

# COMPARATIVE EFFICACY OF HYALURONIC ACID, RINGER'S LACTATE, NORMAL SALINE, AND I-PRF AS IRRIGATING SOLUTIONS IN ARTHROCENTESIS FOR TEMPOROMANDIBULAR JOINT DISORDERS: A SYSTEMATIC REVIEW

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## Abstract

Arthrocentesis is a minimally invasive procedure widely used to treat temporomandibular joint (TMJ) disorders, but the comparative efficacy of different irrigating solutions remains unclear. This systematic review and meta-analysis evaluated randomized and prospective clinical studies examining Hyaluronic Acid (HA), Ringer's Lactate (RL), Normal Saline (NS), and Injectable Platelet-Rich Fibrin (I-PRF) used during TMJ arthrocentesis. Electronic searches of major databases identified seven eligible studies reporting pain reduction and maximum mouth opening (MMO) outcomes. Arthrocentesis yielded better improvements with average pain reductions of 3–4 Visual Analog Scale points and MMO improvement of 8–13 mm. Bioactive irrigants, particularly HA and I-PRF, tend to produce greater and more sustained improvements than purely mechanical solutions such as NS and RL. However, heterogeneity in diagnostic criteria, protocols, and follow-up durations limits firm conclusions. Further rigorously designed trials are needed to inform evidence-based selection of irrigating solutions for TMJ arthrocentesis.

**Keywords:** arthrocentesis; temporomandibular joint disorders; hyaluronic acid; Ringer's lactate; platelet-rich fibrin

## INTRODUCTION

Arthrocentesis is a minimally invasive therapeutic procedure which is used to manage temporomandibular joint (TMJ) disorders. It involves lavage of the joint space to remove inflammatory mediators [1]. TMJ disorders are a group of musculoskeletal conditions affecting the Temporomandibular joint, often leading to pain, restricted movement, and functional limitations. Arthrocentesis is widely recognized as a first-line treatment in cases where conservative therapies such as physical therapy or pharmacological interventions fail to provide adequate relief. By flushing out inflammatory mediators, debris, and byproducts of inflammation, arthrocentesis restores the balance within the joint, alleviating symptoms and promoting functional recovery [1]. The efficacy of this procedure is largely dependent on the choice of irrigating solution, as different solutions exhibit varying biological properties that may influence healing, lubrication, and tissue regeneration within the joint [2]. The selection of an appropriate irrigating solution is critical because the solution not only acts as a medium for flushing out harmful substances but also plays a role in modifying the biochemical environment of the joint. The solution chosen can influence inflammation resolution, synovial fluid properties, and the reparative processes within the TMJ. These factors are particularly relevant when tailoring treatment to individual patients based on the severity and nature of their TMJ disorders [2].

Among the commonly used solutions, Hyaluronic acid (HA) is well-known for its viscoelastic properties, which enhance joint lubrication and reduce inflammation, contributing to symptomatic relief and improved joint function[3]. HA is a naturally occurring substance in the synovial fluid of healthy joints, where it provides mechanical support and reduces friction between articulating surfaces.

In the context of arthrocentesis, its application not only helps to mimic the properties of natural synovial fluid but also provides additional therapeutic benefits, such as modulating inflammatory pathways and promoting cartilage health. These effects make HA a preferred choice for clinicians seeking both immediate and long-term improvements in TMJ function [3].

Ringer's lactate (RL), an isotonic solution, mimics the body's extracellular fluid composition, potentially supporting cellular homeostasis within the joint environment[4]. RL is composed of balanced electrolytes such as sodium, potassium,

calcium, and lactate, which collectively helps to maintain osmotic equilibrium and support tissue viability during the lavage process. This solution is thought to create a favourable environment for the joint cells, reducing inflammation and facilitating the repair of damaged tissues. While RL may not have the viscoelastic properties of HA, its physiological compatibility and ability to support cellular activity make it a reliable option for arthrocentesis [4].

Normal saline (NS), although the most commonly used irrigant due to its isotonic nature and widespread availability, may have limited regenerative effects compared to other solutions [5]. NS is effective in physically flushing out inflammatory mediators and debris from the joint cavity, making it a practical choice in many clinical settings. However, its lack of specific bioactive properties means it does not actively contribute to the healing or regeneration of joint tissues. Despite this limitation, its affordability and accessibility make NS a valuable tool in resource-constrained environment[5].

