Arthrocentesis of the Temporomandibular Joint: Systematic Review and Clinical Implications of Research Findings

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Aims: To review randomized clinical trials on arthrocentesis for managing temporomandibular disorders (TMD) and to discuss the clinical implications. **Methods:** On March 10, 2019, a systematic search of relevant articles published over the last 20 years was performed in PubMed, as well as in Scopus, the authors' personal libraries, and the reference lists of included articles. The focus question was: In patients with TMD (P), does TMJ arthrocentesis (I), compared to any control treatment (C), provide positive outcomes (O)? **Results/Conclusion:** Thirty papers were included comparing TMJ arthrocentesis to other treatment protocols in patients with disc displacement without reduction and/or closed lock (n = 11), TMJ arthralgia and/or unspecific internal derangements (n = 8), or TMJ osteoarthritis (n = 11). In general, the consistency of the findings was poor because of the heterogenous study designs, and so caution is required when interpreting the meta-analyses. In summary, it can be suggested that TMJ arthrocentesis improves jaw function and reduces pain levels, and the execution of multiple sessions (three to five) is superior to a single session (effect size = 1.82). Comparison studies offer inconsistent findings, with the possible exception of the finding that splints are superior in managing TMJ pain (effect size = 1.36) compared to arthrocentesis, although this conclusion is drawn from very heterogenous studies (I^2 = 94%). The additional use of cortisone is not effective for improving outcomes, while hyaluronic acid or platelet-rich plasma positioning may have additional value according to some studies. The type of intervention, the baseline presence of MRI effusion, and the specific Axis I diagnosis do not seem to be important predictors of effectiveness, suggesting that, as in many pain medicine fields, efforts to identify predictors of treatment outcome should focus more on the patient (eg, age, psychosocial impairment) than the disease.
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Temporomandibular disorders (TMDs) are a group of conditions affecting the masticatory muscles, the temporomandibular joints (TMJs), and the related structures.[1] Their etiology is centrally mediated, with a multitude of interacting factors that may be responsible for symptom onset at the individual level.[2]

TMDs are sometimes associated with functional limitations and have an impact on psychosocial functioning and quality of life (QoL), especially if symptoms become chronic.[3] Most TMD patients have intracapsular disorders (ie, disc displacements and/or inflammatory degenerative disorders).[4] Osteoarthritis (OA) usually presents with characteristic signs and symptoms such as pain, stiffness, joint clicks, crepitation, and movement limitation. There are radiographic, histologic, and biochemical findings characteristic of degenerative joint disease.[5]

There is now consensus among experts that TMD treatment is mainly based on strategies for achieving symptomatic management via conservative, reversible, and cost-to-benefit effective approaches.[6] For OA, TMJ arthrocentesis with or without additional medications is a treatment option.[7,8]

Arthrocentesis was introduced to TMD practice more than 20 years ago after an early case series by Nitzan et al described positive effects

on jaw range of motion in patients with closed lock.[9,10] Arthrocentesis classically consists of the placement of two needles in the upper joint compartment using local anesthesia or sedation with the purpose of promoting TMJ lavage. The upper TMJ compartment is filled under pressure with up to 5 mL of fluid to break or lyse any minor adhesions and to achieve a circuit for fluid in- and outflow, allowing for full TMJ lavage. With the single-needle technique proposed by Guarda-Nardini et al, only the syringe is removed, and the patient is asked to make opening and closing movements to allow an outflow of the liquid from the needle, thereby allowing lavage via pumping mechanism.[11] A possible explanation for the effectiveness of joint lavage may be the expansion of the joint space achieved with the introduction of liquid and the lavage of inflammatory mediators and catabolites.[12]

Some medications and drugs can be used in addition to arthrocentesis. For instance, viscosupplementation with hyaluronic acid (HA) has been gaining popularity in recent years to control arthralgia and improve function.[13] The use of this technique in the TMJ developed from the modification of some early works on TMJ arthrocentesis, as well as from knowledge on the application of HA for the management of OA in large joints.[14,15] This approach has been found to be effective in several clinical studies.[16,17] Corticosteroids can also be used as intra-articular drugs to act on inflammatory and immunologic pathways,[18] while platelet-rich plasma (PRP) or human amniotic membrane (HAM) compounds may enhance the regenerative potential of damaged tissues.[19,20]

Thanks to the increasing diffusion of these techniques and the related amount of clinical research papers, arthrocentesis has been the topic of several recent systematic reviews and meta-analyses.[21–25] Nonetheless, most reviews seem more oriented on providing numbers than summarizing the potential clinical applications based on findings from the literature.[26]

Based on these premises, the aim of this paper was to provide a systematic review of the available findings from randomized controlled trials (RCTs) on TMJ arthrocentesis with or without medications, with special focus on the clinical implications for everyday activity and the armamentarium of the TMD practitioner.

Materials and Methods

Data Sources and Searches

On March 10, 2019, a comprehensive electronic search of articles published over the last 20 years was performed to identify all peer-reviewed English-language papers that were relevant to the review's aim within the National Library of Medicine's PubMed database. The search term "temporomandibular joint arthrocentesis" was used to retrieve a first list of citations. The search was limited to clinical studies in humans and was supplemented by expanding to PubMed's related articles, the Scopus database, and the authors' personal libraries. The search was also expanded by browsing the reference lists of the latest review articles.

Inclusion Criteria

Eligibility criteria for inclusion in the review were as follows:

- Study design: RCTs.
- Participants: Adults aged over 18 years and affected by any TMJ condition. Three different groups of studies were identified for data presentation based on the type of diagnosis that was considered an indication for arthrocentesis: disc displacement without reduction with limited opening; viz, closed lock condition; TMJ internal derangements and/or arthralgia; and osteoarthrosis/osteoarthritis.
- Interventions: any technique for TMJ arthrocentesis (ie, single needle, two needles), with or without intra-articular positioning of substances such as anti-inflammatory drugs, PRP, or HA (regardless of the HA molecular weight, the number of sessions, and intervals between the applications).
- Comparisons: any other intervention strategies (eg, arthroscopy, conventional therapy such as analgesics, nonsteroidal anti-inflammatory drugs, low-level laser therapy, oral appliances) or no intervention.
- Patient outcomes: evaluation of maximum mouth opening (MMO); TMJ sounds and crepitus; range of mandibular movements (eg, mouth opening, laterality, and protrusion); assessment of changes in the structure of the mandibular condyle or the TMJ disc position or joint effusion; TMJ pain; functional limitation; and QoL. Outcomes had to be obtained through a validated pain scale, such as a visual analog scale (VAS) or oral health–related QoL (OHRQoL) measures, or carefully defined by the authors of the included studies.

