Scoping Review

Nerve blocks and interventional procedures in the management of temporomandibular joint disorders: a scoping review

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Background: Temporomandibular disorders (TMDs) often present significant challenges in diagnosis and management. The temporomandibular joint (TMJ) is the primary joint involved in mastication, speech and to a lesser extent in activities such as breathing. It is subjected to constant function and friction while performing day to day activities. and TMDs can significantly hamper quality of life of affected individuals. The purpose of this scoping review is to discuss the use of injections as a possible, convenient, economical and minimally invasive management options in temporomandibular joint disorders (TMJDs).

Methods: To compile this scoping review, 8,567 were identified through an electronic search using databases such as PubMed (Medline), Scopus and Google Scholar with key words "TMDs", "temporomandibular disorders", "temporomandibular joint disorders", "arthrocentesis", "arthroscopy", "intraarticular injections" and "nerve block". After exclusion, a total of 69 articles published in English language only from January 1st 1974 to December 31st 2021 were included in the review.

Results: Conservative methods are recommended as first line management by major organizations across the world. Surgical modalities are invasive and involve higher risks with possibilities for more serious adverse outcomes. TMJ interventions are useful, economical, less invasive methods of treatment with good success rates and should be performed before invasive surgical procedures are considered. Various TMJ interventions include auriculotemporal nerve (ATN) block, arthrocentesis, arthroscopy, and intraarticular injections using pharmaceutical agents are discussed in this scoping review.

Conclusions: If carefully performed by a skilled operator with knowledge of the local anatomy, these interventions are relatively safe. Intraarticular injections with or without arthroscopy and arthrocentesis for better results may be considered for treatment of resistant cases of internal derangements and degenerative joint disease, non-responsive to conservative management.

Keywords: Temporomandibular joint disorders (TMJDs); arthrocentesis; arthroscopy; intraarticular injection; nerve blocks

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Introduction

Temporomandibular joint disorder (TMJD) is a complex disorder affecting the temporomandibular joint (TMJ), muscles of mastication and associated structures (1). They have various overlapping manifestations such as pain, clicking, crepitus, mandibular movement restriction, facial deformities, open lock, closed lock, tenderness of muscles, trigger points, referred and radiating pain. Understanding the etiopathogenesis, eliminating predisposing, perpetuating factors, and managing TMDs can be difficult (2). Approximately 88% of patients report complete or substantial improvement in their clinical signs and symptoms with conservative management (3). If conservative management fails, invasive surgical procedures may be considered, which has its own range of risks. Injections into the joint in the form of nerve blocks, intraarticular injections, arthroscopy or arthrocentesis are less invasive and can aid in both TMD diagnosis and management. The purpose of this scoping review is to discuss the use of joint interventions as possible, convenient, economical and minimally invasive options for TMDs.

The objective of this paper is to:

(I) Discuss the functional anatomy of TMJ for the purpose of aiding in joint injection;
(II) Summarize various types and techniques of interventional procedures for the TMJ;
(III) Discuss the use of nerve blocks and interventional procedures including their indications, advantages, and disadvantages in treatment of TMDs.

We present the following article in accordance with the PRISMA-ScR reporting checklist (available at https://joma.amegroups.com/article/view/10.21037/joma-22-9/rc).

Methods

Search strategy

An electronic search using databases such as PubMed (Medline), Scopus and Google Scholar was performed by 2 researchers: (SPS) and (MK), using free text words and MeSH term including "Temporomandibular Joint Disorders" [MeSH], Temporomandibular Disorders" [MeSH] OR "TMDs", "Arthrocentesis" [MeSH], "Arthroscopy" [MeSH], "Intraarticular injections", "Nerve blocks" [MeSH] "Auriculotemporal nerve block" [Mesh], OR ATN block, "Twin block" [MeSH], OR "masseteric nerve block" [MeSH]. In addition, cross references in these articles were also considered whenever applicable. Only those articles or abstracts that were published in English were used to compile this review. The scoping review, systematic review, randomised control trials, case reports/series that were published between January 1st 1974 to December 31st 2021 were included in this review (*Table 1*, and details of keywords explained in Appendix 1). After selecting the articles, data that were included and extracted were: number of articles included; TMD treated; type of intervention, agents used; assessment and results. Also, additional information regarding technique, advantages, indications and various studies using these techniques were compiled using these articles.

Results

A total of 8,567 articles were identified, with 8,439 were eliminated due to title, type of article, inclusion criteria, and language. Furthermore, selected 128 articles were screened by reading the abstract and full text, with 69 articles being included in the scoping review (*Figure 1*).

Anatomy of TMJ and pathophysiology of TMDs

The TMJ is a ginglymus-arthrodial joint that is composed of the condyle, glenoid fossa, articular tubercle, articular disc, retro discal tissue, synovial membrane, and joint capsule (4). Movement occurs in a hinge-like motion (ginglymus), and gliding (arthrodial) motion. Hinge like motion is dominant in the earlier stage of opening in the lower joint compartment, and the sliding movement dominates the later stage of opening in the upper joint compartment. Sliding is also the predominant mechanism of protrusive and lateral movements (5). The joint can be divided into two systems. The first joint system is the tissues that surround the inferior synovial cavity (i.e., the condyle and the articular disc). Because the lateral and medial discal ligaments bind the disc to the lateral and medial poles of the condyle, the only physiologic movement that can occur between these surfaces is sliding of the disc on the condylar articular surface, resulting in hinging motion of the joint. The second system is made up of the condyle-disc complex functioning against the surface of the mandibular fossa. Due to the articular disc's lax attachment to the articular fossa, sliding movement between these surfaces in the superior cavity is allowed. This is referred to as translation, in which the mandible slides anteriorly and posteriorly. Thus, the articular disc acts as a non-ossified bone contributing to both joint systems, and hence the function of the disc

