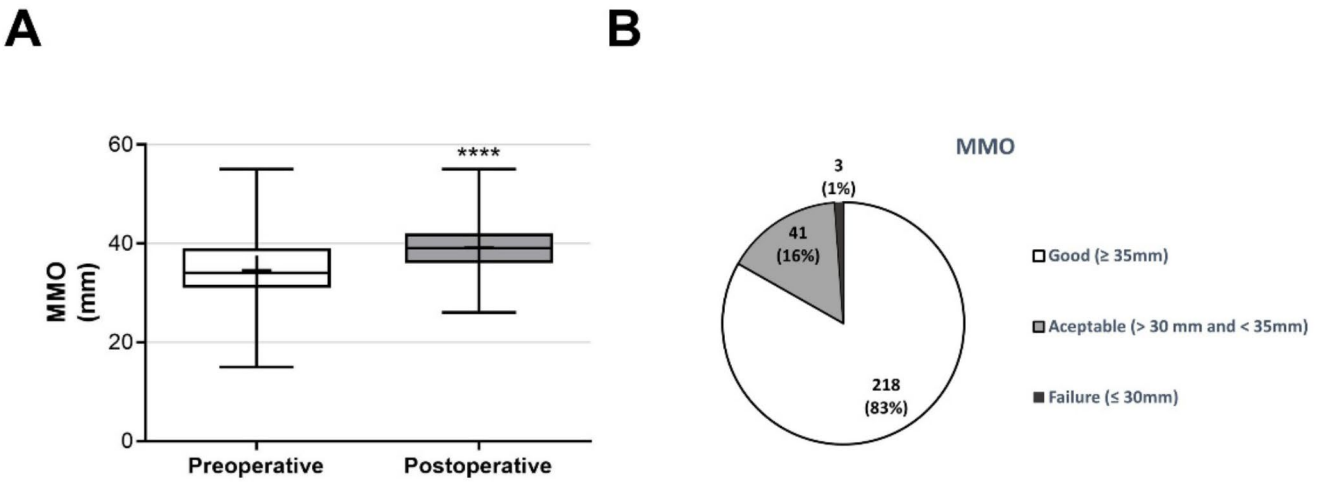

Fig. 2 Statistical test results (**A**) and outcomes (**B**) for MMO comparing preoperative and postoperative MMO results. Error bars indicate mean ± SD; **** $p < 0.0001$ compared to preoperative MMO

Table 3 The success rate of TMJ arthroscopy

Success rate	
Good	179 (68.32%)
Acceptable	33 (12.60%)
Failure	50 (19.08%)

nerve damage (1.9%); intra-articular bleeding (1.5%). 95% recovered after 4 weeks, except for 5% of the patients who needed 8 weeks to achieve a full recovery. No irreversible surgical complications were observed in all patients.

Discussion

This prospective multicenter study showed that implementing a strict protocol for TMJ arthroscopy enables satisfactory results to be obtained by different surgeons and in different populations. Bilateral TMJ arthroscopy was an effective procedure in different stages of TMD, resulting in a significant reduction of pain and improvement in MMO in all severity categories. Although better results were observed in pain reduction in Wilkes II and III patients, no

Table 4 VAS and MMO preoperatively and at follow-up according to Wilkes stages (asterisks indicate statistical significance, $p < 0.0001$)

Wilkes stage		Preoperative	Postoperative	*p*-value preoperative vs. postoperative
II	VAS (Mean ± SD)	4.74 ± 2.69	0.67 ± 1.69	**< 0.001****
	MMO (Mean ± SD)	34.74 ± 6.67	38.82 ± 5.87	**< 0.001****
III	VAS (Mean ± SD)	4.89 ± 2.51	0.92 ± 1.62	**< 0.001****
	MMO (Mean ± SD)	31.73 ± 7.69	38.20 ± 3.42	**< 0.001****
IV	VAS (Mean ± SD)	5.23 ± 2.52	1.14 ± 1.40	**< 0.001****
	MMO (Mean ± SD)	34.70 ± 5.70	38.89 ± 2.85	**< 0.001****
p-value Wilkes stage vs. VAS		0.265	**< 0.001****	
p-value Wilkes stage vs. MMO		0.093	0.824	