Selection of Studies and Data Extraction

Based on title and abstract assessment, studies were selected for full-text retrieval and potential inclusion independently by the three authors (D.M., A.M., and L.N.), who also performed data extraction by consensus decision. Articles were read according to a structured format, and extracted data were stored based on the main PICO (population, intervention, comparison, outcome) question: In patients with TMJ disorders (P), does TMJ arthrocentesis (I), compared to any control treatment (C), provide positive outcomes (O)?

Data extracted regarded the intervention (ie, technique, number of sessions, additional use of intra-articular drugs, amount of saline for joint lavage, combination with other treatment modalities); the patient population (ie, demographic features, type of diagnosis); the study design (ie, follow-up span, number of observations); the outcome variables (ie, VAS pain levels, mouth opening), and the results (ie, comparison between treatment groups). For each study, an effect size (ES) for the effectiveness of arthrocentesis with respect to the comparison treatment for the management of pain levels was calculated. Meta-analysis of data was planned for studies with a similar design as far as the effectiveness on pain levels was concerned. Statistical and graphical elaboration were made with the software RevMan 5 (Cochrane Library).

Results

Study Selection

The first step of the search strategy (ie, performed with the keyword terms "temporomandibular joint arthrocentesis") identified a total of 803 citations, which were reduced to 85 after limiting the results to clinical trials. Based on title and abstract screening, 24 full-text articles were retrieved. Of these, 21 were included in the review. Additional steps for search expansion led to the further inclusion of 9 articles. Thus, a total of 30 articles were included in this review (Fig 1).

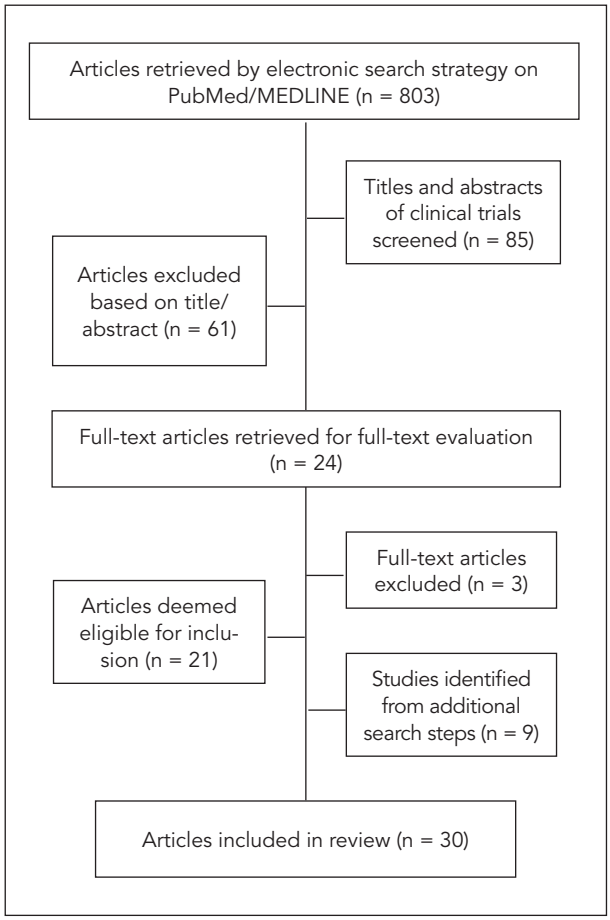

Fig 1 Flowchart of search strategy.

Study Features

Of the included articles, 11 dealt with TMJ arthrocentesis in patients with disc displacement without reduction and/or closed lock,[27–37] 8 included populations of patients with TMJ arthralgia and/or unspecific internal derangements,[38–45] and 11 were trials on TMJ osteoarthritis.[46–56]

Study designs were quite variable. The group of articles on disc displacement without reduction/closed lock accounted for a total of 497 patients (range 20 to 120) with a mean age between 24 and 39 years. The vast majority of patients were women, since all studies but two had sample sizes of at least 80% women. Concerning the interventions, three studies[27,29,35] had multiple comparison groups, with up to four interventions in one study.[27] Arthrocentesis was compared to different regimens, of which arthrocentesis plus oral appliances (three studies),[29,32,34,35] arthrocentesis plus NSAIDs (two studies),[27,33] and arthrocentesis plus viscosupplementation with HA (two studies)[27,37] were adopted in multiple investigations. Two studies compared the effectiveness of two- vs single-needle arthrocentesis.[28,30] The follow-up span ranged from 1 month to 3 years, with 6 to 12 months as the most frequent observation period.

The studies on TMJ arthralgia and/or internal derangement accounted for a total of 333 patients (range: 20 to 80) with a mean age between 26 and 38 years. Women were predominant in the samples, but represented more than 80% of the study sample in less than half of the studies. Multiple comparison groups were recruited in two studies.[39,40] Arthrocentesis plus viscosupplementation with HA (three studies)[38,39,41] or cortisone (three studies)[39,43,45] were the most frequently used comparison interventions. Follow-up observations ranged from 3 to 6 months.

The group of articles on TMJ osteoarthritis accounted for a total of 521 patients (range: 24 to 80), with a mean age between 28 and 56 years. Women represented over 80% of the study population in all studies. Two studies[50,54] had multiple comparison groups, with up to six arthrocentesis protocol regimens.[54] All studies but two included at least one comparison group receiving arthrocentesis plus HA viscosupplementation. This group of studies included the only article that recruited a comparison group of patients who did not receive any active treatment.[56] One study reported data at 4 years via self-report survey,[46] while a follow-up span between 6 and 12 months was the most frequent observation period.

