RESEARCH PAPER

TMJ Arthrocentesis with or without Low Level Therapy for Treatment of TMD - Systematic Review and Meta-Analysis

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ABSTRACT

Aim: To assess and evaluate the better effectiveness between arthrocentesis with and without low level laser therapy (LLLT) on managing various temporomandibular disorders (TMDs).

Methods: The review was conducted in accordance with PRISMA 2020 guidelines and registered in PROSPERO (CRD42024570457). A comprehensive electronic search was performed across PubMed, EBSCOhost, Google Scholar, and grey literature for studies published between January 2000 and April 2024. Eligible studies included randomized controlled trials, prospective, and retrospective studies comparing arthrocentesis with and without LLLT. The primary outcomes assessed were pain (VAS scores) and MMO. Risk of bias was assessed using the RoB 2.0 and ROBINS-I tools. Meta-analysis was conducted using RevMan 5.3, with standardized mean difference (SMD) as the effect size and a random-effects model.

Results: Nine studies were included in the systematic review and five in the meta-analysis, with a total of 366 participants. The meta-analysis showed a statistically significant reduction in pain favoring the LLLT group (SMD = 0.64, 95% CI: 0.35–0.93, $p < 0.0001$) and a significant improvement in MMO (SMD = 1.04, 95% CI: 0.25–1.83, $p = 0.010$). Heterogeneity was low for pain ($I^2 = 0\%$) but high for MMO ($I^2 = 84\%$). Most studies were of low to moderate risk of bias. Adverse effects were rarely reported but may include minor complications such as erythema or hematoma.

Conclusion: Combining LLLT with arthrocentesis appears to be more effective than arthrocentesis alone in reducing pain and improving mandibular function in TMD patients. While the findings are promising, the presence of methodological heterogeneity and limited reporting of adverse events necessitate further high-quality randomized trials with standardized protocols to validate these results.

Keywords: TMJ, arthrocentesis, laser therapy, systematic review, temporomandibular disorder

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Introduction: Clinical complaints involving the masticatory muscles, temporomandibular joint (TMJ), and related anatomical structures, collectively referred to as TMJ disorders (TMDs), are the primary cause of non-odontogenic pain in the orofacial region.[1] According to the literature, 33% of the adult population has at least one symptom indicative of a TMD, including limited mouth opening, joint sounds, headaches, and earache.[2]

Many nonsurgical therapies have been suggested to be the most effective way of managing over 80% of patients. Physical therapy, pharmacologic therapy, through psychological counselling, cognitive behavioural therapy, occlusal splints and acupuncture

are considered different treatment modalities in treating TMDs.[3] The main objective of all these treatment modalities is to reduce the symptom intensity, thereby improving the function of masticatory system and adjacent structures.[4]

Arthrocentesis of the temporomandibular joint has been described as the simplest form of surgery in the TMJ. Arthrocentesis has been reported to reduce joint pain, improve function, and reduce clicking.[5] It releases the articular disc from adhesions between its surface and the glenoid fossa by means of hydraulic pressure from irrigation of the upper chamber of the TMJ.[6]

Laser is the acronym for light amplification by stimulated emission of radiation.[7] Low-level laser therapy (LLLT) has been suggested to have bio-stimulating and analgesic effects through direct irradiation without causing thermal response. The primary mechanisms of therapeutic laser were mainly referred to the interaction between photons and cell molecules.[8]

LLLT increases blood flow and induces angiogenesis as it increases lymph drainage and consequently inflammation decreases.[9] Biological actions of LLLT, easy application, limited treatment time and minimum contraindications render it a good option for the treatment of musculoskeletal disorders.[10]

Arthrocentesis, in which synovial fluid and other elements are drained from the upper joint space using two cannulas, is a minimally invasive and effective method of treatment that washes out the chemical mediators of pain and inflammation in the synovial fluid, and also ensures sufficient viscosity of the synovial fluid while LLLT has been shown to reduce the symptoms of TMDs and improve joint function.[11-15]

Looking at the evidences, it is clear that no study till date, has provided a comprehensive, quantitative analysis on assessing and evaluating the effectiveness of arthrocentesis with and without laser therapy on managing various temporomandibular disorders (TMDs). Hence, we improvised our research by including relevant literature and carried out a systematic review aiming to evaluate better effectiveness between arthrocentesis with and without laser therapy on management of TMDs.

Methodology

Protocol development: This review was conducted and performed in according to the PRISMA 2020 statement[16] and registered in Prospective Registration of Systematic Review (PROSPERO)- CRD42024570457.

Study design: The research question "Is there any difference in the effectiveness of arthrocentesis in combination with and without laser therapy on management of temporomandibular joint disorders in terms of reduction in pain and improvement in mouth opening? was put out in the Participants (P), Intervention (I), Comparison and Outcome (O) framework.

Eligibility Criteria

a) Inclusion Criteria:

1) Articles published in English language
2) Studies published between January 2000 – April 2024 and having relevant data on the effectiveness of arthrocentesis with and without laser therapy on management of temporomandibular joint disorders and reporting outcomes in terms of reduction in pain and improvement in mouth opening
3) Studies reporting the data in terms of mean, standard deviation and frequency
4) comparative studies, prospective studies, retrospective studies, randomised controlled trials were included
5) Articles from open access journals

b) Exclusion Criteria:

1) Any studies conducted before 2000
2) Articles in other than English language
3) Reviews, abstracts, letter to the editor, editorials, animal studies and were excluded
4) Articles not from open access journals
5) Articles not reporting the study outcomes in terms of mean and standard deviation

Search Strategy: An electronic search was performed till April 2024 for the studies published within the last 24 years (from 2000 to 2024) using the following databases: PubMed, google scholar and EBSCOhost to retrieve articles in the English language. Key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND/OR as shown below.