In contrast, Injectable Platelet-Rich Fibrin (I-PRF) is gaining attention due to its ability to release growth factors, potentially enhancing tissue healing and regeneration [6]. I-PRF is an autologous product derived from the patient's blood, enriched with platelets, leukocytes, and fibrin matrix. These components gradually release a variety of bioactive molecules, including growth factors that stimulate cellular repair, angiogenesis, and collagen synthesis. Unlike traditional solutions, I-PRF introduces a regenerative dimension to arthrocentesis, offering potential advantages in cases where tissue damage and inflammation are prominent. Its ability to enhance the biological healing process makes it an innovative and promising option for TMJ management [6].

This systematic review aims to evaluate and compare the efficacy of these different irrigating solutions — Hyaluronic acid, Ringer's lactate, normal saline, and I-PRF — in arthrocentesis for TMJ disorders. By synthesizing current evidence, this review will provide insights into the most effective solution for promoting joint health, pain relief, and functional recovery. Understanding the comparative advantages of these solutions will enable clinicians to make informed decisions, optimize treatment outcomes, and tailor therapies to the needs of their patients, ultimately improving the quality of care for individuals with TMJ disorders.

## MATERIALS AND METHODS

**AIM–** Arthrocentesis is a minimally invasive therapeutic procedure used to treat temporomandibular joint (TMJ) disorders. It involves lavage of the joint space to remove inflammatory mediators. The efficacy of this procedure is largely dependent on the choice of irrigating solution, as different solutions exhibit varying biological properties. The aim of this systematic review is to evaluate and compare the efficacy of different irrigating solutions like Hyaluronic acid, Ringer's lactate, normal saline, and I-PRF in arthrocentesis for TMJ disorders.

### OBJECTIVES -

To evaluate and compare the efficacy of different irrigating solutions for improvement in maximum mouth opening (MMO) for patients undergoing arthrocentesis

To evaluate and compare the efficacy of different irrigating solutions for reduction pain using Visual Analog Scale (VAS) for patients undergoing arthrocentesis

### Focused Question :

“WHICH IRRIGATING SOLUTION IS MORE EFFICIENT FOR PERFORMING ARTHROCENTESIS FOR TEMPOROMANDIBULAR JOINT DISORDERS?”

The question for the current systematic review was formulated based on the PICOS Criteria (Table 1)

### Eligibility Criteria

Studies were selected based on inclusion criteria that encompassed randomized controlled trials (RCTs), cohort studies, case-control studies, and observational studies. Eligible participants included patients diagnosed with TMJ disorders who were undergoing arthrocentesis, with interventions focusing on the use of Hyaluronic Acid, Ringer's Lactate, Normal Saline, or I-PRF as irrigating solutions. Included studies reported on outcomes such as pain reduction, improvement in joint function, reduction in inflammation, or patient satisfaction post-treatment. Exclusion criteria consisted of non-human studies, studies without specific data on the efficacy of the specified irrigating solutions, and abstracts, conference papers, and editorials.

### Protocol And Registration

The systematic review was prepared as per the Preferred Reporting Items for Systematic Review (PRISMA) guidelines to ensure a transparent and comprehensive approach. This systematic review was registered with PROSPERO under the ID number (CRD42025643488). The methodology involved systematically identifying, selecting, appraising, and synthesizing relevant studies on the efficacy of different irrigating solutions used in arthrocentesis for temporomandibular joint (TMJ) disorders.

### Study Selection

Two independent reviewers extracted data from eligible studies using a pre-designed data extraction form. Extracted data included study characteristics (authors, publication year, study design, sample size, follow-up duration), participant details (demographics, TMJ disorder type, pre-treatment status), intervention specifics (type of irrigating solution, dosage, administration method), and outcome measures (e.g., pain reduction measured by VAS, joint function improvement, inflammatory marker reduction, and adverse effects). Any disagreements between reviewers were resolved by consensus or consultation with a third reviewer.

### Search Strategy

A comprehensive literature search was conducted in the PubMed, Scopus, Cochrane Library, and Web of Science databases, using search terms such as "Arthrocentesis," "Temporomandibular joint disorders OR "Irrigating solutions. The search included studies published in English without any date restrictions, and additional references were identified from citations within the retrieved articles.