Table 1 The search strategy summary

Items	Specification
Date of search	5th Jan 2022
Databases and other sources searched	PubMed (Medline), Scopus and Google Scholar
Search terms used	"Temporomandibular Joint Disorders" [MeSH], Temporomandibular Disorders" [MeSH] OR "TMDs", "Arthrocentesis" [MeSH], "Arthroscopy" [MeSH], "Intraarticular injections", "Nerve blocks" [MeSH] "Auriculotemporal nerve block" [Mesh], OR ATN block, "Twin block" [MeSH], OR "masseteric nerve block" [MeSH]
Timeframe	January 1st, 1974 to December 31st, 2021
Inclusion and exclusion criteria	Inclusion criteria: articles or abstract published in English only
	Type of article included: the narrative review, systematic review, randomised control trials, case reports/series
	Exclusion criteria: articles other than English language, titles and abstracts of those articles that did not fulfil search criteria
Selection process	Independent search was conducted by two authors MK, SPS in indexed databases using MeSH terms. The articles were screened based on title and abstract

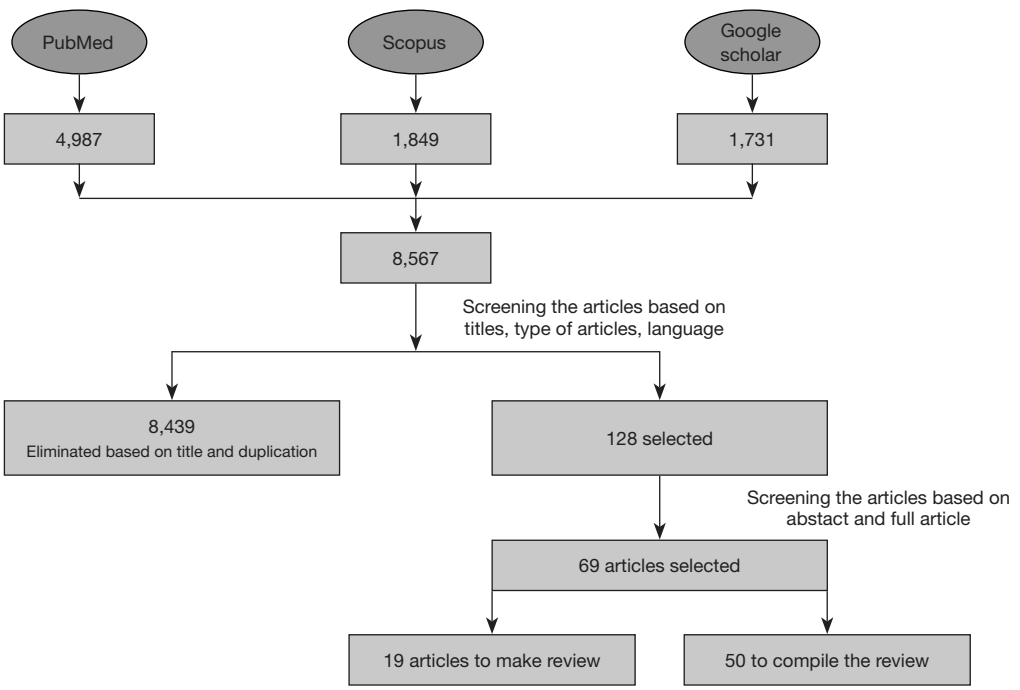

Figure 1 Search strategy.

justifies classifying the TMJ as a true compound joint (6). A mass of soft tissue occupies the space behind the disc and condyle. It is often referred to as the posterior attachment. The posterior attachment is a loosely organized system of collagen fibres, branching elastic fibres, fat, blood and lymph vessels, and nerves (7) (*Figures 2,3*). Discal ligaments restrict the excessive movement of articular disc.