Table 5 Success rate of TMJ arthroscopy according to Wilkes stage

	Success rate					
Wilkes	II-II	II-III	III-III	III-IV	IV	p-value
Good - acceptable	78 (79.6%)	51 (78.5%)	25 (83.3%)	24 (88.9%)	34 (81.0%)	0.845
Failure	20 (20.4%)	14 (21.5%)	5 (16.7%)	3 (11.1%)	8 (19.0%)	

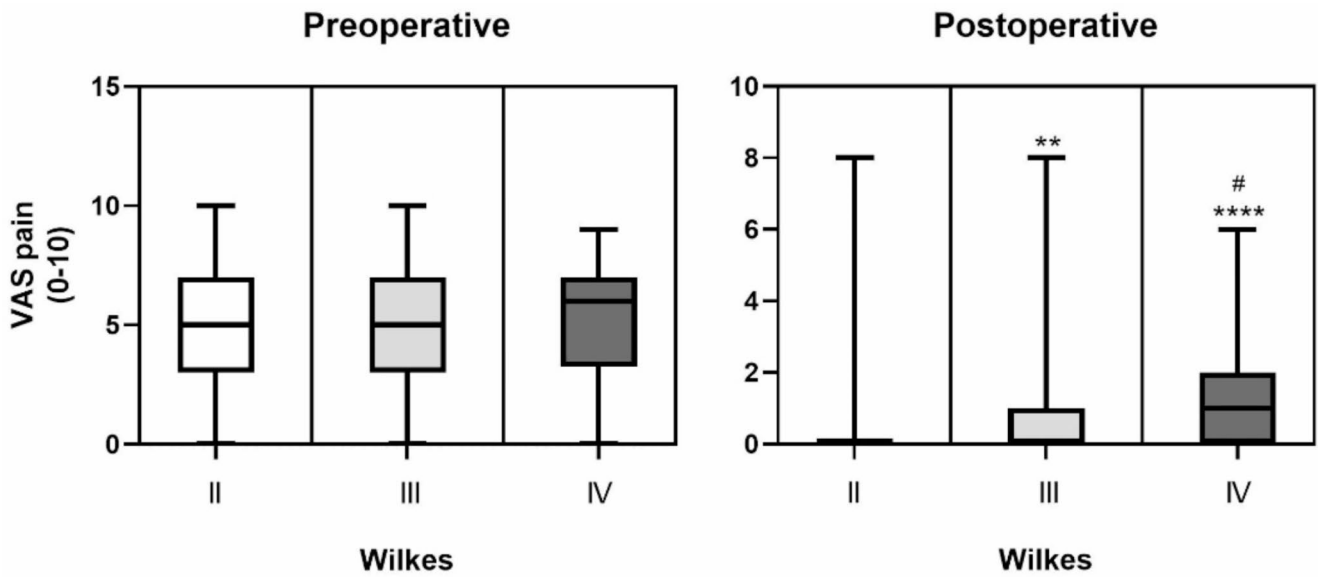

Fig. 3 VAS pain in different Wilkes stages pre-and- postoperatively. * $p < 0.001$ and ****$p < 0.0001$ comparing with Wilkes II; $^{\#}p < 0.05$ comparing with Wilkes III

Table 6 VAS and MMO preoperatively and at follow-up according to arthroscopy level (asterisks indicate statistical significance, $p < 0.0001$)

Surgery level		Preoperative	Postoperative	*p*-value preoperative vs. postoperative
I	VAS (Mean ± SD)	4.52 ± 2.95	0.78 ± 1.69	**< 0.001****
	MMO (Mean ± SD)	33.00 ± 7.33	39.76 ± 4.83	**0.017****
II	VAS (Mean ± SD)	4.98 ± 2.61	0.76 ± 1.68	**< 0.001****
	MMO (Mean ± SD)	34.43 ± 7.02	39.04 ± 5.00	**< 0.001****
III	VAS (Mean ± SD)	4.89 ± 2.50	0.98 ± 1.49	**< 0.001****
	MMO (Mean ± SD)	35.14 ± 5.27	39.34 ± 4.28	**< 0.001****
p-value Arthroscopy Level vs. VAS		0.320	**0.018***	
p-value Arthroscopy Level vs. MMO		0.459	0.788	