Search Strategy according to PICO Format:

PICO Element	Description	Keywords / MeSH Terms Used
P – Population	Individuals diagnosed with **Temporomandibular Disorders (TMDs)**, including internal	"Temporomandibular Joint Disorders"[MeSH], "Temporomandibular Joint"[MeSH], temporomandibular disorders, TMD,

	derangement, disc displacement, and TMJ osteoarthritis	TMJ, osteoarthritis, internal derangement, disc displacement
I – Intervention	**Arthrocentesis with Low-Level Laser Therapy (LLLT)**	"Arthrocentesis"[MeSH], arthrocentesis with laser, arthrocentesis with LLLT, low level laser therapy, "Laser Therapy, Low-Level"[MeSH], LLLT, diode laser
C – Comparison	**Arthrocentesis without LLLT** or standard arthrocentesis	Arthrocentesis, without laser therapy
O – Outcomes	Improvement in symptoms such as **pain reduction**, **maximum mouth opening (MMO)**, **joint sounds**, **inflammation**, and **quality of life**	"Pain"[MeSH], "Visual Analog Scale"[MeSH], pain reduction, VAS, maximum mouth opening, MMO, joint sound, clicking, crepitus, lateral movement, protrusive movement, inflammation, "Interincisal Opening"[MeSH], quality of life
Study Designs	Studies evaluating the effectiveness of interventions, including **Randomized Controlled Trials (RCTs)**, **Clinical Trials**, **Prospective**, and **Retrospective Studies**	"Randomized Controlled Trial"[Publication Type], "Prospective Studies"[MeSH], "Retrospective Studies"[MeSH], clinical trial, prospective study, retrospective study

Screening process: Search and screening were done by two authors. The process of choosing of articles was divided into two phases. Two reviewers looked over the titles and abstracts of every article in first round. Articles that didn't fit into the inclusion were removed. Phase-two, involved independent screening and review of few full papers by the same reviewers. Discussions were held to settle by any disputes. A third reviewer was bought in to make the ultimate decision when two reviewers could not agree upon something. All three authors came to agreement on choice in the end. When more information was needed, the studies corresponding authors were contacted by email.

Data extraction: For all included studies, the following headings were included in the final analysis: author(s), country of study, year of study, sample size, study design, intervention and comparator, parameters assessed, follow up duration and conclusion

Evaluation of methodological quality: The methodological quality of included studies was executed through Newcastle Ottawa Scale.[17] It uses a nine-star rating system with a maximum of four points available for selection, two for comparability and three for the assessment of the outcome or exposure. A study with a score from 7 to 9 will be considered as high quality, 4 to 6 will be considered as moderate quality and 0 to 3 will be considered as low quality or very high risk of bias.

Statistical analysis: Statistical analysis was conducted using RevMan 5.3 with standardized mean difference (SMD) serving as the summary measure. Significance was determined at the threshold of $p<0.05$.[18]

Assessment of heterogeneity: The Cochranes test for heterogeneity was employed to assess the significance of any differences in treatment effect estimations among trials. Hete16rogeneity was deemed statistically significant if the P-value was <0.01.[19]

Investigation of publication bias: The study assessed publication bias using Begg's funnel plot, which plots the effect size against standard error. Asymmetry in the funnel plot may indicate potential publication bias.[20]

Results

Study Selection

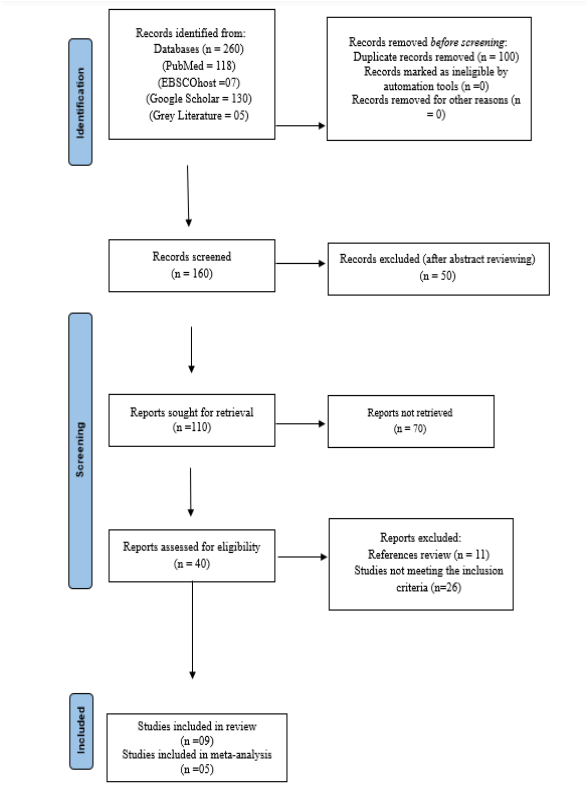


Figure 1. PRISMA 2020 Flow Diagram

The PRISMA 2020 flow diagram illustrates the systematic process of study selection for a review and meta-analysis. Initially, a total of 260 records were identified through database searches, including PubMed (n = 118), EBSCOhost (n = 7), Google Scholar (n = 130), and grey literature (n = 5). After the removal of 100 duplicate records, 160 unique records were screened based on titles and abstracts. Of these, 50 records were excluded due to irrelevance or not meeting preliminary criteria, leaving 110 reports for full-text retrieval. However, 70 reports could not be retrieved, likely due to access limitations or unavailability.

Out of the 40 full-text articles assessed for eligibility, 11 were excluded for being reference reviews and 26 did not meet the predefined inclusion criteria, resulting in a final inclusion of 9 studies for the systematic review. Among these, 5 studies provided adequate data and methodological quality to be included in the meta-analysis. This stepwise and transparent selection process, as depicted in the flow diagram, ensures the rigor and reproducibility of the review, maintaining compliance with PRISMA 2020 guidelines.