TMD's are broadly classified in TMJD and masticatory

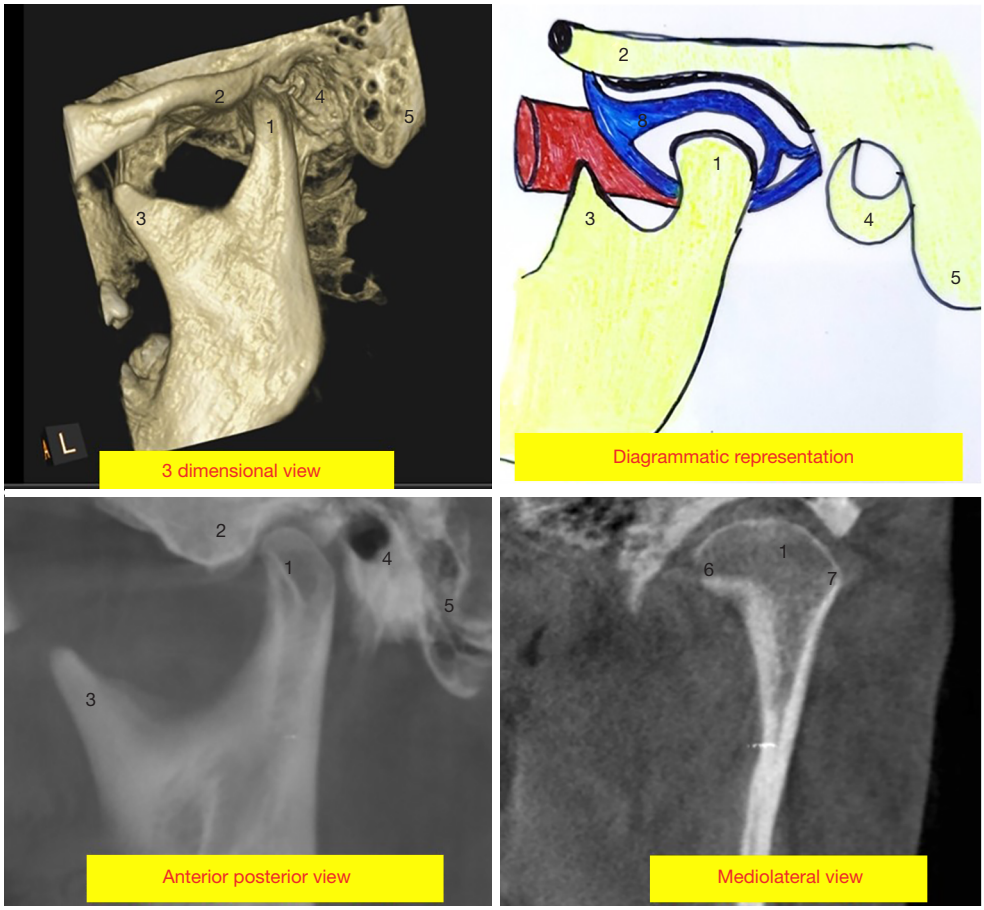

Figure 2 Anatomy of temporomandibular joint. 1. Condyle; 2. articular eminence; 3. coronoid process; 4. external acoustic meatus; 5. mastoid process; 6. medial pole; 7. lateral pole; 8. articular disc.

muscle disorders (MMDs) (8,9). TMJD includes joint pain, joint disorders, joint diseases, fractures and congenital or developmental disorders. MMD includes muscle pain, contracture, hypertrophy, neoplasm, movement disorders, and masticatory muscle pain attributed to systemic or central pain disorders. In this article we will be detailing interventional procedures and injections for TMJD (8,9).

When subjected to constant function, the ligaments can get elongated causing disc to be displaced anteriorly, medially, posteriorly or laterally leading to disc derangements. Further, microtrauma can lead to hypoxia-reperfusion in the articular disc resulting in adhesions in the articular disc leading to its derangement. TMJ is supplied by auriculotemporal nerve (ATN) (branch of posterior division of mandibular nerve), masseteric nerve (branch of anterior division of mandibular nerve) and deep temporal nerve. Hence to perform joint interventions, blocking these nerves is necessary. ATN nerve can be directly blocked by ATN nerve block, whereas masseteric nerve can be blocked directly or as a part of Temporo-Masseteric Nerve Block (TMNB) previously called the Twin block (TB) procedure along with deep temporal nerve (10).

TMJ nerve block and interventional procedures

TMJ interventions can be anesthetic, diagnostic or therapeutic. TMJ nerve blocks can be used to anesthetize the TMJ before other procedures, as in the case of an ATN block before intraarticular steroid injections or manual reduction procedures for TMJ disc displacement without reduction and TMJ luxation. TMJ nerve blocks can be used diagnostically to distinguish TMJ arthralgia from central pain or referred pain from odontogenic and non-odontogenic sources. TMJ interventional nerve blocks and

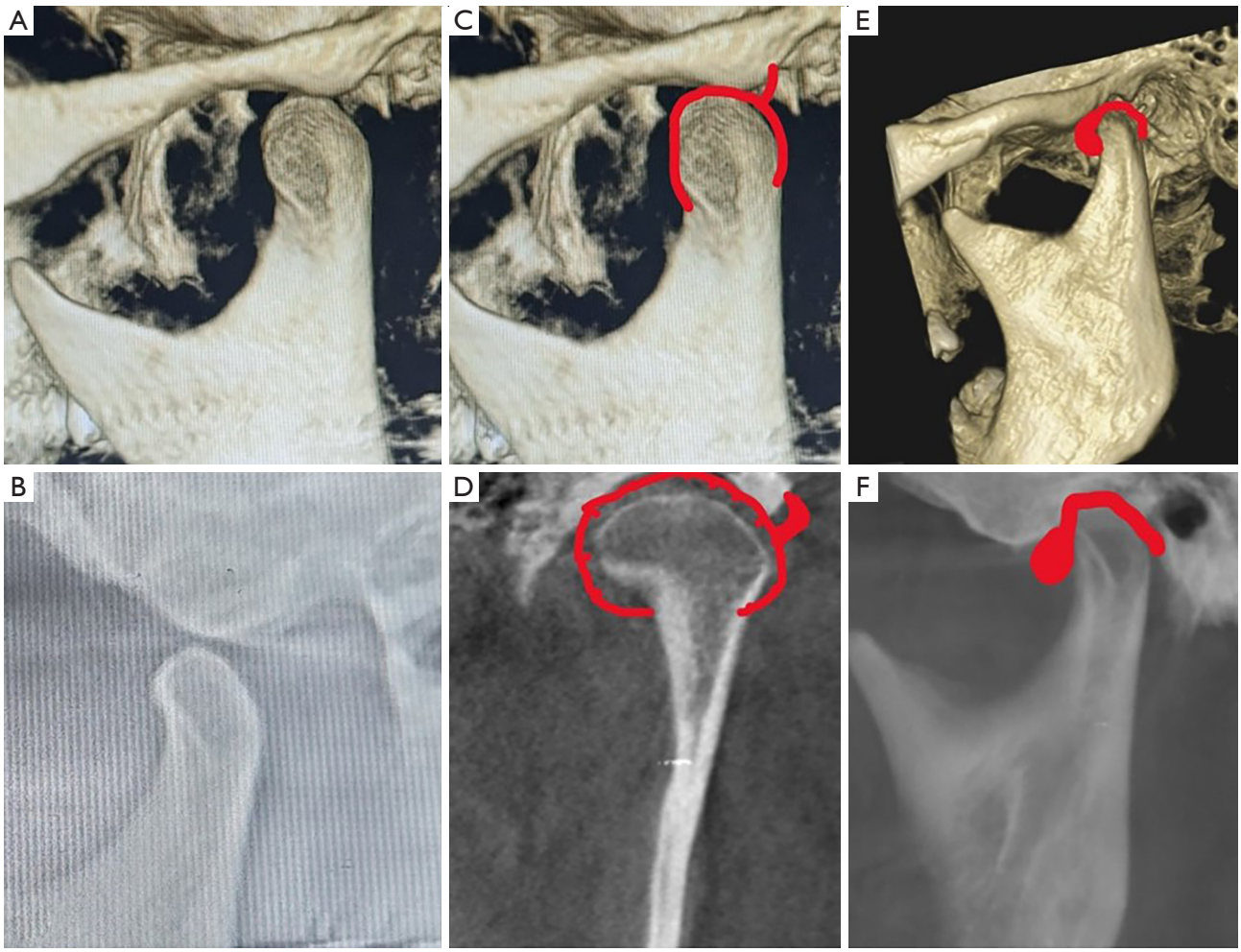

Figure 3 Condyle-disc relationship in normal and in disc derangements. (A,B) Condyle position at open mouth; (C,D) disc at open mouth; (E,F) disc interference in closed lock. The red areas indicate articular disc.