Table 1 Studies on TMJ Arthrocentesis in Patients with Disc Displacement Without Reduction and/or Closed Lock

Study, y	Population, total no. (% female)	Intervention	Comparison	Outcome
Yapici-Yavuz et al,[27] 2018	44 (86.3) No age data Exclusion: previous treatment, myalgia, depression	Two-needle single-session A 15–20 min, 200 mL	A + C, A + HA, A + NSAID	No differences at 6 mo.
Grossman et al,[28] 2017	26 (69.3–100; two groups) Mean age: 39–42 y (two groups) Exclusion: myalgia Inclusion: previous treatment failure, only unilateral pain	Two-needle single-session A 300 mL	Single-needle single-session A 4 mL	No differences at 1 y for pain and MMO.
Tatli et al,[29] 2017	120 (82.5–97.5; three groups) Mean age: 34.8–38.9 y (three groups) Inclusion: previous treatment failure	Two-needle single-session A + HA 120 mL	A + S, S	A and A + S showed similar outcomes at 6 mo. A showed better short-term outcomes than S for pain and function.
Şentürk et al,[30] 2016	40 (60–90; two groups) Mean age: 32-33 y (two groups) Inclusion: unresponsive to previous treatments	Two-needle single-session A + postop S 100 mL	Single-needle (Y-shape soldered needles) single session A + postop S	No differences at 1 mo.
Baker et al,[31] 2015	34 (91.1) Mean age: 38.9 y Exclusion: Axis II impairment	Two-needle single-session A 50 mL	Anesthesia	No differences at 3 y (self-report).
Ghanem,[32] 2011	20 (100) Mean age: 34 y Inclusion: all bruxers, previous nonsurgical treatments	Two-needle single-session A + C (betamethasone) 200 mL	A + S	A + S showed better outcomes than A at 1 y.
Aktas et al,[33] 2010	21 (81) Mean age: 26.4 y Inclusion: evaluation of depression scores	Two-needle single-session A + C (tenoxicam)	A + NSAID	No differences at 6 mo.
Diraçoğlu et al,[34] 2009	120 (87.6) Mean age: 33.4–34.8 y (two groups) Inclusion: pain and/or click for > 3 wk	Two-needle single-session A 60 mL + multispecialist team (unspecified roles)	Conventional (S + hot pack + exercises) + multispecialist team (unspecified roles)	A showed better results than conventional treatment at 1 y for pain.
Alpaslan et al,[35] 2008	45 (91.1) Mean age: 28.9–31.6 y (three groups) Inclusion: first-step regimen	Two-needle single-session A 100 mL	A + hard S, A + soft S	No differences at 6 mo.
Sanromán,[36] 2004	24 (76.9) Mean age: 24.3 y Inclusion: previous treatment failure	Two-needle single-session A + HA 200 mL	Arthroscopy + HA	No differences at 2 y.
Alpaslan and Alpaslan,[37] 2001	31 (83.8) Mean age: 27 y Inclusion: all internal derangements	Two-needle single-session A 200–300 mL	A + HA	A + HA showed better outcomes than A at 2 y.

A = arthrocentesis; C = cortisone; HA = hyaluronic acid; MMO = maximum mouth opening; NSAIDs = nonsteroidal anti-inflammatory drugs; S = splint (oral appliance).

Study Results

The studies on patients with disc displacement without reduction/closed lock retrieved some inconsistent findings (Table 1). The additional use of an oral appliance after TMJ arthrocentesis was found to be more effective than arthrocentesis alone in one study,[32] while two studies did not report any differences in treatment outcome concerning pain and mouth opening.[29,35] One of the latter studies also reported a superiority of arthrocentesis with respect to oral appliance alone in the short term for the management of pain and reduced function,[29] which is in line with

Table 2 Studies on TMJ Arthrocentesis in Patients with Arthralgia and/or Unspecific Internal Derangements

Study, y	Population, total no. (% female)	Intervention	Comparison	Outcome
Ozdamar et al,[38] 2017	24 (71) Mean age: 26.8 y Inclusion: Wilkes stage II/IV, previous treatment failure Excluded: over/open bite	Two sessions of two-needle A	A + HA	A + HA showed better outcomes than A for MPO levels at 3 mo.
Bouloux et al,[39] 2017	102 (90) Mean age: 39.6/51.8 y (two groups) Inclusion: no previous treatment	Two-needle single-session A 200 mL	A + HA, A + C	No differences at 3 mo.
Patel et al,[41] 2016	30 (70) Unspecified age (43.3% between 21 and 30 y) Exclusion: muscle disorders	Two-needle single-session A 300 mL	A + HA	A + HA showed better outcomes than A at 6 mo.
Hancı et al,[42] 2015	20 (75) Mean age: 26.3 y Inclusion: previous treatment failure	Two-needle single-session A + postop S (1 wk) 100 mL	PRP + postop S (1 wk)	PRP showed better outcomes than A at 6 mo.
Hosgor et al,[40] 2015	40 (90) Mean age: 30.5 y Inclusion: all types of disc displacements Exclusion: arthrosis, previous treatments	Two-needle single-session A 100 mL	S, NSAIDs, LLLT	No differences at 6 mo.
Tabrizi et al,[43] 2014	60 (78) Mean age: 28 y Inclusion: previous treatment failure Exclusion: Axis II impairment	Two-needle single-session A 200 mL	A + C	No differences at 6 mo.
Vos et al,[44] 2014	80 (75) Mean age: 38.3 y Inclusion: previous failure treatment (ibuprofen) Exclusion: muscle pain	Two-needle single-session A 300 mL	Conventional (S + soft diet + exercises)	A showed better outcomes than conventional treatment in the short term. No differences at 26 wk.
Huddleston Slater et al,[45] 2012	28 (82.1) Mean age: 33.9 y Inclusion: previous failure treatment (ibuprofen)	Two-needle single-session A + postop ibuprofen for 5 d 300 mL	A + C	No differences at 24 wks.