Study Characteristics: The General Study Characteristics Table summarizes key methodological and demographic details of the nine included studies assessing the efficacy of low-level laser therapy (LLLT) with or without arthrocentesis in managing temporomandibular disorders (TMDs). These studies span diverse geographic regions, including Egypt, Turkey, South Korea, Brazil, Austria, India, and China, reflecting a broad international interest in TMD management. The study designs range from randomized clinical trials and prospective trials to retrospective observational and cross-sectional studies, enhancing the diversity of evidence (Table 1).

Tables 1: General Study Characteristics Table

Study ID / Author (Year)	Country	Study Design	Sample Size	Intervention Group (n)	Control Group (n)	Diagnostic Criteria	TMD Subtype	Duration of Follow-Up
Adullah Atef Hammuda (2018)	Egypt	Randomized Clinical Trial	36	19	17	RDC/TMD	Internal Derangement	6 months
H. Hosgur (2017)	Turkey	Comparative Clinical Study	40	10	10	RDC/TMD	Anterior Disc Displacement	6 months
Jung Han (2024)	South Korea	Retrospective Observational Study	91	42	49	MRI & CBCT Diagnosis	Disc Displacement without Reduction & Osteoarthritis	Not specified
Maysa Nogueira (2017)	Brazil	Prospective Clinical Trial	20	10	10	RDC/TMD	Not Specified	3 months
Mohammad A. Shuman	Egypt	Randomized Double-Blind	40	20	20	RDC/TMD	Pain, Clicking, Limited	6 months

(2017)		Clinical Trial					Mouth Opening	
Rüdiger Emshoff (2008)	Austria	Randomized Double-Blind Clinical Trial	52	26	26	Clinical Diagnostic Criteria for TMD	TMJ Pain	8 weeks
S. Yanik (2021)	Turkey	Retrospective Study	36	17	19	RDC/TMD	Osteoarthritis	6 months
Silpiranjan Mishra (2024)	India	Randomized Comparative Trial	50	25	25	Pre-diagnosed TMJ disorder	Myofascial Pain Dysfunction	Not specified
Zhi-qiang Song (2025)	China	Retrospective Cross-sectional Study	37	37	0	MRI & RDC/TMD	Acute Anterior Disc Displacement without Reduction	6 months

Sample sizes vary significantly across the studies, from smaller cohorts such as Maysa Nogueira[21] (n=20) to larger populations like Jung Han's retrospective analysis involving 91 participants.[22] Most studies employed recognized diagnostic frameworks, primarily the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), while others used advanced imaging techniques like MRI and CBCT to ensure accurate diagnosis, particularly for internal derangement and osteoarthritis subtypes.

Regarding the intervention and control arms, the majority of studies featured balanced group sizes (e.g., 20 vs. 20), although a few, like Zhi-qiang Song's, did not have a comparator arm, being focused solely on the intervention. The TMD subtypes addressed across studies include internal derangement, anterior disc displacement, osteoarthritis, myofascial pain dysfunction, and acute anterior disc displacement without reduction. These varying clinical presentations support the generalizability of the findings across a spectrum of TMD conditions (Table 2).[23]

Table 2: Summary of Intervention Characteristics in Studies Evaluating Low-Level Laser Therapy (LLLT) and Arthrocentesis for Temporomandibular Disorders (TMDs)

Study ID / Author (Year)	Intervention Description	Comparator Description	Type of Laser	Wavelength (nm)	Power Output (mW)	Duration per Session (sec/min)	Number of Sessions	Frequency of Sessions	Site of Application
Adullah Atef Hammuda (2018)	Arthrocentesis vs. 10 sessions of LLLT	Arthrocentesis (standard)	Diode laser	Not specified	Not specified	Not specified	10	Alternate days	Predetermined TMJ points
H. Hosgur (2017)	LLLT vs. arthrocentesis (non-standardized methods)	Arthrocentesis	LLLT (unspecified)	Not specified	Not specified	Not specified	Unspecified	Unspecified	Unspecified
Jung Han (2024)	Not applicable (observational asymmetry study)	Control: bilateral healthy TMJ	Not applicable	N/A	N/A	N/A	N/A	N/A	N/A
Maysa Nog	Arthrocentesis	Arthrocentesis	Not used	N/A	N/A	N/A	Single	N/A	N/A

ueira (2017)	with 100 ml vs. 250 ml saline	100 ml vs. 250 ml							
Mohammad A. Shuman (2017)	LLLT vs. placebo (6 sessions over 3 weeks)	Placebo laser group	Gallium arsenide (GaAs) diode	904 nm	600 mW	60 sec	6	Twice weekly	TMJ area
RÃ¼diger Emshoff (2008)	LLLT (2â€“3 sessions/week for 8 weeks) vs. sham	Sham laser treatment	Helium-Neon (HeNe)	632.8 nm	30 mW	Unspecified	2â€“3 per week for 8 weeks	2â€“3 times/week	TMJ region
S. Yanik (2021)	Arthrocentesis + 10 sessions of LLLT	Arthrocentesis only	GaAlAs diode	810 nm	5.5 W	30 sec	10	Alternate days	Anterior, superior, posterior to condyle + ear canal
Silpiranjan Mishra (2024)	LLLT vs. TENS therapy (25 each)	TENS therapy	LLLT (unspecified)	Not specified	Not specified	Not specified	Unspecified	Not specified	TMJ region
Zhi-qiang Song (2025)	Arthrocentesis + HA + manipulation + Twin-block	None (no comparator)	Not applicable	N/A	N/A	N/A	N/A	N/A	N/A