injections may also be used therapeutically for management of various TMD's such as internal derangements, and degenerative joint disorders. Steroids may be therapeutically injected into TMJ to decrease inflammation. Arthrocentesis may be used to flush and mobilize TMJ (summarized in *Table 2*) (11).

Preoperative preparation for interventional procedures of TMJ

Patient's head is covered with head cap and secured with micropore tape or forceps. Hair in the region of interest can be shaved off. Surgical site can be marked for outline of TMJ, reference lines with markers. The interventional sites must be sterilized with 2% chlorhexidine solution or povidone iodine solution for asepsis. Materials required for the interventional procedures of TMJ include syringes, sterilized gauze and cotton, gloves, anesthetics, pharmaceutical agent, saline, arthroscopic equipment (for arthroscopy), markers, micropore tapes, drapes and head caps.

Interventional procedures

ATN block

The ATN is a branch of the posterior division of the mandibular branch of the trigeminal nerve. ATN arises from main trunk and loops middle meningeal artery and then passes backward between lateral pterygoid and neck of the condyle, turning laterally behind the joint. It then passes upward over zygoma and entering temple region.

Table 2 Summary of nerve blocks and interventional procedures of TMJ

Intervention	Indication	Advantages	Disadvantages
ATN block	For local anaesthesia while performing TMJ procedure As diagnostic block	Effective in pain reduction	Delicate joint structures may be traumatized during the procedure
Masseteric nerve block and TMNB	For local anaesthesia while performing TMJ procedure Reduction of TMJ, pain relief in internal derangements	Relatively safe technique	Temporary loss of blink reflex
Arthrocentesis	Chronic joint pain, acute degenerative or rheumatoid arthritis, disc derangements, post traumatic arthritis	Washes out inflammatory mediators; disrupts adhesions; releases disc Increases disc mobility Safe and less invasive procedure	Pain, edema, transient facial nerve paralysis, bleeding into joint
Arthroscopy	Internal derangement, closed lock, osteoarthrosis, pain reduction	Allows direct joint visualization; lavages the joint by removing loose bodies; allows introduction of pharmaceutical agents; breaks adhesion	Tympanic membrane puncture, nerve injury, haemorrhage, hemarthrosis, laceration of cartilage, glenoid fossa perforations and instrument breakage
Intracapsular or intraarticular injection	Acute synovitis, osteoarthritis, rheumatoid arthritis, gout, and psoriatic arthropathy	Less invasive than surgery Can be performed with other joint procedures Provides short term and intermediate term relief in patients who failed with conservative therapies	Mild pain after injection

TMJ, temporomandibular joint; ATN, auriculotemporal nerve; TMNB, Temporo-Masseteric Nerve Block.

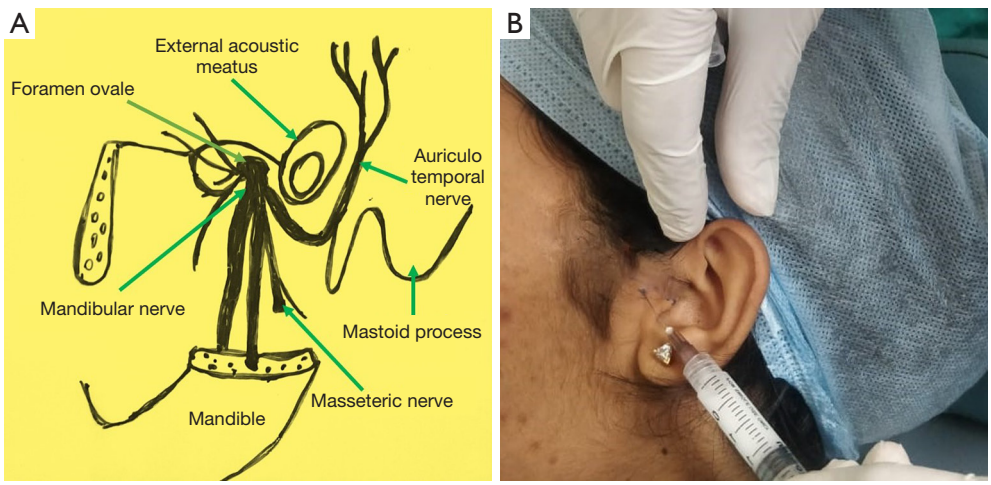

Figure 4 Anatomy and nerve block technique for auriculotemporal nerve. (A) Anatomy of auriculotemporal nerve; (B) auriculotemporal nerve block.

ATN has articular, auricular and superficial temporal branches and articular branch supplies TMJ (*Figure 4A*). A 27-gauge long needle is inserted into the skin at a point just inferior and anterior the junction of the earlobe and the tragus. The needle is advanced until it reaches the posterior neck of the condyle, then transposed posteriorly until the needle tip passes the posterior side of the condylar neck. As soon as the needle tip contacts the condylar neck, it is rotated antero-medially to a depth of 1 cm, then aspirated. After negative aspiration, the 2% lidocaine with 1:100,000

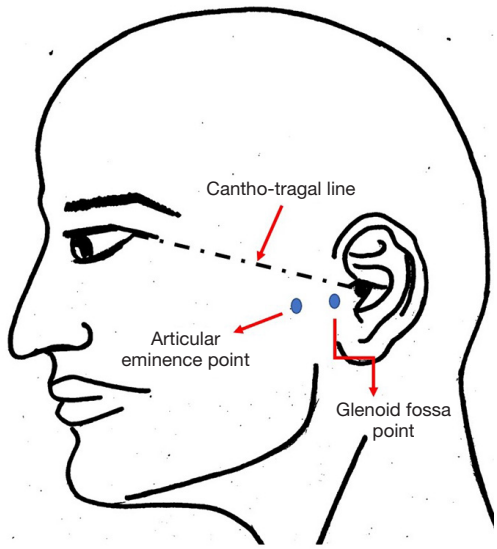

Figure 5 Reference lines and points for arthrocentesis.

adrenaline is deposited (*Figure 4B*) (12-14).