A = arthrocentesis; C = cortisone; HA = hyaluronic acid; S = splint (oral appliance); LLLT = low-level laser therapy; MPO = metalloproteinases; NSAIDs = nonsteroidal antinflammatory drugs; PRP = platelet-rich plasma.

findings from other studies describing better outcomes with arthrocentesis than conventional treatment.[34] The two studies on viscosupplementation yielded contrasting results of superior[37] or equal[27] effectiveness with respect to arthrocentesis alone, even if at different follow-up periods. The additional use of NSAIDs after arthrocentesis was not found to be more beneficial than arthrocentesis alone in either of the two studies adopting such a comparison intervention.[27,33] Similarly, there was no different outcome between the classic two-needle and single-needle techniques for performing TMJ arthrocentesis.[28,30]

The studies on patients with TMJ arthralgia or internal derangements supported an absence of difference between arthrocentesis and the additional intra-articular positioning of cortisone,[39,45] as well as the potential superiority of PRP with respect to arthrocentesis (Table 2).[42] Studies on viscosupplementation after arthrocentesis suggested that it may be effective for reducing inflammatory mediators (ie, MPO),[38] but findings concerning pain management are contrasting.[39,41] Similarly, while there is a report of superior effectiveness of arthrocentesis compared to conventional treatment including an oral appliance in the short term,[44] another study did not find any differences compared to other treatment regimens (ie, oral appliances, NSAIDs, laser therapy).[40]

Table 3 Studies on TMJ Arthrocentesis in Patients with Osteoarthritis

Study, y	Population, total no. (% female)	Intervention	Comparison	Outcome
Bergstrand et al,[46] 2019	40 (64–95; two groups) Mean age: 51 y Inclusion: previous treatment failure	Two-needle single-session A + paracetamol as needed	A + HMWHA	No differences at 4 y.
Cömert Kilic and Güngörmüş,[47] 2016	31 (76.9–88.9; two groups) Mean age: 28–32 y (two groups) Exclusion: previous treatment	Two-needle single-session A + HA 100 mL	A + PRP	No differences at 1 y.
Comert Kilic,[48] 2016	24 (76.9–84.2; two groups) Mean age: 31–34 y (two groups) Exclusion: previous treatment	Two-needle single-session A 100 mL	A + C	No differences at 1 y.
Comert Kilic et al,[49] 2015	30 (76.9–86.1; two groups) Mean age: 32.3–35 y (two groups) Exclusion: previous treatment	Two-needle single-session A 100 mL	A + PRP	A + PRP showed better outcomes than A at 1 y.
Guarda-Nardini et al,[50] 2015	30 (90) Mean age: 56.4 y Inclusion: pain from 6 mo Exclusion: Axis II impairment	Single-needle A + HA 10 mL	Single-needle A + HMWHA, 5A + HA	5A + HA showed better outcomes than A + HA and A + HMWHA at 6 mo.
Guarda-Nardini et al,[51] 2014	50 (82) Mean age: 48.4 y Inclusion: pain from 6 mo Exclusion: Axis II impairment	Single-needle 5A + HA (no JE) 10 mL	Single-needle 5A + HA (JE)	No differences at 6 mo.
Guarda-Nardini et al,[52] 2012	40 (88) Mean age: 52.9 y Inclusion: pain from 6 mo	Single-needle 5A + HA 10 mL	Single-needle 5A + HA (different MW)	No differences at 6 mo.
Guarda-Nardini et al,[53] 2012	80 (90) Mean age: 56.9 y Inclusion: pain from 6 mo	Two-needle 5A + HA 300 mL	Single-needle 5A + HA	No differences at 6 mo.
Manfredini et al,[54] 2012	60 (85) Mean age: 50.1 y Inclusion: pain duration of 6 mo	Two-needle 5A 300 mL	A + HA, A + C, 5A + TNHA, 5A + SNHA, 5A + HMWHA	5A + HA showed better outcomes at 3 mo.
Guarda-Nardini et al,[55] 2012	76 (86.8) Mean age: unspecified (range: 28–81) Inclusion: pain duration of 6 mo	Two-needle 5A + HA 50 mL	A + HA (different age groups)	A + HA most effective in patients over 65 y at 6 mo.
Guarda-Nardini et al,[56] 2005	60 (91.6) Mean age: 51.4 y	Two-needle A + HA 50 mL	S, no treatment	A + HA and S showed similar outcomes, but both were better compared to no treatment, at 6 mo.

A = arthrocentesis; C = cortisone; HA = hyaluronic acid; HMWHA = high molecular weight hyaluronic acid; JE = joint effusion; MW = molecular weight; PRP = platelet rich plasma; S = splint (oral appliance); SNHA = single needle hyaluronic acid; TNHA - two-needle hyaluronic acid; 5A = five sessions.