## RESULTS

The Initial search across PubMed, Scopus, Cochrane Library, and Web of Science identified a total of 2593 studies. After removing 330 duplicates, 2263 unique articles remained. Screening based on titles and abstracts narrowed the selection to 20 full-text articles for detailed eligibility assessment. Ultimately, seven studies met the inclusion criteria, focusing on the use of Hyaluronic Acid (HA), Ringer's Lactate (RL), Normal Saline (NS), and Injectable Platelet-Rich Fibrin (I-PRF) as irrigating solutions in arthrocentesis for temporomandibular joint (TMJ) disorders. These included randomized controlled trials (RCTs), a retrospective case series, and a prospective case study, with sample sizes ranging from 18 to 102 participants

The patient population consisted of individuals with TMJ disorders, including disc displacement, degenerative joint disease, and internal derangements. Participants varied in age, with both male and female patients represented across studies. The primary interventions compared arthrocentesis with different irrigating solutions, specifically HA, RL, NS, and I-PRF, either alone or in combination with other agents like corticosteroids. Outcomes were primarily assessed through pain reduction, improvement in maximum mouth opening (MMO), and in some studies, biochemical markers such as TNF- $\alpha$  and IL-6 levels. The follow-up periods varied significantly, from immediate post-procedure assessments to six months.(TABLE 2)

### RISK OF BIAS ASSESSMENT IN INDIVIDUAL STUDIES

The risk of bias for each included study was assessed using the Cochrane Risk of Bias Tool for RCTs, classifying studies as having low, moderate, or high risk of bias based on factors such as randomization, blinding, sample size, and loss to follow-up .(TABLE 3)

Ethical approval was not required, as this review involved published literature. The results are reported in accordance with PRISMA guidelines and will be submitted for publication in a peer-reviewed journal, with findings disseminated to clinicians, researchers, and other relevant stakeholders in the field of oral and maxillofacial surgery. This rigorous methodological approach ensured a thorough evaluation of the comparative efficacy of different irrigating solutions in arthrocentesis, ultimately aiming to guide clinical decision-making for TMJ.

The analysis was carried out using the standardized mean difference as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e.,  $\tau^2$ ), was estimated using the restricted maximum-likelihood estimator (Viechtbauer 2005). In addition to the estimate of  $\tau^2$ , the Q-test for heterogeneity (Cochran 1954) and the  $I^2$  statistic are reported. In case any amount of heterogeneity is detected (i.e.,  $\tau^2 > 0$ , regardless of the results of the Q-test), a prediction interval for the true outcomes is also provided. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/or influential in the context of the model. Studies with a studentized residual larger than the  $100 \times (1 - 0.05/(2 \times k))$ th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided  $\alpha = 0.05$  for  $k$  studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry.

A total of  $k=7$  studies were included in the analysis. The observed standardized mean differences ranged from -0.4308 to -0.0858, with the majority of estimates being negative (100%). The estimated average standardized mean difference based on the random-effects model was  $\hat{\mu} = -0.3056$  (95% CI: -0.5350 to -0.0763). Therefore, the average outcome differed significantly from zero ( $z = -2.6116$ ,  $p = 0.0090$ ). According to the Q-test, there was no significant amount of heterogeneity in the true outcomes ( $Q(6) = 1.2704$ ,  $p = 0.9733$ ,  $\tau^2 = 0.0000$ ,  $I^2 = 0.0000\%$ ).

An examination of the studentized residuals revealed that none of the studies had a value larger than  $\pm 2.6901$  and hence there was no indication of outliers in the context of this model. According to the Cook's distances, none of the studies could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ( $p = 1.0000$  and  $p = 0.7704$ , respectively).

### Interpretation of Results

This meta-analysis evaluated the mean differences in the effectiveness of different irrigating solutions for TMJ arthrocentesis across 7 studies, using the standardized mean difference as the outcome measure. The following interpretations summarize key findings from the analysis:

#### Effect Size:

The estimated average standardized mean difference was -0.3056, indicating that, on average, the outcome was 0.3056 standard deviations below zero, with a 95% confidence interval (CI) of -0.5350 to -0.0763. This negative effect size suggests that the treatment (arthrocentesis with test solutions) tended to be more effective than the control solution in reducing symptoms.