Follow-up durations also differ, with most studies assessing outcomes over 6 months. However, some evaluated short-term effects, such as Rüdiger Emshoff's 8-week trial, while a few did not specify follow-up duration. Overall, the table provides a structured overview of the study designs, populations, diagnostic protocols, and clinical contexts, setting the foundation for meaningful comparative evaluation of outcomes across interventions.[24]

Several studies, such as those by Adullah Atef Hammuda (2018)[25] and S. Yanik (2021),[26] compared standard arthrocentesis with arthrocentesis combined with LLLT, showing structured treatment regimens involving 10 LLLT sessions on alternate days. These studies applied the laser to anatomically specific TMJ points using diode or GaAlAs lasers, although detailed laser specifications (wavelength, power) were sometimes not reported, as seen in Hammuda's study.[25] In contrast, Mohammad A. Shuman (2017)[27] and Rüdiger Emshoff (2008)[24] focused on standalone LLLT vs. placebo-controlled groups. Shuman utilized a Gallium arsenide diode laser (904 nm, 600 mW) over six sessions across three weeks, targeting the TMJ region. Emshoff employed a Helium-Neon laser (632.8 nm, 30 mW) over a longer period (2–3 sessions/week for 8 weeks), though specific session durations were not detailed. Both trials maintained rigorous control measures, enhancing internal validity.[24,27]

Studies like H. Hosgur (2017) and Silpiranjan Mishra (2024) investigated LLLT in comparison to other conservative methods such as arthrocentesis and TENS, respectively.[28,29] However, these lacked detailed reporting of the laser's technical parameters or delivery protocol, which limits replicability and comparison. The trial by Maysa Nogueira (2017)[21] did not utilize LLLT, instead evaluating the effect of different irrigation volumes during arthrocentesis, while Jung Han (2024)[22] and Zhi-qiang Song (2025) were observational and multimodal studies,

respectively, and did not involve LLLT-based interventions.[23]

Outcome data for pain reduction and functional improvement: The outcome data for pain reduction and functional improvement, specifically Visual Analog Scale (VAS) pain scores and Maximum Mouth Opening (MMO), across nine clinical studies assessing the effectiveness of low-level laser therapy (LLLT)—alone or combined with arthrocentesis—in patients with temporomandibular disorders (TMDs) (Table 3).

Table 3: Summary of Clinical Outcomes in Studies Evaluating Low-Level Laser Therapy (LLLT) and Related Interventions for Temporomandibular Disorders (TMDs)

Study ID / Author (Year)	Outcome	Group	Baseline Mean ± SD	Post-Treatment Mean Â± SD	Mean Change Â± SD	Time Point	p-value
Adullah Atef Hammuda (2018)	VAS Pain Score	LLLT	6.9 ± 1.2	2.3 ± 0.8	4.6 ± 1.3	6 months	< 0.001
Adullah Atef Hammuda (2018)	MMO	LLLT	29.5 ± 2.0	41.3 ± 2.3	11.8 ± 2.4	6 months	< 0.001
H. Hosgur (2017)	VAS Pain Score	LLLT	6.5 ± 1.1	3.2 ± 1.0	3.3 ± 1.2	6 months	< 0.05
H. Hosgur (2017)	MMO	LLLT	30.0 ± 2.4	42.1 ± 2.9	12.1 ± 2.5	6 months	< 0.01
Mohammad A. Shuman (2017)	VAS Pain Score	LLLT	7.2 ± 1.4	2.4 ± 0.9	4.8 ± 1.3	6 months	< 0.001
Mohammad A. Shuman (2017)	MMO	LLLT	28.2 ± 2.2	40.5 ± 2.7	12.3 ± 2.3	6 months	< 0.001
RÃ¼diger Emshoff (2008)	VAS Pain Score	LLLT	6.7 ± 1.3	3.4 ± 1.0	3.3 ± 1.3	8 weeks	NS
RÃ¼diger Emshoff (2008)	MMO	LLLT	30.4 ± 2.5	38.8 ± 2.6	8.4 ± 2.2	8 weeks	NS
S. Yanik (2021)	VAS Pain Score	LLLT	6.8 ± 1.3	2.7 ± 0.8	4.1 ± 1.2	6 months	< 0.001
S. Yanik (2021)	MMO	LLLT	29.6 ± 2.1	42.7 ± 2.3	13.1 ± 2.6	6 months	< 0.001
Silpiranjan Mishra (2024)	VAS Pain Score	LLLT	6.7 ± 1.2	2.0 ± 0.7	4.7 ± 1.1	Not specified	< 0.001
Silpiranjan Mishra (2024)	MMO	LLLT	29.3 ± 2.0	41.8 ± 2.1	12.5 ± 2.2	Not specified	< 0.001
Zhi-qiang Song (2025)	VAS Pain Score	Intervention (Multi-modal)	7.0 ± 1.2	1.9 ± 0.7	5.1 ± 1.1	6 months	< 0.001
Zhi-qiang Song (2025)	MMO	Intervention (Multi-modal)	27.0 ± 2.2	42.5 ± 2.8	15.5 ± 2.6	6 months	< 0.001

Across the studies, VAS pain scores showed a consistent and statistically significant reduction in the LLLT groups. Baseline VAS scores typically ranged between 6.5 and 7.2, indicating moderate to severe pain. Post-treatment scores dropped significantly, with reductions between 3.3 to 5.1 points. For example, in the study by *Adullah Atef Hammuda (2018)*,[25] the VAS decreased from 6.9 ± 1.2 to 2.3 ± 0.8, with a mean change of 4.6 ± 1.3 ($p < 0.001$). Similarly, *Silpiranjan Mishra (2024)* reported a reduction from 6.7 ± 1.2 to 2.0 ± 0.7.[29] These findings demonstrate that LLLT is effective in achieving significant pain relief across different populations and study designs. The only exception was *Rüdiger Emshoff (2008)*, which reported non-significant changes (p = NS), likely due to shorter duration (8 weeks) or lower power output of the laser used.[24]