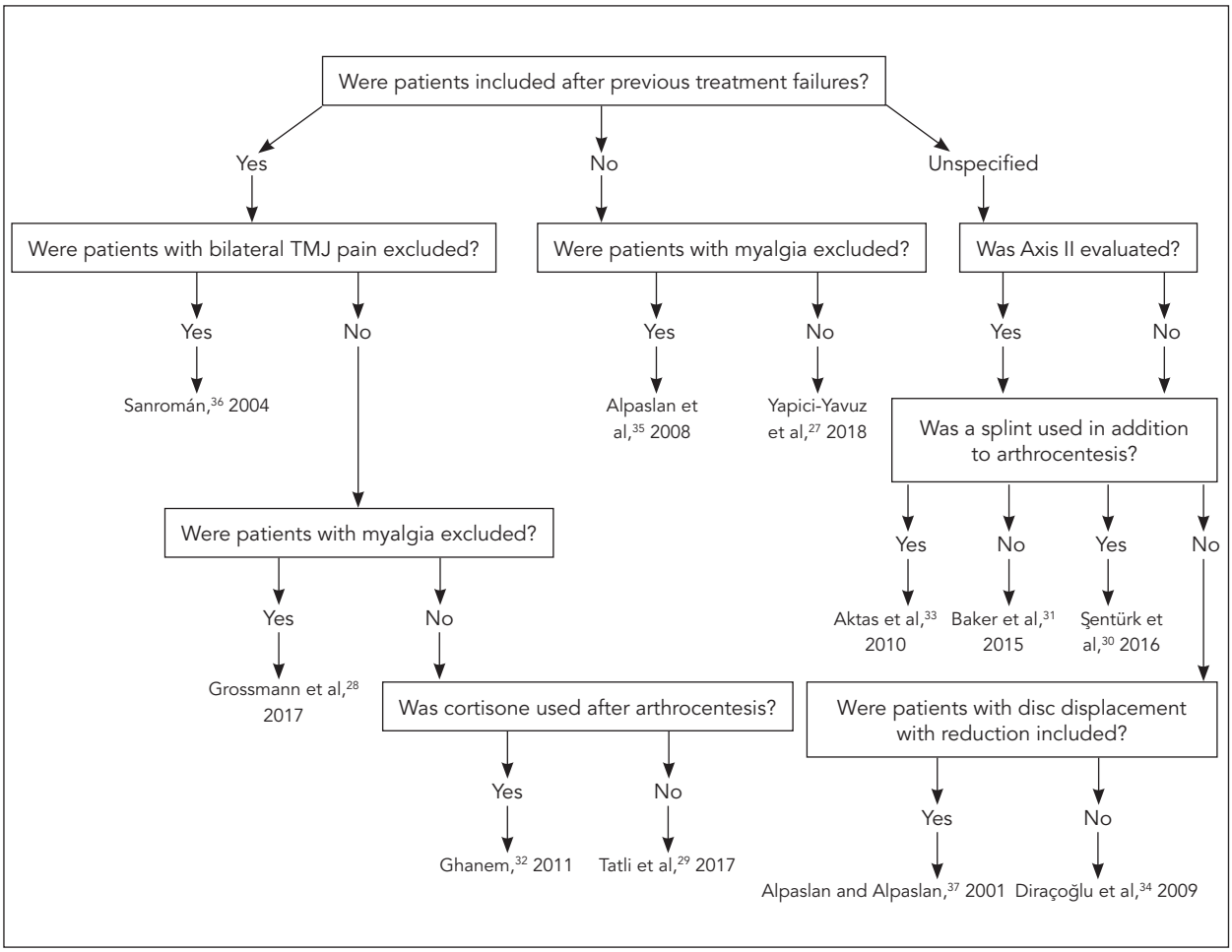

Fig 2 Example flowchart showing the heterogeneity of studies on arthrocentesis for disc displacement without reduction/closed lock.

The studies on patients with TMJ osteoarthritis offered miscellaneous findings, with different protocols for each study (Table 3). Only four included one intervention group receiving arthrocentesis alone. The other seven papers provided arthrocentesis plus viscosupplementation as the reference treatment. Findings suggested that multiple sessions are more beneficial than a single intervention[50,54] and that arthrocentesis plus HA viscosupplementation is more effective in patients aged over 65 years.[55] In addition, there are no differences in treatment outcomes depending on the technique (two- vs single-needle),[53] the HA weight,[52] or the baseline presence of joint effusion.[51] Also, providing HA or PRP after arthrocentesis did not result in any significant differences,[47] while a protocol of arthrocentesis plus HA was equal to oral appliances and superior to no treatment.[56] As for arthrocentesis alone, it was equal to a single session of providing additional viscosupplementation[46] or cortisone,[48] but inferior to additional PRP positioning[49] and to multiple sessions of arthrocentesis plus HA.[54]

The study designs across the various investigations differed such that the meta-analysis for basic effects was approached conservatively, and these results should be interpreted cautiously. Figures 2 and 3 provide example flowcharts showing the different study samples and protocols for articles on TMJ disc displacement without reduction/closed lock and on TMJ pain/internal derangement. Concerning the group of articles on TMJ osteoarthritis, only three research groups were involved, each providing different experimental (ie, arthrocentesis technique–related) protocols.