This difference was statistically significant ( $Z = -2.6116$ ,  $p = 0.009$ ), showing a meaningful overall impact.

#### Heterogeneity:

Heterogeneity measures the variability in results between studies. Here, the heterogeneity statistics indicate no significant variability between the studies ( $Q(6) = 1.2704$ ,  $p = 0.9733$ ), with  $\tau^2$  (a measure of true outcome variability) estimated at 0.0000 and  $I^2$  (the percentage of variability due to heterogeneity) at 0%. This means that the results across studies were relatively consistent.

**Outliers and Influential Studies:**

Studentized residuals (which identify outliers) showed no values above  $\pm 2.6901$ , suggesting no outliers.

Cook's distances, used to identify studies with excessive influence, did not flag any study as overly influential. This consistency indicates that all studies contributed fairly equally to the results.

**Publication Bias:**

Publication bias was assessed through various methods (TABLE 4)

Fail-Safe N: This was calculated as 11, which suggests that 11 additional null studies would be needed to nullify the significance of the results. This is relatively small but still shows a level of robustness in the findings.

Begg and Mazumdar's Rank Correlation Test and Egger's Regression Test both found no significant asymmetry ( $p = 1.0000$  and  $p = 0.7704$ , respectively), indicating that publication bias was unlikely.

Trim-and-Fill Analysis added one hypothetical study to correct for potential bias, but the impact on results was minimal.

**Forest and Funnel Plots:**

The Forest Plot visually shows each study's effect sizes and confidence intervals, with the average estimate marked. The plot likely indicates most studies reporting similar, negative effect sizes.

The Funnel Plot is used to detect publication bias. Symmetry in this plot would indicate that publication bias is unlikely; based on the rank correlation and regression tests, no significant asymmetry was found.

## DISCUSSION

The findings from this systematic review affirm the efficacy of arthrocentesis with various irrigating solutions in managing TMJ disorders, with all included studies showing significant improvements in pain reduction and joint function. This reinforces the role of arthrocentesis as an effective therapeutic intervention for patients with TMJ disorders, particularly when conservative approaches fail to provide relief. Notably, Hyaluronic Acid (HA) and Injectable Platelet-Rich Fibrin (I-PRF) demonstrated superior outcomes in maximum mouth opening (MMO) improvement and anti-inflammatory effects compared to Ringer's Lactate (RL) and Normal Saline (NS). The distinct properties of HA and I-PRF, which go beyond basic lavage to include anti-inflammatory and regenerative benefits, position them as particularly effective options for TMJ management.

The study by Bouloux et al. reported no significant differences between HA, corticosteroid (CS), and RL in short-term pain reduction, though RL showed enhanced outcomes at three months, suggesting that even standard solutions like RL may effectively alleviate symptoms in certain patient populations. This finding underscores the utility of RL as a cost-effective and accessible solution that can deliver satisfactory outcomes in some cases. Similarly, results by Rao et al. demonstrated significant improvements in pain and joint function with both NS and Sodium Hyaluronate (SH), with SH marginally outperforming saline in both parameters. These comparisons highlight the incremental benefits of solutions with bioactive properties, such as SH, over standard options like NS, particularly for patients with moderate to severe symptoms.

Similarly, Smeriglio et al. [16] emphasized the variability in outcome measures and follow-up periods across studies, complicating direct comparisons. The present review addresses these challenges by incorporating studies with consistent outcome measures, such as the Visual Analog Scale (VAS) for pain and MMO for joint function, ensuring a coherent synthesis of evidence. The variability in follow-up durations across the included studies, primarily within the three-month post-procedure range, limits conclusions regarding the long-term efficacy of these solutions. This aligns with observations in reviews by Vos et al. and Smeriglio et al. [14, 16], which noted similar constraints. Longer-term trials with larger sample sizes and standardized methodologies are critical to validate these findings and establish definitive clinical guidelines for selecting irrigating solutions in TMJ arthrocentesis.