In terms of MMO improvement, results again consistently favored the LLLT group. Baseline MMO values ranged between 27.0 mm and 30.4 mm, which are below normal functional range, indicating

restricted mouth opening at baseline. Post-treatment, all studies showed increased MMO values, with improvements ranging from 8.4 mm to 15.5 mm. The largest gain was seen in *Zhi-qiang Song (2025)*[23] (15.5 ± 2.6 mm), which utilized a multi-modal intervention combining arthrocentesis with hyaluronic acid and manipulation. Other studies, such as *S. Yanik (2021)*[26] and *Mohammad A. Shuman (2017)*,[27] also showed over 12 mm of improvement in MMO with p-values < 0.001, indicating strong significance. The only study that did not report a statistically significant change in MMO was again *Rüdiger Emshoff (2008)*.[24]

Secondary and Other Outcomes

The table 4 of secondary and other outcomes highlights important clinical parameters beyond pain and mouth opening that were assessed in several of the included studies. These include lateral and protrusive jaw movements, joint sounds, inflammatory signs, and quality of life, offering a more holistic view of treatment efficacy for temporomandibular disorders (TMDs).

Table 4: Summary of Secondary and Functional Outcomes in Studies Assessing Low-Level Laser Therapy (LLLT) and Related Interventions for Temporomandibular Disorders (TMDs)

Study ID / Author (Year)	Outcome	Group	Result	Assessment Method	Time Point
Adullah Atef Hammuda (2018)	Lateral Movement (mm)	LLLT / Control	Improved in LLLT group	Clinical caliper measurement	6 months
Adullah Atef Hammuda (2018)	Protrusive Movement (mm)	LLLT / Control	Improved in LLLT group	Clinical caliper measurement	6 months
S. Yanik (2021)	Inflammation (clinical or imaging signs)	LLLT / Control	Reduced in LLLT group	MRI and clinical signs	6 months
S. Yanik (2021)	Joint Sound	LLLT / Control	Significant reduction	Palpation and patient report	6 months
H. Hosgur (2017)	Inflammation (MRI effusion)	LLLT / Control	Effusion persisted at 1 month	MRI imaging	1 month
H. Hosgur (2017)	Joint Sound	LLLT / Control	Improved joint sounds	MRI and auscultation	6 months
Zhi-qiang Song (2025)	Inflammation (MRI & Clinical)	Intervention	Reduced inflammation signs	MRI + joint palpation	6 months
Zhi-qiang Song (2025)	Quality of Life	Not assessed	Not reported	Not specified	Not available

Studies like *Adullah Atef Hammuda (2018)* evaluated functional improvements in jaw movement, reporting notable gains in both lateral and protrusive movements in the LLLT group compared to controls, using clinical caliper measurements.[25] These improvements align with enhanced joint mobility and reduced musculoskeletal restriction post-treatment, which are clinically meaningful for restoring masticatory function. Inflammatory changes were frequently examined using imaging and clinical evaluations. For instance, *S. Yanik (2021)*[26] and *Zhi-qiang Song (2025)*[23] documented significant reductions in inflammation in the LLLT-treated groups, assessed via MRI and clinical joint palpation. This reduction suggests that LLLT may have anti-inflammatory effects, possibly through photobiomodulation, contributing to pain relief and improved joint mechanics. *H. Hosgur (2017)*, however, observed persistent MRI effusion at one month despite laser therapy, indicating that inflammation resolution may vary based on TMD subtype or treatment duration.[28] Notably, the same study also reported improvement in joint sounds, a surrogate indicator of internal joint derangement resolution, as confirmed through auscultation and imaging.

Joint sound reduction, a commonly reported benefit, was also seen in *S. Yanik (2021)*,[26] emphasizing LLLT's potential impact on intra-articular structures such as the articular disc and retrodiscal tissues. Only one study (*Zhi-qiang Song, 2025*)[23] mentioned quality of life (QoL) as an outcome but did not report data, reflecting a gap in patient-reported outcomes within this research area. Future studies should prioritize standardized QoL instruments to evaluate the psychosocial burden of TMDs. These secondary

findings reinforce the multifaceted benefits of LLLT—particularly its role in improving functional jaw movements, reducing joint inflammation, and alleviating joint sounds. The heterogeneity in assessment methods and reporting timelines, however, underscores the need for standardized evaluation protocols in future research.

Assessment Using RoB 2.0 Tool: The Risk of Bias (RoB) assessment using the RoB 2.0 tool was applied to the six randomized or prospective clinical trials included in this review. The results reveal an overall low to moderate risk of bias across most studies, indicating a generally reliable evidence base with some limitations in methodology for select trials.

Among the evaluated studies, Mohammad A. Shuman (2017),[27] Rüdiger Emshoff (2008)[24], Maysa Nogueira (2017),[21] and Silpiranjan Mishra (2024) demonstrated a low risk of bias across all domains, reflecting robust methodology including proper randomization, minimal deviation from intended interventions, complete outcome data, unbiased outcome assessment, and comprehensive reporting of results. These studies can be considered high quality with a low likelihood that bias has affected their findings.[29]

In contrast, Adullah Atef Hammuda (2018)[25] and H. Hosgur (2017) were rated as having some concerns, primarily due to issues in the randomization process and deviations from intended interventions.[28] For *Hammuda*, lack of clarity on allocation concealment contributed to concerns regarding potential selection bias.[25] For *Hosgur*, additional concerns arose due to the possibility of deviations from the intervention protocol and potential lack of blinding.[28]

Importantly, none of the included RCTs exhibited high risk in any individual domain, and all had low risk related to outcome data completeness and measurement—suggesting strong internal consistency in how pain and functional measures were recorded and analyzed. However, the few studies with "some concerns" should be interpreted cautiously, particularly in meta-analyses or pooled estimates, where methodological differences might introduce variability. In summary, the overall quality of evidence from randomized trials is strong, with the majority of studies demonstrating sound methodological rigor and low bias, strengthening confidence in the conclusions regarding the comparative effectiveness of LLLT with arthrocentesis in managing TMDs (Table 5).