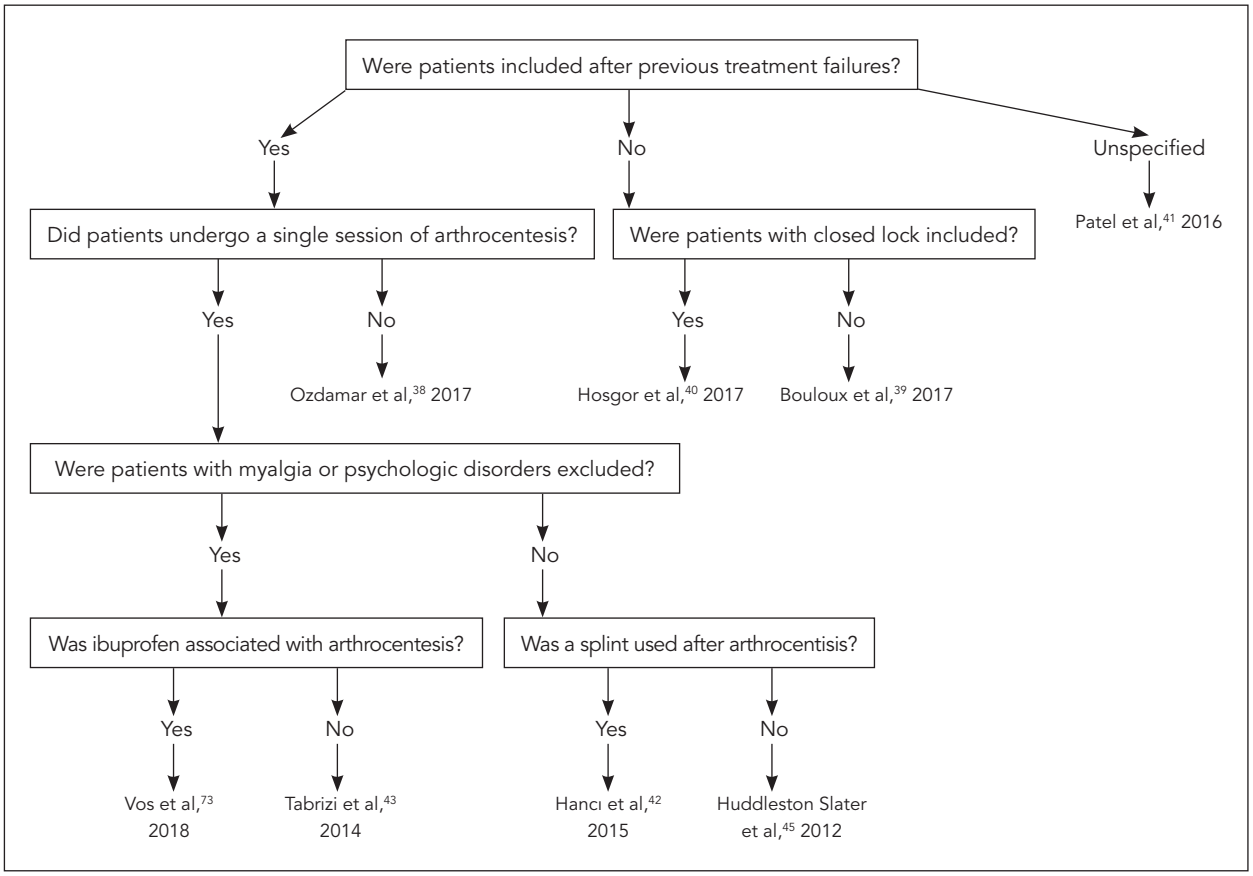

Fig 3 Example flowchart showing the heterogeneity of studies on arthrocentesis for TMJ osteoarthritis.

	Arthrocentesis		Arthrocentesis plus HA			Mean difference
Study, y	Mean (SD)	Total	Mean (SD)	Total	Weight (%)	IV, random, 95% CI
Bergstrand et al,[46] 2019	3.5 (3.2)	17	2.3 (1.45)	20	29.3	1.20 (–0.45, 2.85)
Patel et al,[41] 2016	5.27 (0.67)	15	6.47 (0.92)	11	42.0	–1.20 (–1.84, –0.56)
Yapici-Yavuz et al,[27] 2018	6.45 (2.77)	11	6.54 (0.69)	11	28.8	–0.09 (–1.78, 1.60)
Total (95% CI)		**43**		**42**	**100.0**	**–0.18 (–1.67, 1.31)**

Heterogeneity: $\tau^2 = 1.27$; $\chi^2 = 7.83$, df = 2 ($P = .02$); $I^2 = 74\%$
Test for overall effect: z = 0.23 ($P = .81$)

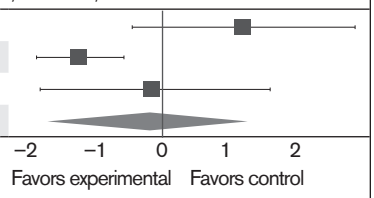

Fig 4 Forest plot showing the individual and cumulative effect sizes (ES) of studies comparing the effectiveness of single-session arthrocentesis (control treatment) vs arthrocentesis plus viscosupplementation (experimental treatment) for managing TMJ pain at 6 months.

Despite these premises, some cumulative findings of studies adopting similar experimental and control protocols—independent of the features of patient populations—were calculated for the effects of TMJ arthrocentesis on TMJ pain levels. Cumulative ES for additional viscosupplementation with respect to TMJ arthrocentesis alone was –0.18 based on three studies (heterogeneity statistics $I^2 = 74\%$; Fig 4).[27,41,46] Two studies with multiple sessions showed superiority over a single session (ES = –1.82; $I^2 = 0\%$; Fig 5).[50,54] Two studies on a single-needle technique showed equivalence with respect to the classical two-needle technique (ES = 0.11; $I^2 = 0\%$; Fig 6).[28,53] Three studies suggested that TMJ arthrocentesis may be superior to splints (ES = 1.36), but there was very high heterogeneity among the studies ($I^2 = 94\%$; Fig 7).[34,40,56] Based on four studies, additional intra-articular cortisone is not superior to arthrocentesis alone (ES = 0.19; $I^2 = 78\%$; Fig 8).[27,39,43,45] Positive values of ES favor arthrocentesis, while negative values favor the comparison treatment.

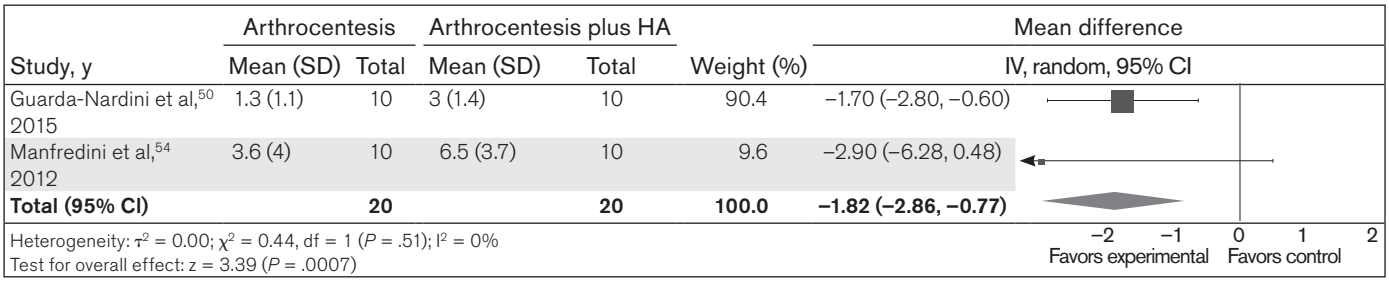

Fig 5 Forest plot showing individual and cumulative effect sizes (ES) of studies comparing the effectiveness of single- (control treatment) vs multiple-session (experimental treatment) arthrocentesis for managing TMJ pain at 3 months.

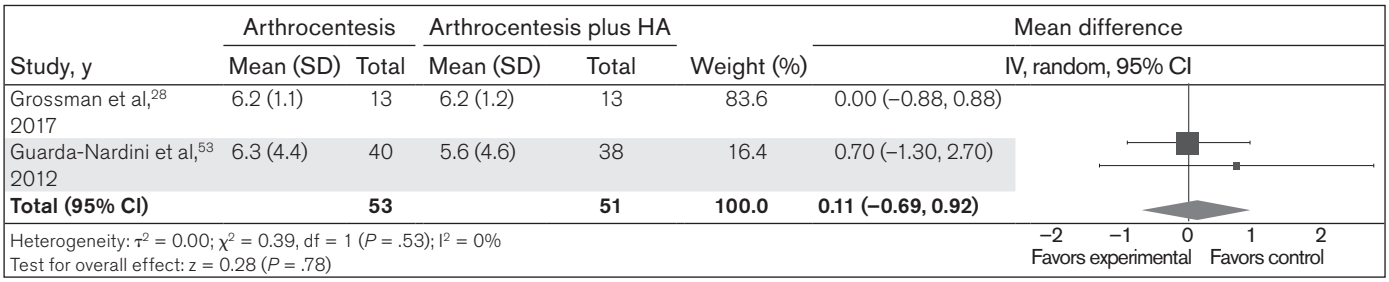

Fig 6 Forest plot showing individual and cumulative effect size (ES) of studies comparing the effectiveness of two-needle (control treatment) vs single-needle (experimental treatment) arthrocentesis for managing TMJ pain at 6 months.