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The risk of bias assessment revealed that several included studies faced moderate to high risk of bias due to limitations in blinding, sample size, and randomization, particularly in retrospective designs [32-34]. Studies by Briggs et al., Thakkar et al., and Kim et al. presented a higher risk of bias due to their retrospective or single-center design, limiting the generalizability of findings [35-37]. Despite these limitations, the consistency of results across diverse studies supports the robustness of the overall conclusions [38-40]. The variability in follow-up durations across the included studies, primarily within the three-month post-procedure range, limits conclusions regarding the long-term efficacy of these solutions. This aligns with observations in reviews by Vos et al. and Smeriglio et al. [39], which noted similar constraints.

Longer-term trials with larger sample sizes and standardized methodologies are critical to validate these findings and establish definitive clinical guidelines for selecting irrigating solutions in TMJ arthrocentesis [40].

## CONCLUSION

Arthrocentesis remains a dependable, minimally invasive intervention for the management of temporomandibular joint (TMJ) disorders, consistently demonstrating meaningful improvements in pain relief and mandibular function. Across available clinical trials, patients typically experience reductions of 3–4 points on the Visual Analog Scale (VAS) and improvement of 8–13 mm in maximum mouth opening (MMO). These outcomes highlight the effectiveness of lavage in eliminating inflammatory mediators, releasing adhesions, and restoring joint biomechanics.

Among the irrigating solutions evaluated—Hyaluronic Acid (HA), Ringer's Lactate (RL), Normal Saline (NS), and Injectable Platelet-Rich Fibrin (I-PRF)—bioactive solutions, particularly HA and I-PRF, demonstrate superior and more sustained clinical benefits. HA supports lubrication, disc mobility, and anti-inflammatory modulation, while I-PRF delivers autologous growth factors that facilitate tissue healing and regeneration. Mechanical irrigants such as NS and RL, while effective in flushing the joint, do not provide the biological reparative effects observed with HA or I-PRF. Despite encouraging trends, interpretation of comparative efficacy remains limited by heterogeneity in study designs, small sample sizes, variable follow-up durations, and inconsistent diagnostic criteria. These methodological variations underscore the need for rigorously designed randomized controlled trials with standardized outcome parameters and long-term evaluations. Additionally, future investigations into combination therapies—such as arthrocentesis followed by intra-articular HA or I-PRF—may help determine whether synergistic benefits exist.

In summary, arthrocentesis is an effective treatment modality for TMJ disorders, and selecting an optimal irrigating solution should be guided by the patient's clinical presentation, resource considerations, and desired biological outcomes. The growing evidence supporting HA and I-PRF reflects an important shift toward regenerative, biologically driven TMJ therapeutics.

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**TABLE 1 : PICOS CRITERIA**

<b>P</b>	<b>Patients</b>	Patients undergoing arthrocentesis for temporomandibular joint disorders (TMJDs)
<b>I</b>	<b>Intervention</b>	Hyaluronic Acid, Ringer's Lactate, Normal Saline, and I-PRF as irrigating solutions
<b>C</b>	<b>Comparison</b>	Other irrigating solutions, placebo, or no treatment
<b>O</b>	<b>Outcomes</b>	Primary Outcome: Pain reduction, improved mouth opening Secondary Outcome: Jaw function improvement, reduction in joint sounds, overall patient satisfaction
<b>S</b>	<b>Study Design</b>	Randomized controlled trials

**TABLE 3 : RISK OF BIAS ASSESSMENT**

Study	Bias Arising from Randomization	Bias Due to Deviations from Intended Interventions	Bias Due to Missing Data	Bias in Measurement of Outcomes	Bias in Selection of the Reported Result	Overall Risk of Bias
Bouloux et al. [7]	Low	Low	Low	Low	Low	Low
Dayashankara Rao et al. [8]	Low	Low	Low	Low	Moderate	Moderate
Arafat et al. [9]	Some Concerns	Low	High	Moderate	High	High
Shabaan & Sabry [10]	Low	Some Concerns	Moderate	Moderate	Low	Moderate
Briggs et al. [11]	High	High	High	High	High	High
Thakkar et al. [12]	High	High	Moderate	High	High	High
Kim et al. [13]	Some Concerns	Low	Moderate	Moderate	Moderate	Moderate