differences in success rates were noticed. As expected, preoperative joint pain value distribution increased as Wilkes stage increased. This trend was observed in the postoperative stage in an opposite manner: the lowest level of arthralgia was recorded in stage II, then stage III, and finally stage IV. This can be interpreted as high levels of baseline pain are associated with higher levels of pain in the postoperative phase. In fact, level 3 arthroscopy procedures presented post-operative higher rates of post-operative pain, compatible with a greater surgical manipulation. Moreover, this difference in postoperative pain is more likely to be observed in the early post-operative weeks. This is consistent with the literature [23]: level 3 arthroscopy showed a longer period of post-operative pain than level 2 arthroscopy. Gaete C et al. [24] found a restricted number of patients undergoing level 3 arthroscopy were associated with Wilkes II but had disc perforation. In our population, we found too elongated or damaged discs, and not only in advanced Wilkes degrees, making any kind of arthroscopic discopexy unfeasible. This phenomenon is quite common in the literature due to the reduced diagnostic specificity of preoperative imaging

Table 7 Success rate of TMJ arthroscopy according to arthroscopy level

Surgery level (joints)	Success rate					p-value
	I	I/II	II	II/III	III	
Good-acceptable	11 (78.6%)	18 (69.2%)	110 (80.9%)	20 (87.0%)	53 (84.1%)	0.515
Failure	3 (21.4%)	8 (30.8%)	26 (19.1%)	3 (13.0%)	10 (15.9%)	