Masseteric nerve block and TMNB

Masseteric nerve, branch of anterior division of mandibular nerve also supplies TMJ. Masseteric nerve passes in close proximity to the roof of the infratemporal fossa reaches to the mandibular notch from above the superior head of the lateral pterygoid. The nerve supplies TMJ and runs in downward and forward direction to innervate masseter muscle. TMJ procedures may necessitate blocking this nerve, which can be accomplished with a masseteric nerve block, which blocks only the masseteric nerve, or a TMNB, which blocks both the masseteric and deep temporal nerves in a single puncture.

For masseteric nerve block, mandibular notch is located with index finger, below zygomatic arch. A 27-gauge needle is inserted to a depth of 1.5 cm, at a point posterior to the index finger. The needle is inserted at an obtuse angle to the condylar neck and directed towards condylar fovea, depositing full carpule of 2% lidocaine with 1:100,000 adrenaline.

For TMNB, 27-gauge long needle, 1.5-inch size attached with 1.8 mL syringe loaded with of 2% lidocaine with 1:100,000 adrenaline is used. It is a supra zygomatic injection. The needle is placed 1cm posterior to the posterior border of the frontal process of the zygomatic bone at a point of depression of the greater wing of the sphenoid bone over the temporal region. The needle is inserted at a 35–45-degree angle to the calvarium, right angle to the zygomatic arch and 1.8mL of solution is deposited after negative aspiration of the syringe (10,15).

Arthrocentesis

Şentürk and Cambazoğlu classified arthrocentesis into single-puncture and double puncture arthrocentesis (16). Single puncture arthrocentesis has been subclassified as type 1 (single-needle cannula method) and type 2 (single-puncture method using a double or dual-needle cannula). Double puncture arthrocentesis is a traditional method of arthrocentesis using two cannulas and two punctures. Before the arthrocentesis, the TMJ should be anesthetized with ATN block. The patient's head is held in an upright position and tilted to the opposite side. A reference line drawn from outer canthus of the eye to the tragus (the cantho-tragal line or the Holmlund line). Two points, corresponding to the glenoid fossa and articular eminence should be marked as entry points in reference to this line. The glenoid fossa point is marked at a point 2 mm below the reference line and 10 mm in front of the tragus. Articular eminence point is marked at a point 10 mm below the reference line and 20 mm anterior to the tragus (*Figure 5*). During this procedure, patient keeps the mandible protruded and mouth wide open. Two needles are used: one to deposit the solution, and the other to allow drainage of the solution. These needles are introduced into the upper joint space. Needle is inserted at an angle of 45 degree at glenoid fossa in a superior, medial and anterior direction, and 2 mL of ringer solution is deposited to distend the upper joint compartment. At the articular eminence point, the second needle is inserted in posteriorly, superiorly and medially. With both needles in position, solution is deposited through the first needle for lavage, while second needle acts as a portal for outflow of lavage materials (17,18). A meta-analysis by Monteiro *et al.* found no differences between the two techniques in terms of mouth opening or operative time (19).

Arthroscopy

An arthroscopic telescope (1.8–2.6 mm in diameter) with an attached camera is introduced into the upper compartment of the TMJ, and its two-dimensional image is viewed in a monitor. Another access point 10–15 mm anterior to the arthroscope is placed as portal for outflow and instrumentation (20). General or local anaesthetic is used before arthroscopy. If arthroscopy is the only surgery to be performed, local anaesthesia is used; if another procedure is to be performed, general anaesthesia is used. The

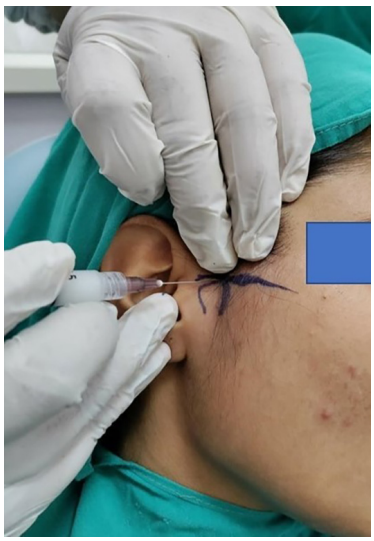

Figure 6 The figure depicts intraarticular injection technique.

preferred local anaesthetic is 2% lidocaine with 1:100,000 epinephrine. This method, like arthrocentesis, employs the same cantho-tragal reference line. First, a 21-gauge needle is placed at 90 degrees to the skin at a point 12 mm anterior to the tragus and 2 mm below the cantho-tragal referral line with a 10 mL syringe containing saline. To penetrate the superior joint space, the needle is directed anteriorly and superiorly. Another puncture incision is made 5–8 mm anterior to the first point, to insert a sleeved trocar, to which a scope with an eye piece or a chip camera can be attached to visualise the joint space. If there are adhesions or loose bodies in the joint space, they can be removed (21).

Intracapsular or intraarticular injection

Intraarticular injections are given to the upper compartment as they are larger and easy to locate. During the procedure, the TMJ area is prepared using antiseptic, and the mouth is kept in a partially opened position. A 23-gauge needle with a 2 mL syringe is inserted at a point 8 to 10 mm anterior to the tragus and 2 to 3 mm inferior to the zygomatic arch (*Figure 6*). The needle is introduced into the upper compartment posterior and superior to the lateral pole of the condyle. After reaching the upper compartment, a local anesthetic is injected, the needle is left in place, and the syringe is withdrawn and replaced with one carrying medication. The needle is removed once the medication has been injected, and pressure is applied for 1 to 2 minutes (22,23).