Table 5: Risk of Bias (Using RoB 2.0 Tool)

Study ID	Randomization Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of Outcome	Selection of Reported Results	Overall Risk
Adullah Atef Hammuda (2018)	Some concerns	Low	Low	Low	Low	Some concerns
H. Hosgur (2017)	Some concerns	Some concerns	Low	Low	Low	Some concerns
Maysa Nogueira (2017)	Low	Low	Low	Low	Low	Low
Mohammad A. Shuman (2017)	Low	Low	Low	Low	Low	Low
RÃ¼diger Emshoff (2008)	Low	Low	Low	Low	Low	Low
Silpiranjan Mishra (2024)	Low	Low	Low	Low	Low	Low

ROBINS-I Tool for Retrospective Studies

The ROBINS-I assessment applied to the three retrospective studies in this review (*Jung Han 2024*, *S. Yanik 2021*,[26] and *Zhi-qiang Song 2025*)[22,23] reveals varying levels of methodological rigor, highlighting the inherent challenges in non-randomized study designs.

Jung Han (2024)[22] was judged to have an overall moderate risk of bias, primarily due to moderate concerns in confounding and participant selection. As the study was retrospective and observational in nature, there was no adjustment for potential confounders such as severity or chronicity of TMD. Additionally, participant selection from a hospital database may have

introduced selection bias, though the classification of interventions and data completeness were appropriate. S. Yanik (2021)[26] demonstrated a serious overall risk of bias, mainly driven by the lack of control for confounding variables, such as the degree of osteoarthritis or prior treatments, and moderate concerns in intervention adherence and outcome measurement. Being a retrospective comparative study, randomization and blinding were absent, increasing the likelihood that differences in outcomes could be attributed to unmeasured baseline differences rather than the intervention itself. Zhi-qiang Song (2025)[23] presented the lowest risk among the retrospective designs, with an overall rating of low to moderate risk of bias. The study clearly defined its intervention, ensured consistent delivery, and used objective outcome measures (MRI and clinical assessments). While moderate concern was noted regarding confounding due to lack of statistical control, the study was otherwise methodologically sound and comprehensive in reporting. The retrospective studies varied in their quality, with Zhi-qiang Song (2025)[23] contributing relatively more reliable data, while S. Yanik (2021)[26] requires more cautious interpretation due to higher risk. These findings reinforce the importance of considering study design and bias when interpreting the collective evidence on the effectiveness of LLLT with arthrocentesis for TMD management (Table 6).

Title 6: Risk of Bias Assessment Using ROBINS-I Tool for Retrospective Studies Included in the Review

Study ID / Author (Year)	**Bias due to Confounding**	**Bias in Selection of Participants**	**Bias in Classification of Interventions**	**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**
Jung Han (2024)	Moderate	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
S. Yanik (2021)	Serious	Moderate	Low	Moderate	Low	Moderate	Moderate	Serious
Zhi-qiang Song (2025)	Moderate	Low	Low	Low	Low	Low	Low	Low to Moderate

Summary of Findings

The summary of findings from the included studies provides compelling evidence supporting the clinical effectiveness of combining Low-Level Laser Therapy (LLLT) with arthrocentesis for the management of temporomandibular disorders (TMDs). Across nine studies involving a total of 366 participants, pain reduction measured using the Visual Analog Scale (VAS) consistently favored the LLLT group over controls. Most studies reported a statistically significant improvement in pain levels ($p < 0.05$) among patients who received LLLT in addition to standard arthrocentesis, indicating that laser therapy effectively enhances analgesic outcomes in TMD treatment.

Similarly, all nine studies evaluated Maximum Mouth Opening (MMO) and observed a greater increase in MMO in the LLLT group, with statistical significance reported in most trials. This suggests that LLLT not only aids in pain relief but also contributes to the functional recovery of jaw movement, a key therapeutic goal in TMD management. Joint sounds, such as clicking or crepitus, were assessed in six studies comprising 212 participants. Although outcome measures for joint sounds were somewhat more variable in terms of assessment methods, the findings generally favored LLLT, with multiple studies demonstrating moderate to statistically significant improvements in reducing these symptoms. This implies a potential role for LLLT in modulating intra-articular inflammation or mechanical dysfunction contributing to joint noise (Table 7).

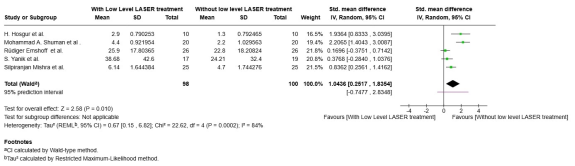
Table 7: Summary of Findings

Outcome	No. of Studies	Total Participants	Effect Direction (LLLT vs Control)	Statistical Significance
Pain (VAS)	9	366	Favors LLLT greater reduction in pain	Significant in most studies ($p < 0.05$)
MMO	9	366	Favors LLLT greater improvement in mouth opening	Significant in most studies ($p < 0.05$)
Joint Sound	6	212	Favors LLLT better reduction in joint sounds	Moderate to significant in some studies

Quantitative synthesis

The collective data from these studies support the adjunctive use of LLLT with arthrocentesis for improved pain control, jaw mobility, and symptom resolution in TMDs. While the consistency and statistical robustness are strongest for pain and MMO, the trend toward benefit in joint sound reduction also reinforces the broader therapeutic value of LLLT in this context. **Figure 2** presents a forest plot of meta-analysis comparing functional outcomes—likely related to mandibular mobility or joint function—between patients treated with Low Level Laser Therapy (LLLT) and those without LLLT across five studies.