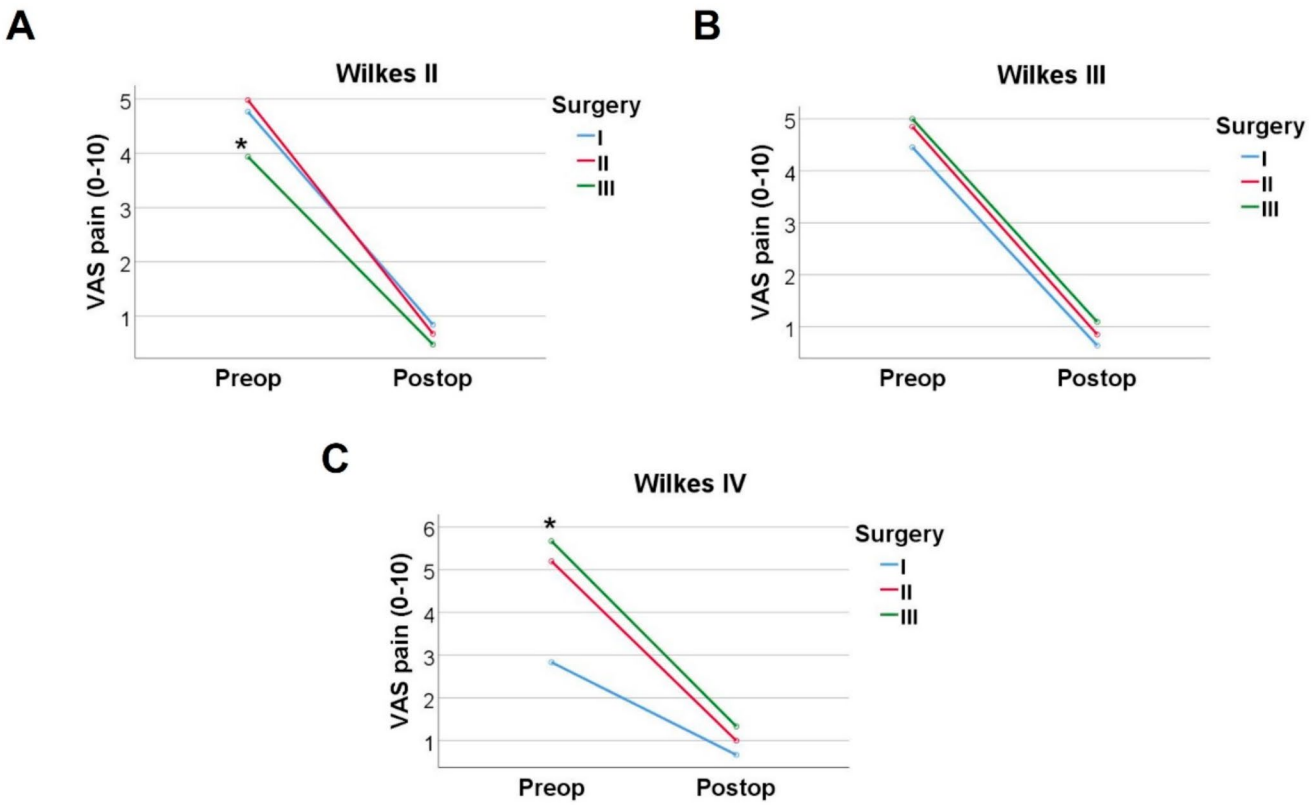

Fig. 4 VAS pain in Wilkes II (**A**), Wilkes III (**B**), and Wilkes IV (**C**) among the different surgery levels. *$p < 0.05$ compared with surgery level I

in patients undergoing arthroscopy. Vervaeke K et al. [25] conducted a retrospective cohort study to establish the correlation between MRI and arthroscopic findings with clinical outcomes. Their study demonstrated that MRI findings can be used to predict the outcomes of TMJ arthroscopy. Disc shape and a crumpled disc's absolute/probable absence might be used as a predictive variable, a positive sign of an early damaged joint. The absence of eminence deformation on MRI also predicted good outcomes. Perioperative findings such as degenerative joint disease or absolute or probable absence of disc reduction can predict lower outcomes [26].

Predictive factors for TMJ arthroscopy are still a topic of discussion in the literature. In a study from the group of Ulmner M et al. [11] bilateral masticatory muscle tenderness on palpation was the only preoperative factor found to have a significant impact on the outcome of TMJ arthroscopy. This evidence was supported by Ângelo DF et al. [27] in their study about inco-botulin neurotoxin A (inco-BoNT/A) used as preoperative medication in patients undergoing TMJ arthroscopy. BONT/A improved the outcomes as an adjunctive treatment in patients who were candidates for TMJ arthroscopy, reducing arthralgia and myalgia in the long term. The inco-BoNT/A group also experienced a reduced incidence of persistent symptoms after post-treatment and the subsequent necessity of further treatments [27].

TMJ arthroscopy procedure has been advanced through various surgical techniques and modifications. The current described surgical steps are portal triangulation, coblation of zones of synovitis and chondromalacia, resection of adhesions, biopsies of fibrocartilage, myotomy, and disc repositioning by capsular scarring, discopexy, subsynovial or intra-articular infiltrations with various substances such as corticosteroids, hyaluronic acid, with and without PRP. Ângelo DF [28] proposed the inverted portal technique for TMJ arthroscopy to enhance retrodiscal coblation. This technique aimed to improve the effectiveness of retrodiscal coblation in treating TMJ disorders, increasing the area to treat, particularly the posterolateral one [28]. In some specific cases, arthroscopic disc repositioning and different suturing techniques are employed. The intra-procedural variety, given the many techniques that can be performed, opens interpersonal preferences among surgeons. In this study although the populations of the two centers examined were extremely similar, differences were recorded in the choice of arthroscopic discopexy type, with a peak of level III arthroscopies in the Brazilian population. Despite this difference, postoperatively, across all Wilkes stages and varying levels of arthroscopy surgery, a comparable reduction

in VAS pain scores is observed. No differences were found in the success rate when comparing the arthroscopy levels. Plus, there were no variations in the success rate when different levels of arthroscopy were compared. Santos TS et al. [23] conducted a systematic review and meta-analysis comparing open surgery versus arthroscopic techniques for disc repositioning and suturing. Their conclusions indicated that both techniques effectively achieved successful outcomes, with no significant difference in their effectiveness. This suggests that TMJ arthroscopy can provide comparable results to traditional open surgery intra-articular procedures, while offering the benefits of minimally invasive surgery [23].