Postoperative instructions: after the above procedure, patient may require administration of analgesics, intermittent ice application for next 48 hours.

Discussion

In this review, the existing literature was analysed and various joint interventional procedures are evaluated and explained (*Table 3*). TMDs are a result of multifactorial causes which are compounded by local, systemic, psychological and structural factors. Trauma and parafunctional habits may initiate the TMD, which is further complicated by dynamic mechanical and muscular disharmony, condition of articular disc and retro discal tissue. These elements act singly or together causing increase in inflammatory mediators, cytokine production, and cartilage destruction, thus altering joint homeostasis and causing arthritic changes, and disc pathologies (*Figure 7*). These inflammatory mediators, as well as some pathologies like adhesions and loose bodies, can be flushed out or eliminated by these interventional procedures. TMDs produce overlapping symptoms, often challenging the diagnosis and management. Distinguishing site and source of pain are critical for successful management (41-44). Nerve blocks can aid in diagnosis or used before interventional procedures to anesthetise the region or therapeutically in the management of TMDs.

TMJ interventions when performed under local anesthesia, requires ATN block and masseteric nerve block to temporarily anesthetize the region. The ATN block eliminates pain temporarily, differentiates primary pain from referred pain, differentiates true joint pain from other pain such as pain originating from muscles, odontogenic causes or central pain (12,13). It is useful before invasive treatment to rule out if the TMJ is involved or not. This block also decreases pain and protective muscle splinting, which helps in achieving increased range of motion. It helps in other therapies such as joint exercises and therapeutic injections (14). Zhou *et al.* found satisfactory outcome in patients with closed lock when ATN block was performed along with mandibular exercises (13) Majumdar blocked the ATN before interventional procedures for hypermobility of the TMJ (14). Demirsoy *et al.* investigated efficacy of ATN block as a conjunction therapy along with conservative therapy in 22 patients with disc displacements and found significant differences in mouth opening and pain reduction at regular post treatment follow ups (12).

Masseteric nerve block suppresses sensory impulses from masseter muscle and is indicated for pain, myalgia, soreness, spasm of masseter muscle origin, protractive muscle splinting,

Table 3 Summary of various meta-analysis of joint interventions published in literature

Reference	Number of articles included	TMD	Type of intervention	Agents used	Assessment	Results
Liu Y *et al.* (24)	11 RCTs	Temporomandibular osteoarthritis	Intra articular injections	Hyaluronic acid, corticosteroids, corticosteroid plus hyaluronic acid, morphine, tramadol, PDGF, placebo, arthrocentesis alone	Pain Movements of jaw	Pain reduction and improved jaw function was excellent in intra articular injections of morphine, tramadol, and PDGF after arthrocentesis Short term benefit of maximal mouth opening was seen with hyaluronic acid intraarticular injections Combination intraarticular injections (corticosteroids and hyaluronic acid) reduced symptoms than when used alone
Al-Moraissi EA (25)	6 (2 RCTs, 2 controlled clinical trials, and 2 retrospective studies)	Internal derangement of TMJ	Arthroscopy *vs.* Arthrocentesis	Arthroscopy- checked for synovial membrane adhesions and disc perforations; release of adhesion and no other intervention. Arthrocentesis was under local anesthesia; Intra-articular injection with saline, hyaluronidase, or corticosteroids	Pain Jaw function	Pain reduction and jaw function improvement was more effective using arthroscopy than arthrocentesis
Li DTS *et al.* (26)	11 articles: 8 RCTs, 3 prospective clinical studies	Disc displacement with or without reduction, arthralgia, Wilkes stages 3 and 4, internal derangement	Timing of Arthrocentesis *vs.* conservative management	3 groups: Arthrocentesis as the initial treatment, *vs.* as early treatment *vs.* late treatment	Pain Mouth opening	Beneficial results in all 3 groups when arthrocentesis was done within 3 months of conservative treatment
Nagori SA (27)	12 RCTs, 1 retrospective	Osteoarthritis Disc displacement with or without reduction TMJ inflammatory and degenerative diseases Joint pain	Arthrocentesis	Single-puncture arthrocentesis (type 1 or 2) *vs.* double-puncture arthrocentesis	Pain Maximal mouth opening Operating time Needle relocation	Operating time was less for Single-puncture type-2 arthrocentesis in comparison with the double-puncture method. Operating time difference was insignificant between type-1 single puncture and double-puncture arthrocentesis Single puncture type 2 arthrocentesis had less needle relocation No difference between pain reduction or maximal mouth opening between two techniques
Al-Hamed FS *et al.* (28)	9 RCTs	Osteoarthritis and disc displacement	Intraarticular injection	Platelet concentrates *vs.* hyaluronic acid or saline solution	Pain Mouth opening	In comparison with hyaluronic acid, Platelet concentrate reduces pain 3 months post-treatment In comparison with saline, platelet concentrate reduces pain and increases mouth opening for long term
Liu S *et al.* (29)	9 RCTs	Anterior disc displacement with or without reduction	Intraarticular injection and TMJ arthrocentesis	Intra-articular analgesic injections used were non-steroidal anti-inflammatory drugs and opioids	Pain Mouth opening	Statistically insignificant improvement of mouth opening or pain reduction using Intra-articular non-steroidal anti-inflammatory drugs with TMJ arthrocentesis Statistically significant pain reduction (at 1 week, 1, 3, and 6 months) and mouth opening (at 1 week, 1 and 6 months) using intraarticular injections of opioids with arthrocentesis of TMJ

Table 3 (*continued*)

Table 3 (*continued*)