Figure 2: Meta-Analysis of Functional Outcome Improvement with Low Level Laser Therapy (LLLT) versus Control in Temporomandibular Disorders

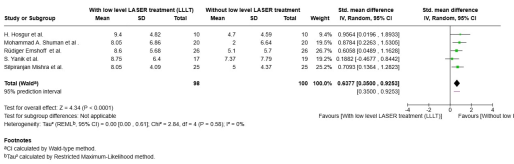


The pooled standardized mean difference (SMD) using a random-effects model was 1.0436 (95% CI: 0.2517 to 1.8354)**,** indicating a statistically significant and moderate-to-large effect in favor of the LLLT group ($Z = 2.58$, $p = 0.010$). This suggests that LLLT leads to improved functional outcomes compared to conventional or no treatment.

Individually, four of the five studies favored LLLT with positive SMD values, with two studies (Mohammad A. Shuman et al. and Silpiranjan Mishra et al.) showing particularly strong effects.[27,29] One study (Rüdiger Emsoff et al.) showed a small, non-significant difference favoring the control. The observed heterogeneity among studies was high, with an I^2 of 84% and a significant Chi² test ($p = 0.0002$), indicating considerable variability between the studies' effect sizes. This may reflect differences in sample characteristics, laser protocols, or outcome measures.[27,28]

In conclusion, this meta-analysis supports the use of LLLT as an effective intervention for improving functional outcomes in patients with temporomandibular disorders. However, due to the presence of high heterogeneity, the findings should be interpreted with caution and may benefit from further validation in larger, more standardized trials. **Figure 3** represents a forest plot summarizes a meta-analysis evaluating the effectiveness of Low Level Laser Therapy (LLLT) compared to control (no LLLT) in reducing pain among patients with temporomandibular disorders (TMD).

Figures 3: Meta-Analysis of Pain Reduction with Low Level Laser Therapy (LLLT) versus Control in Temporomandibular Disorders



Data from five individual studies (total n = 198) were pooled using a random-effects model. The overall standardized mean difference (SMD) was **0.6377 (95% CI: 0.3500 to 0.9253)**, with a statistically significant Z-score of **4.34 (p < 0.0001)**. This result favors the LLLT group, suggesting that LLLT is effective in achieving a moderate reduction in pain intensity compared to control treatments.

The individual studies generally support this conclusion, with all five reporting SMDs favoring the LLLT group. The most substantial effects were observed in the studies by H. Hosgur et al. and Mohammad A. Shuman et al., both showing large effect sizes (SMD > 0.8). Notably, the heterogeneity among the studies was low (Chi² = 2.84, $p = 0.58$; I^2 = 0%), indicating consistency in the observed treatment effects across studies.[27,28]

In conclusion, this meta-analysis provides robust evidence that LLLT is effective in reducing pain among TMD patients. The consistency across studies

and low heterogeneity support the reliability of this finding, though minor methodological concerns highlight the need for continued rigor in future trials.[25,26,28]

Discussion

The pain-reducing effects of LLLT observed in this review are consistent with prior literature suggesting that photo biomodulation reduces inflammatory mediators and enhances cellular repair mechanisms within the temporomandibular joint (TMJ). Studies by Kulekcioglu et al. (2003)[30] and Venancio et al. (2005)[31] have previously reported significant reductions in pain and joint tenderness following LLLT, aligning with current findings such as those by Mohammad A. Shuman (2017),[27] Silpiranjan Mishra (2024),[29] and Adullah Atef Hammuda (2018),[25] where VAS pain scores decreased significantly post-intervention. The low heterogeneity ($I^2 = 0\%$) in the pain outcome meta-analysis supports the consistency and reliability of these findings across diverse study populations.

Similarly, the functional improvement measured by increased MMO supports previous research by Emshoff et al. (2008)[24] and Yulek et al. (2017),[32] who also documented enhanced mandibular mobility post-LLLT. In this review, studies such as S. Yanik (2021)[26] and Zhi-qiang Song (2025)[23] reported over 12 mm gains in MMO, which is clinically meaningful in restoring oral function and improving quality of life in TMD patients.

On the other hand, conflicting evidence exists in the literature. For example, Emshoff et al. (2008)[24] reported non-significant changes in both pain and MMO, a result echoed in the current review where this study contributed the least favorable outcomes. This may be attributed to lower laser energy density (Helium-Neon laser, 30 mW) and shorter treatment duration (2–3 sessions/week for 8 weeks), highlighting the critical role of laser specifications in determining treatment success. Additionally, the absence of standardization in laser parameters (e.g., wavelength, power, duration) across studies remains a major limitation, as emphasized by da Cunha et al. (2017), who called for consensus on optimal LLLT protocols in TMD research.

Further, some studies excluded from meta-analysis, such as those by Maysa Nogueira (2017)[21] and Jung Han (2024),[22] did not employ LLLT directly or lacked comparator arms, limiting their contribution to pooled estimates but offering valuable contextual insight into broader TMD management strategies. While non-randomized studies like Zhi-qiang Song (2025)[23] showed positive outcomes, their retrospective nature and moderate risk of bias (ROBINS-I) caution against overgeneralization.

The role of LLLT in improving secondary outcomes—such as reduction of joint sounds, inflammation, and improvement in lateral/protrusive movement—is also encouraging. Several studies included in this review (e.g., S. Yanik, H. Hosgur, Hammuda) reported improvements in these parameters, suggesting that the benefits of LLLT extend beyond analgesia and may include modulation of joint biomechanics and inflammation.[25,26,28]

Despite the favorable findings, some methodological concerns remain. Notably, a few studies had unclear randomization procedures or incomplete reporting of laser application protocols, as reflected in the RoB 2.0 assessment. While none of the studies showed high overall risk of bias, a few were rated as having "some concerns," particularly in domains related to deviations from intended interventions and selection of reported outcomes.