Another advantage of TMJ arthroscopy is its possibility of being performed under either local or general anesthesia [21]. This procedural flexibility allows for personalized patient care and can accommodate individual preferences or medical considerations. Sah MK et al. [29] compared the modalities of TMJ arthroscopy performed under local anesthesia (LA) versus general anesthesia (GA). No significant post-operative difference was found in pain reduction outcome and mouth opening improvement. The LA group's median operative time and hospital stay duration were significantly less than the GA group. TMJ arthroscopy for LA group was performed in a minor procedure setup, reducing the surgery costs. The post-operative disc position was excellent and good, with an overall success rate of 95%. The choice of anesthesia did not significantly affect the outcomes of the procedure, indicating that both options can be equally effective, and local anesthesia arthroscopy furnished even additional benefits related to hospital costs and median operative time [21]. In this study, all procedures were performed under general anesthesia. The approach is based on two main fundaments: patients' comfort and use of muscle relaxantsto mobilize the joint during the procedures. We believe that these points increase the procedure's success rate granting a smooth performance.

A relevant success in outcomes like MMO and VAS pain level should be attributed to TMJ arthroscopy as part of a well-defined preoperative, intraoperative and postoperative protocol. In this multicentric shared protocol we included intraoperative intra-articular injections of therapeutic substances such as hyaluronic acid. Nowadays, the injection of intra-articular substances during arthroscopic procedures is a well-established additional procedure. Gutiérrez IQ et al. [30] conducted a systematic review to evaluate the effectiveness of intra-articular injections of platelet-rich plasma (PRP) and plasma rich in growth factors (PRGF) with arthrocentesis or arthroscopy in treating TMJ disorders. The PRP and PRGF intra-articular injections demonstrated significant differences in pain reduction in three studies and improved mandibular function in two. The treatment with PRP or PRGF intra-articular injections demonstrated better clinical results than the control group. Leketas M et al. [31] conducted a randomized clinical trial to evaluate the effect of different intra-articular injection substances on the early postoperative period following TMJ arthroscopy. The study demonstrated that the choice of injection substance can influence the postoperative outcomes: hyaluronic acid injection following temporomandibular joint arthroscopy can decrease pain better than saline and platelet-rich plasma during the first postoperative week [31].

In this study only reversible complications were observed, which resolved within a maximum of 8 weeks. Considering the reduced invasiveness of the procedure, the complications related to the arthroscopic technique are not numerous. They are mainly represented by extravasation of the fluids used for irrigation with the possibility of pharyngeal edema, intra-articular bleeding during myotomy in the anterior recess, iatrogenic joint damage (disc perforations, fragmentation of the articular eminence, excessive synovial fibrillation), and damage to the external auditory canal or middle ear [8, 32]. From a technical point of view, double portal procedures have a higher incidence of intra-operative complications if compare with single portal ones, especially for articular bleeding and preauricular area edema [33]. In cases where the outcome is unsatisfactory, the further step could be open surgery, but some authors suggest repeating the arthroscopic procedure. Re-arthroscopy should be offered to patients where it is still possible to perform further operative and more advanced techniques, especially when the previous stage is not advanced (Wilkes stage IV or V) [12].

One of the possible limitations of our study is the differences between the two populations; although similar, they are not totally equal. Similarly, concerns interpersonal surgical preferences: although the end result is still disc repositioning, discopexy in level 2 and level 3 have different disability criteria.

Conclusion

In this prospective multicentric study, the implementation of a unified protocol by different surgeons shows that bilateral TMJ arthroscopy is a safe technique with a high degree of efficacy in reducing pain and increasing maximum mouth opening, regardless of the degree of severity and complexity of the technique. The results were stable throughout the follow-up period.

Through advancements in surgical techniques and research, TMJ arthroscopy continues to evolve and improve, providing better outcomes for patients with TMJ disorders. Healthcare professionals dealing with temporomandibular

joint surgery need to stay updated with the latest research and advancements in TMJ arthroscopy to ensure the delivery of optimal care to patients. We encourage more multicenter studies to be conducted, involving more centers and a larger population.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval This study was approved by the ethics committee of the organizing center (Instituto Português da Face - PT/IPFace/RCT/1901/02).

Consent to participate and to publish Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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