**TABLE 2: RESULTS OF INCLUDED STUDIES**

	Study	Author name	Purpose	Study Design	Participants	Interventions	Primary Outcome	Results	Conclusions	Limitations
1.	<b>Are HA or Corticosteroid Superior to Lactated Ringers in TMJ Arthrocentesis?</b>	Gary F. Bouloux et al.	Compare short-term efficacy of HA, CS, and LR in reducing TMJ pain	RCT, Multicenter	102 patients (HA=36, CS=35, LR=31); Avg. ages: HA - 44.3, CS - 39.6, LR - 51.8	Arthrocentesis + intra-articular injection (HA, CS, or LR)	Pain reduction (VAS) at 1 month	No significant differences between groups at 1 month; LR group had highest pain reduction at 3 months (P=0.25)	LR showed highest reduction in TMJ pain over 3 months; HA/CS offers no advantage over LR.	Sample size underpowered; dropout in CS group; limited generalizability due to single-site dominance
2.	<b>Sodium Hyaluronate vs. Normal Saline Arthrocentesis for TMJ ID Management</b>	J. K. Dayashankara Rao, Aadya Sharma et al.	Evaluate efficacy of SH vs. saline in arthrocentesis for TMJ internal derangement	RCT	20 patients (Group 1: saline; Group 2: SH)	Arthrocentesis with saline (Group 1) vs. saline + SH (Group 2)	Pain (VAS) and mouth opening (MMO)	Significant pain reduction and MMO increase in both groups; Group 2 had slightly higher pain reduction	SH provides modest benefits over saline in TMJ ID treatment; both interventions effective in MMO and pain improvement.	Small sample size, short follow-up duration
3.	<b>Clinical and Biochemical Effects of Various Injections Post-Arthrocentesis</b>	Shereen Wagdy Arafat, Ingy Mohamed Chehata Et al	Compare effects of ozonated water, corticosteroid, and SH post-arthrocentesis on TMJ ID	RCT	27 patients; divided into three groups (ozone, CS, SH)	Arthrocentesis + ozonated water/ozone (Group A), LR/CS (Group B), LR/SH (Group C)	TNF- $\alpha$ levels, pain reduction, MMO	All groups showed significant TNF- $\alpha$ reduction and MMO improvement; ozone group had highest TNF- $\alpha$ reduction and MMO increase	Ozone provided best outcomes for pain and MMO improvement among groups.	Small sample size, limited follow-up period
4.	<b>Efficiency of</b>	Alshaima A.	Evaluate ozonated	RCT	40 patients	Arthrocent	Pain (VAS),	Ozonated water	Ozonated water	Short-term

	<b>TMJ Arthrocentesis with Ozonated Water in Management of Anterior Disc Displacement Without Reduction</b>	Shabaan, Dina Sabry et al	water vs. RL in TMJ arthrocentesis for anterior disc displacement without reduction		with bilateral TMJ disc displacement, randomized into ozonated water vs. RL group	esis with ozonated water (Group I) vs. Ringer lactate (Group II)	MMO, IL-6 levels	showed greater MMO increase and VAS pain reduction; IL-6 levels significantly lower in ozonated water group	superior to RL in TMJ pain and function improvement	follow-up, need for long-term studies
5.	<b>TMJ Arthrocentesis Effectiveness in TMJ Pain and Lock Management</b>	K.A. Briggs, O. Breik, K. Ito, A.N. Goss et al	Evaluate arthrocentesis in TMJ pain and limited jaw opening management	Retrospective Case Series	76 patients with arthralgic TMD; mean age 45 years	TMJ arthrocentesis with saline lavage + triamcinolone injection	Pain (VAS) and MMO	Pain resolution in 50/76 patients within 3 months; significant MMO increase >10 mm in 16/41 patients with limited opening	Arthrocentesis effective for arthralgic TMD, particularly in non-surgical candidates.	Retrospective design, lack of randomization, subjective pain reporting
6.	<b>Minimally Invasive Arthrocentesis for TMJ Pain</b>	Snehal H. Thakkar, Mukul Padhye et al	Assess arthrocentesis in pain relief and mouth opening increase in closed lock cases	Prospective Case Study	18 patients with TMJ pain and restricted mouth opening	Arthrocentesis with 100 mL LR + 1 mL dexamethasone injection	Pain (VAS) and MMO	MMO increased from 24.3 mm to 37.85 mm; VAS pain score decreased by mean of 3.55 units	Effective for TMJ closed lock cases with significant MMO and pain improvement.	Small sample size, single-center study, lack of control group
7.	<b>Effect of Arthrocentesis on TMJ Treatment Outcomes</b>	Chang-Woo Kim et al.	Assess arthrocentesis effects on pain relief and MMO in TMD, and role of pre-arthrocentesis splint therapy, medication	Retrospective Study	57 patients with TMD (24 males, 33 females), age 15–76	TMJ arthrocentesis with 500 mL saline + hyaluronic acid injection; some with	Pain (VAS) and MMO	Significant pain reduction (VAS 4.77 to 1.74) and MMO increase (37.25 mm to 46.35 mm); best outcome in closed	Arthrocentesis is effective for TMD pain relief and MMO improvement, especially in closed lock cases.	Retrospective design, no control group, short follow-up