Reference	Number of articles included	TMD	Type of intervention	Agents used	Assessment	Results
Bouchard C *et al.* (30)	5 RCTs	TMJ pain, arthralgia, disc displacement without reduction	Arthrocentesis or arthroscopy *vs.* nonsurgical treatment	Arthrocentesis and arthroscopy Nonsurgical treatment: soft diet, physiotherapy, splints, NSAIDs, corticosteroids, local analgesics, exercises	Pain TMJ function-mouth opening, chewing improvement; increased quality of life; complications	Pain reduction at 6 months and 3 months in intervention group No significant difference in improvement in mouth opening was observed at 6 and 1 month
Al-Moraissi EA *et al.* (31)	33 RCTs for maximal mouth opening, 36 for pain	Arthrogenous temporomandibular disorders (internal derangement and TMJ osteoarthritis)	Conservative treatment *vs.* Intra articular injections *vs.* arthrocentesis *vs.* arthroscopy *vs.* open joint surgery	Conservative treatment: exercises, splint therapy Intraarticular injections: hyaluronic acid or corticosteroid arthrocentesis: alone or with pharmaceutical agents Arthroscopy: alone or with HA and PRP open joint surgery: with physiotherapy	Pain and maximal mouth opening	Combination with intraarticular injection with adjuvant pharmacological agents showed more short and intermediate term effectiveness than conservative treatments in terms of improved mouth opening and pain reduction
Nagori SA *et al.* (32)	3 RCTs, 2 controlled clinical trials and 1 retrospective study	Closed lock, disk displacement, capsulitis, degenerative joint disease, synovitis	Arthrocentesis with or without splint therapy	Arthrocentesis: 2 needle technique followed by intra articular injection Splint therapy: hard and soft splint	Pain Mouth opening Mandibular movement: Protrusive movement, lateral movement, chewing ability or life index	No statistically significant difference in pain reduction or maximal mouth opening after arthrocentesis with or without splint therapy
Monteiro JLGC *et al.* (19)	9	Disc displacements with or without reduction Degenerative and inflammatory joint disease Osteoarthritis	Arthrocentesis	Single puncture arthrocentesis (type 1 and type II) *vs.* double puncture arthrocentesis	Pain Mouth opening Operative time	No statistical difference in improvement of mouth opening between single and double puncture arthrocentesis Double puncture arthrocentesis showed slightly better results in terms of pain reduction No statistically significant difference between operative time of type 1 single puncture arthrocentesis compared to double puncture arthrocentesis
Chung PY *et al.* (33)	5 RCTs	Osteoarthritis	Intraarticular injection after arthroscopy or arthrocentesis	Platelet rich plasma *vs.* placebo (hyaluronic acid, saline, or no injection	Pain Mouth opening	Pain reduction was better in plasma rich platelet injection compared to placebo. No difference in mouth opening in both groups
Liu Y *et al.* (34)	8 RCTs	Osteoarthritis of TMJ	Intraarticular injection	Corticosteroid *vs.* hyaluronic acid or placebo	Pain Mouth opening	Pain reduction was better with corticosteroid injections with arthrocentesis compared to placebo in the long-term, but was inferior in improving mouth opening Reduction in pain and improved mouth opening in both Corticosteroid and hyaluronate injections without arthrocentesis; however success rate of the corticosteroid group significantly lower than the hyaluronate group

Table 3 (*continued*)

Table 3 (*continued*)

Reference	Number of articles included	TMD	Type of intervention	Agents used	Assessment	Results
Reston JT *et al.* (35)	Prospective case series: 11, retrospective comparative study: 16, RCTs: 3	Disc displacement with or without reduction Degenerative joint disease	Surgical techniques	Arthrocentesis, arthroscopy, discectomy without replacement, or disc repair/ repositioning	Pain Mouth opening	For disc displacement without reduction, arthroscopy and arthrocentesis were effective significantly Highest improvement rate was statistically significant for disc repair/repositioning
Haigler MC *et al.* (36)	5 (3 RCTs; 2 CTs)	Osteoarthritis	Intraarticular injection	Study group: platelet-rich plasma or platelet-rich growth factor intraarticular injection Control group: no injection or saline injection or hyaluronic acid injection	Pain Mouth opening	No significant improvement in mouth opening in platelet-rich plasma or platelet-rich growth factor intraarticular injection group or control group or hyaluronic acid group Pain reduction was favorable in platelet-rich plasma or platelet-rich growth factor intraarticular injection group or control group or hyaluronic acid group
Vos LM *et al.* (37)	3 RCTs	TMJ arthralgia Disc displacement without reduction, closed lock	TMJ lavage *vs.* nonsurgical treatment	TMJ lavage: arthroscopy and arthrocentesis Nonsurgical: medical treatment, splint therapy, hot packs, exercises, physical therapy	Pain Mandibular range of movements	The statistically significant difference in pain reduction in TMJ lavage group. No difference in mouth opening improvement in both groups
Sakalys D *et al.* (23)	2 RCTs	Anterior disc displacement with or without reduction Osteoarthritis	Intraarticular injections with arthroscopy	Intraarticular injections used were plasma rich in growth factors and hyaluronic acid, followed by arthroscopy	Pain	Statistically significant pain reduction in plasma rich in growth factors intraarticular injections group compared with hyaluronic acid injections Pain management was better with intraarticular injections followed by TMJ arthroscopy
Moldez MA *et al.* (38)	7 RCTs	Arthritis Disc displacement with or without reduction Intracapsular TMDs Osteoarthritis	Intraarticular injection	Hyaluronic acid *vs.* corticosteroids	Pain	No statistical difference between hyaluronic acid or corticosteroids in pain reduction, but hyaluronic acid was better than placebo
Li F *et al.* (39)	6 RCTs	Osteoarthritis of TMJ	Intraarticular injection	Platelet rich plasma *vs.* placebo or hyaluronic acid	Pain	Pain reduction in platelet rich plasma injection group was more effective than placebo (at 6 months and 12 months post injection) Statistically significant pain reduction in platelet rich plasma injection group compared with hyaluronic acid injections at 12 months post injection
Li C *et al.* (40)	4 RCTs	Disc displacement with or without reduction Inflammatory and osteoarthritis	Intraarticular drug injection of Inferior or double TMJ spaces versus superior TMJ space	Hyaluronic acid and corticosteroid	Pain Mouth opening	Significantly increase in mouth opening and pain reduction in inferior or double spaces intraarticular injection technique compared with superior space injection technique, inferior or double spaces intraarticular injection technique were beneficial in long term than superior space injection

TMD, temporomandibular disorder; RCT, randomized control trial; PDGF, platelet-derived growth factor; TMJ, temporomandibular joint; NSAID, non-steroidal anti-inflammatory drug; HA, hyaluronic acid; PRP, platelet rich plasma; CT, control trial.