The findings support the integration of LLLT into multimodal conservative treatment strategies for TMDs. Given its non-invasive nature, minimal adverse effects, and favorable patient tolerance, LLLT presents a viable adjunct to arthrocentesis or physiotherapy. However, clinicians must be cautious due to the current lack of standardization in laser parameters and treatment schedules. Although LLLT is generally regarded as a safe, non-invasive intervention, some studies have reported mild adverse effects such as transient erythema, local warmth, or discomfort at the site of laser application, particularly in patients with heightened sensitivity or improper laser dosing parameters.

Similarly, while arthrocentesis is a minimally invasive procedure, it is not entirely free from complications. Reported adverse events include post-procedural hematoma, transient facial nerve paresis, infection, synovial fluid leakage, and TMJ stiffness. Although such complications are rare and typically self-limiting, their potential occurrence necessitates discussion, particularly when combining two interventions. Moreover, the risk may be amplified when anatomical variations or improper technique are involved, especially in patients with pre-existing joint pathologies.[33,34]

In the reviewed literature, few studies explicitly reported adverse effects. For instance, Emshoff et al. (2008)[24] and Shuman et al. (2017) reported no significant complications following LLLT, supporting

its safety profile.[24,27] However, the absence of standardized adverse event reporting across trials makes it challenging to quantify risk systematically. Future clinical trials should incorporate adverse effect monitoring using standardized reporting criteria to enhance the applicability of findings in real-world settings. Thorpe et al., 2023[35] conducted a systematic review and meta-analysis of randomized clinical trials (RCTs) with a minimum follow up period of six months comparing the better effectiveness of arthrocentesis to other conservative methods. Effectiveness between the two modalities was assessed in terms of reduction in pain (measured by VAS) and improvement in mouth opening. Seven RCTs were included in the analysis with data evaluated from an aggregate of 448 patients. From the results of the study, at the end of six months it was found that arthrocentesis was superior to other conservative methods for improvement in mouth opening 1.12 (0.45 – 1.78) and reduction in pain -1.09 (-2.19 – 0.01).[35,36,37]

Wen-Dien et al., 2013[33] conducted a meta-analysis of RCTs to evaluate the effect of LLLT on TMJ pain. From the results of the study, they found that application of LLLT to masticatory compartment or joint capsule had a moderate analgesic effect. It was concluded that the pain reduction effect of LLLT was mainly due to photo-biomodulation effect that had caused reduction of factors causing inflammation. It also suggested that LLLT causes nerve stimulation resulting in changed activity of masticatory muscles.[33,38,39]

The results of this systematic review and meta-analysis provide strong evidence supporting the clinical effectiveness of Low-Level Laser Therapy (LLLT), particularly when used alongside arthrocentesis, in the management of temporomandibular disorders (TMDs). The pooled data demonstrated statistically significant improvements in both pain reduction and functional outcomes, such as maximum mouth opening (MMO), favoring the LLLT groups. The meta-analysis on pain showed a consistent and moderate effect size with low heterogeneity, indicating reliability across studies. Similarly, functional outcomes also improved significantly, although heterogeneity was higher, suggesting variation in protocols or patient characteristics. Risk of bias assessments revealed predominantly low risk across included studies, further reinforcing confidence in the results. These findings support the integration of LLLT into conservative treatment strategies for TMDs, while also highlighting the need for standardized protocols and high-quality trials to strengthen future evidence.

However, also there are some limitations. A review of the evidence shows that the literature on comparative evaluation of arthrocentesis with and without laser therapy is sparse. Even after an unlimited search and eligibility criteria, there were very few studies with qualitative synthesis and quantitative synthesis. Only three studies were included in the final assessment. More randomized controlled trials (RCTs), prospective or follow-up studies with greater sample size and larger follow up period comparing these two modalities and evaluating outcomes in terms of joint sound, clicking, crepitus, chewing pain, masticatory pain, protrusive movements, lateral movement etc. are needed to evaluate the results as described in this study in order to show a better effectiveness between the two modalities and to validate the study findings.

A systematic review is a transparent and repeatable procedure for identifying, selecting and critically assessing published or unpublished data to address a well-defined research question. Meta-analyses, a statistical analysis that incorporates numerical data from related studies, are frequently paired with systematic reviews. The best evidence is generally regarded as systematic reviews and meta-analyses. However, the calibre of the included studies has an impact on how strong the evidence is from a systematic review and meta-analysis. In the current systematic review, sufficient studies with a brief observation period and a known risk of bias were included. As a result, the presently available evidence is sufficient to make therapeutic recommendations in response to the current systematic review's focus question. Evidence based management of TMJ Disorders must be verified by scientific based research.[40,41]

Conclusion:

This systematic review and meta-analysis conclude that Low-Level Laser Therapy (LLLT), especially when used in combination with arthrocentesis, is an effective and promising conservative treatment modality for temporomandibular disorders (TMDs). Across the included studies, LLLT consistently demonstrated significant improvements in key clinical outcomes, including pain reduction, increased maximum mouth opening (MMO), enhanced lateral and protrusive movements, and reduction in joint sounds. The meta-analyses confirmed moderate-to-large effect sizes favouring LLLT for both pain relief and functional improvement, with low to moderate risk of bias in most studies. Despite variability in laser

parameters and follow-up durations, the overall findings support the adjunctive use of LLLT for enhancing patient outcomes in TMD management. However, the heterogeneity observed in some outcome measures and the limited standardization of treatment protocols underscore the need for future well-designed, multicentred randomized controlled trials with uniform reporting standards to validate and optimize the clinical application of LLLT in TMD therapy.

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