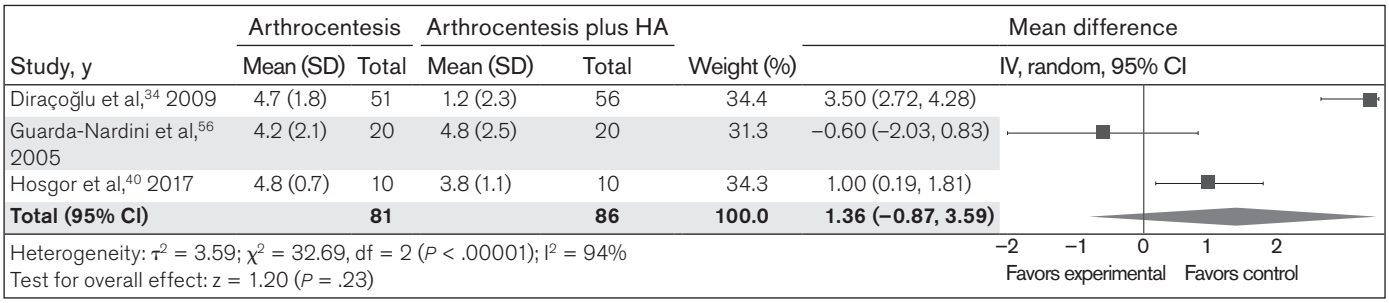

Fig 7 Forest plot showing individual and cumulative effect size (ES) of studies comparing the effectiveness of single-session arthrocentesis (control treatment) vs splints (experimental treatment) for managing TMJ pain at 6 months.

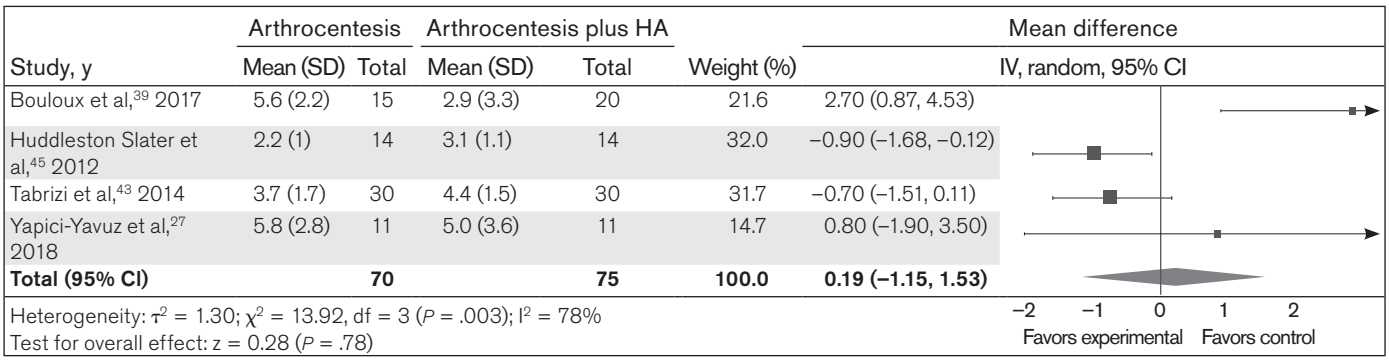

Fig 8 Forest plot showing individual and cumulative effect sizes (ES) of studies comparing the effectiveness of arthrocentesis (control treatment) vs arthrocentesis plus interarticular cortisone (experimental treatment) for managing TMJ pain at 6 months.

Discussion

Within the general framework of providing conservative treatment to patients with TMJ diagnoses, joint lavage and lysis (ie, arthrocentesis) has gained popularity over the past 20 years. The main rationale for performing arthrocentesis is to wash inflammatory components out of the joint cavity through a joint lavage with saline solution. Such lavage may also be combined with viscosupplementation with HA or with positioning of drugs, such as cortisone, or other compounds, such as PRP. There is general con-

sensus among experts that arthrocentesis is a safe procedure that may be of potential benefit for reducing clinical symptoms in patients with intra-articular TMDs.[7,17,21] Based on these premises, this review aimed to provide an overview of clinical research on the efficacy of such a procedure, with a specific focus on the possible transfer of literature findings to everyday practice.

A total of 30 RCTs were included in the review. The study populations had wide heterogeneity in terms of gender (showing a predominance of women, but with different ratios to men), mean age (from 23 to 60.8 years), and inclusion features (eg, presence of concurrent muscle pain, history of previous treatment failures). In addition, the technical details to perform arthrocentesis (eg, number of needles, amount of saline fluid) and the concurrent use of co-treatments (eg, pain killers, splints) are not consistent.

Because of the heterogeneity of signs and symptoms and study protocols, it is important to caution against the overuse of meta-analyses as an attempt to provide operational guidelines.[26,57] This is an important general remark, especially considering that several studies do not explicitly state the specific diagnosis, do not use standardized assessment guidelines, and do not even use the term "TMD" as a diagnosis. This heterogeneity is evident in the arthrocentesis literature, which includes plenty of segmental works, as well as reviews with contrasting results and lack of sufficient information on which to base clinical practice.