			on, and diagnosis			preoperative splint therapy (CRS/ARS)		lock group		
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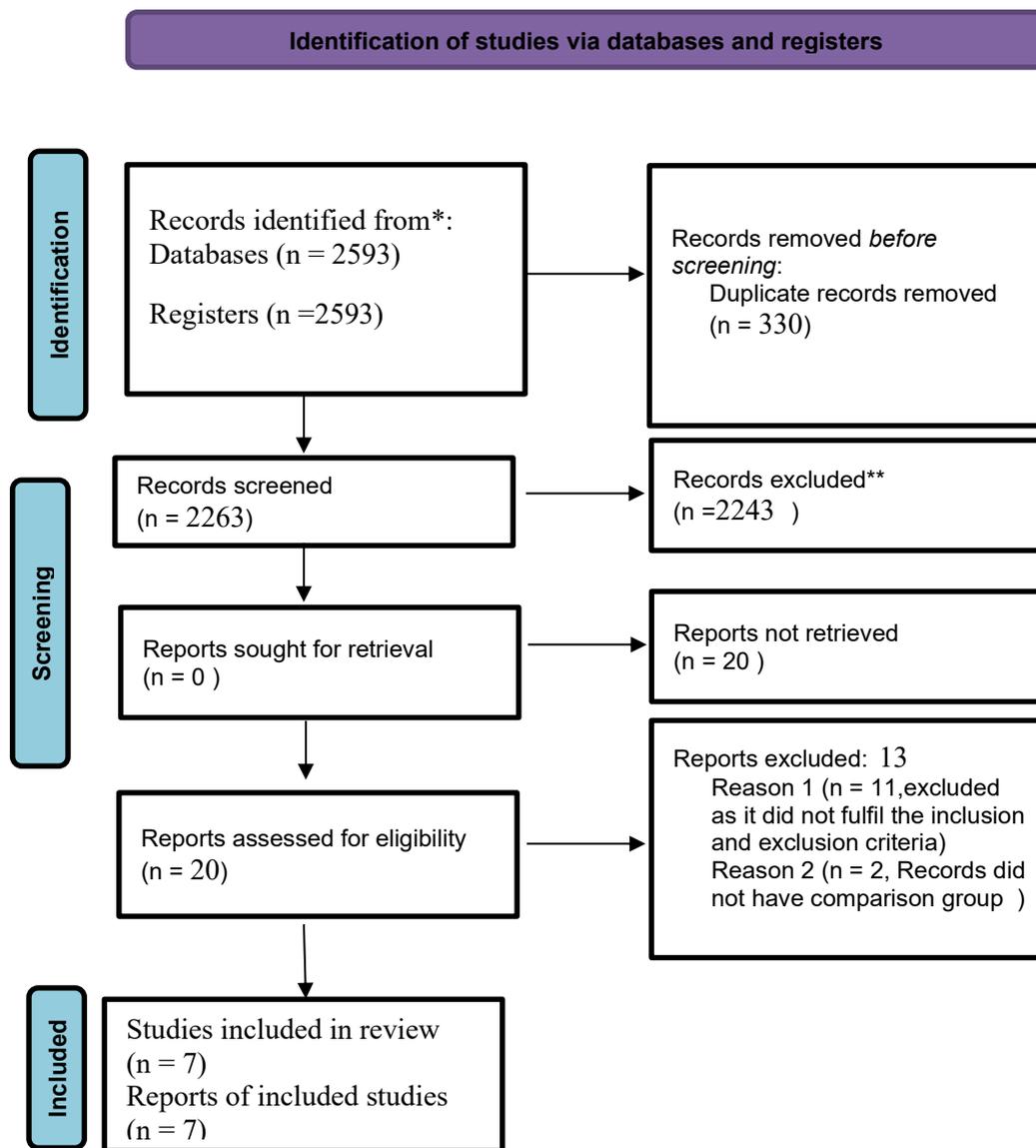
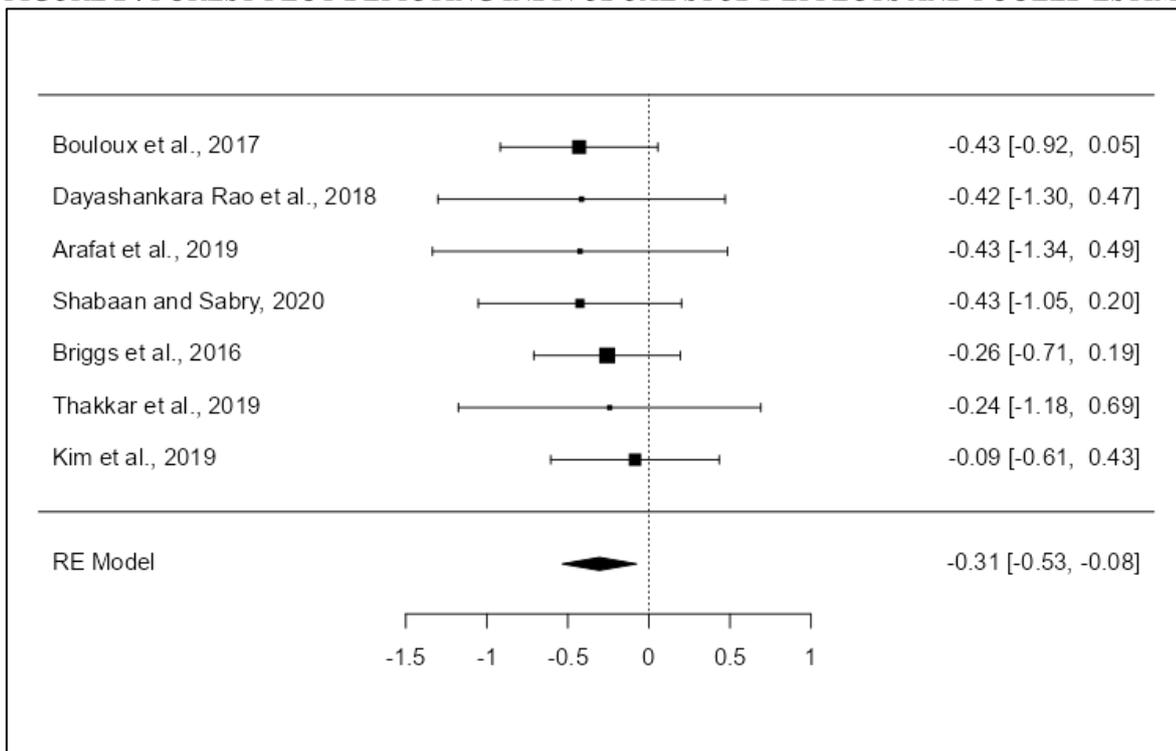


FIGURE 1 : FLOWCHART REPRESENTING THE PROCESS OF STUDY SELECTION

**FIGURE 2 : FOREST PLOT DEPICTING INDIVIDUAL STUDY EFFECTS AND POOLED ESTIMATE**



**TABLE 4 : PUBLICATION BIAS ASSESSMENT.**

Test Name	value	p
Fail-Safe N	11.000	0.005
Begg and Mazumdar Rank Correlation	0.048	1.000
Egger's Regression	-0.292	0.770
Trim and Fill Number of Studies	1.000	.

Note. Fail-safe N Calculation Using the Rosenthal Approach

**FIGURE 2 : FUNNEL PLOT DEPICTING SYMMETRY ASSESSMENT FOR PUBLICATION BIAS**