Thus, as a first step toward the attempt to provide clinically useful information, some historical notes on the use of TMJ arthrocentesis may be useful. This technique is derived from arthroscopy, which became popular in the previous decade due to the popularization of mini-arthroscopes and the development of dedicated miniature surgical instruments.[58] With the progressive decline of TMJ disc repositioning concepts and parallel increase of knowledge about the positive effects of conservative treatments,[59,60] less invasive approaches for the management of joint-related TMD were developed. Within this framework, arthrocentesis was introduced at the beginning of the 1990s as a strategy to solve acute, sudden-onset closed lock.[10] The proposed mechanism of action to explain the positive outcomes in early case series was that capsular distension and joint washing were instrumental to break the intra-articular adherences responsible for the limited jaw range of motion. Clinical outcomes were remarkable and drew attention to an innovative concept for the times: obtaining similar results to those achieved with an arthroscope by simply using two needles.[61]

While there is no doubt about the milestone roles of those papers, there are a couple of observations that must be considered to explain the conceptual evolution of the potential indications for TMJ arthrocentesis and, subsequently, its clinical outcomes. First, a positive evolution of closed lock conditions has been described as a result of many conservative treatments based on oral appliances, anti-inflammatory drugs, and cognitive-behavioral strategies.[62] The natural course of the condition plays a role in explaining its benign evolution,[63–65] but what is important to remember is that antalgic muscle contracture is emerging as the main factor responsible for limited mouth opening in patients with TMDs. This adds to the discussion the unspecific use of TMJ arthrocentesis as a strategy to increase mouth opening, which is a finding that is partly confirmed by the reviewed literature findings, which seem to support the usefulness of arthrocentesis in the short term and the equivalence when compared to other approaches over time. Second, mechanisms of lubrication impairment have been suggested to explain the increased joint friction and reduced motion to address with viscosupplementation.[13] On the other hand, the orthopedic literature shows that the main indication to implement lubrication via HA positioning is the presence of osteoarthritis.[66,67] This led to the first studies on TMJ osteoarthritis, in which viscosupplementation was preceded by arthrocentesis in an attempt to provide a better environment for the HA compound.[14] Results were generally good in all early case series[16,17] and formed the basis for the modern era of TMJ arthrocentesis.

The above general considerations suggest that arthrocentesis cannot be considered a one-fits-all approach for closed lock and that it should be potentially used for the same indications as in orthopedic medicine (ie, degenerative joint diseases). Thus, the evolution of clinical research on this technique should pursue the need for tailoring indications and identifying outcome predictors. Unfortunately, this is not a message that can be grasped by the literature, which still comprises plenty of investigations that do not try to phenotype the candidates for the technique. The category of studies on patients with TMJ arthralgia and/or internal derangement, as depicted in Fig 3, best exemplifies the difficulties in having homogenous study populations.

On average, TMJ arthrocentesis is effective in reducing pain levels and increasing the jaw range of motion in patients with disc displacement without reduction/closed lock and in patients with osteoarthritis. It is also perceived as effective by the majority of patients. Per se, these findings are not novel and do not justify its routine use. This is why efforts should be directed to identify predictors of outcome. Interestingly, the reviewed findings do not support the superiority of any technique-based strategies, since no significant differences in effectiveness were shown between the single- and two-needle techniques[28,30,53] or between joints with and without effusion.[51] Also, the actual effectiveness of additional viscosupplementation with HA or other drugs and compounds is support-

ed only in part.[37,47,52] At the group level, multiple sessions are more effective than a single procedure.[50,54] Interestingly, TMJ pain reduction after arthrocentesis is also associated with improvement in neck function.[68] On the other hand, some studies suggest that the main outcome predictors do not seem to be related to the disease,[69] but are potentially related to the patient's age and psychosocial profile.[55,70]

Based on that, TMD practitioners might keep in mind that older patients with lower levels of psychosocial impairment (ie, absence of moderate to severe depression and somatization symptoms, low pain-related impairment) are the best responders to the reference cycle of five arthrocentesis sessions with HA viscosupplementation. These observations are important because of their possible common implications with clinical experiences in TMD epidemiology and other treatment modalities, as well as with other joint conditions. Indeed, the fact that patients belonging to the younger age group respond less to TMJ arthrocentesis than older subjects suggests the need to discriminate diagnostic findings at the individual level; namely, younger patients may have signs and symptoms of TMJ arthritis that are not actually "pure," but are potentially part of a combined clinical picture of muscle and articular overload.[1,4] As for findings on the importance of psychosocial factors, they are in line with the clinical literature on the predictive role of Axis II aspects for treatment outcomes in many fields of pain medicine.[71,72] Thus, a cautionary tale for clinicians could be to remember that the higher the Axis II scores, the lower the percentage of VAS improvement.[70]

Within these premises, future research should take all these considerations into account when designing study protocols by focusing on the patient and not the disease. In the end, it is noteworthy that TMJ arthrocentesis has been suggested to have an excellent cost-to-benefit ratio, which may be instrumental for full consideration as part of the TMD practitioner's armamentarium.[73]

Conclusions

In the field of TMJ arthrocentesis, there are many segmental works without a full view of what has been investigated by other authors, which led to the adoption of different protocols and inconsistent results. Because of that, any cumulative ES calculated in this paper should be taken with caution. Thus, in this review, the literature produced over the past 20 years was mainly discussed as a basis to steer future research and to suggest the possible following clinical implications:

- In general terms, TMJ arthrocentesis is useful to improve jaw function and reduce pain levels in patients with disc displacement without reduction/closed lock and in patients with osteoarthritis, but comparison studies offer inconsistent findings as far as the possible superiority over other treatment modalities is concerned.
- Indeed, RCTs on TMJ arthrocentesis do not support any clear pattern of superiority or inferiority with respect to other treatment regimens, with the possible exception of superiority over splints to manage TMJ pain, even if findings are drawn from heterogenous studies (ES = 1.36; I^2 = 94%).
- The additional use of cortisone is not effective to improve outcomes, while HA or PRP positioning may have a specific additional value according to some studies. Literature findings are not consistent and need to be re-appraised carefully in the future after performing comparative trials with similar designs.
- Patient-related predictors, such as older age and low psychosocial impairment, may be important predictors of effectiveness.
- The execution of multiple sessions (three to five) could be further tested for possible superiority over a single session (ES = 1.82).
- The type of intervention, the baseline presence of MRI effusion, and the specific Axis I diagnosis do not seem to be important predictors of effectiveness.
- As in many pain medicine fields, future efforts to identify predictors of treatment outcome should focus more on the patient than the disease.

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