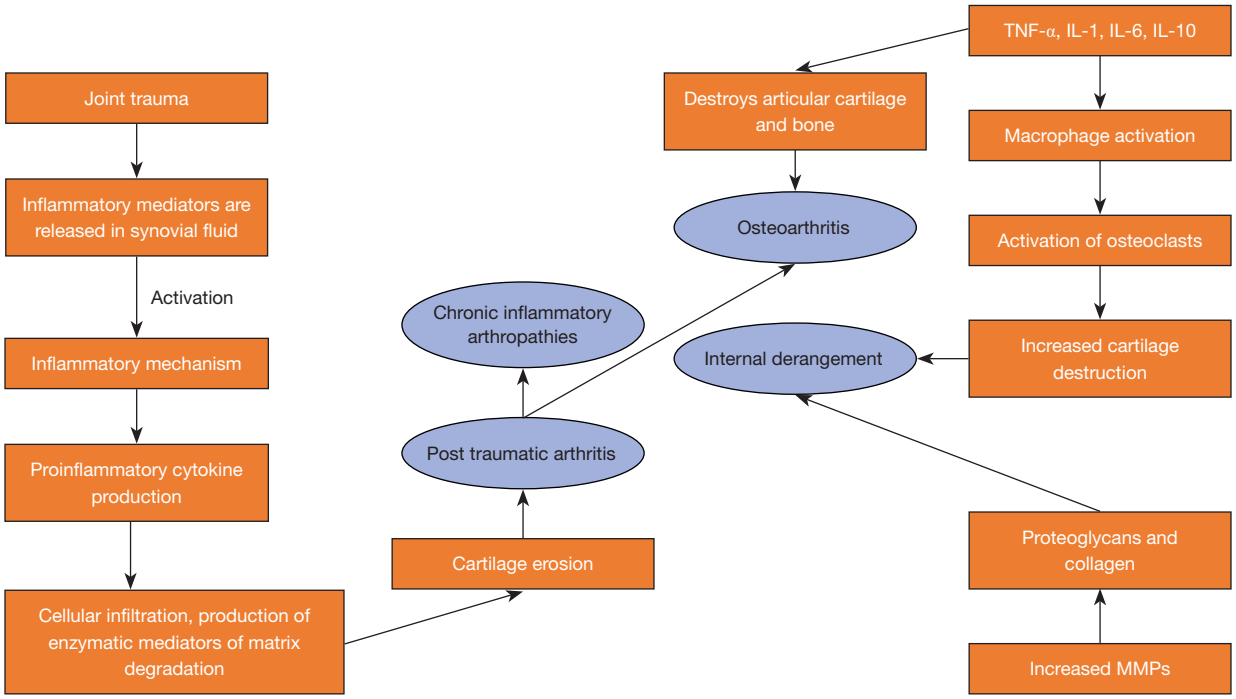

Figure 7 Pathophysiology of TMDs. TNF, tumor necrosis factor; IL, interleukin; MMP, matrix metalloproteinase; TMD, temporomandibular disorders.

chronic masseter muscle pain, subluxation and mandibular dislocations. Masseteric nerve is blocked effectively along with deep temporal nerve through extraoral approach via TMNB (45). For TMJDs, Young used TMNB for the reduction of resistant unilateral dislocated condyle which allowed minimally painful reduction of condyle (46) and recently it has also been reported to be effective in relieving pain in an internal derangement case of disc displacement without reduction (47). TNMB effectively reduces pain and improves jaw functions as it blocks both sensory and motor components of the nerve (48). Although a relatively safe technique without complications, temporary loss of blink reflex can occur due to anaesthesia of the temporal branch of the facial nerve as a result of penetration of anaesthetic agent into the parotid facia.

Arthroscopy involves direct visualization of the upper compartment of the joint using two ports; in one port a scope can be attached to visualize the joint, while small instruments pass through the other. Certain interventions such as washing out the joint, removing loose bodies, introducing pharmaceutical agents and breaking adhesion can be performed by skilled surgeons (49,50). Arthroscopy can be performed in cases of internal derangement, closed lock and osteoarthrosis. Arthroscopy allows inspection of the synovial lining, disc, articular cartilage, adhesions, loose bodies, perforation of the disc, and attachment of the disc. This procedure increases mandibular range of movement by improving disc mobility, and helps in pain reduction (20). Abboud *et al.* evaluated the efficacy and safety of lysis and lavage of the TMJ through arthroscopy in 47 patients with chronic close lock and found a 77% success rate with increased maximal mouth opening (21). Although a relatively safe procedure, some complications such as puncture of the tympanic membrane, nerve injury, hemorage, hemarthrosis, laceration of cartilage, glenoid fossa perforations and instrument breakage are some of the complications encountered (51). González-García encountered otologic, ocular and neurologic complications in 670 joints with TMJ derangement who underwent arthroscopy (52).

Arthrocentesis is an interventional procedure involving lavage of the TMJ, washing out inflammatory mediators, releasing the articular disc, and disrupting adhesions. The mechanism behind arthrocentesis is through the flushing out of inflammatory mediators that accumulate during the diseases process, such as interleukin (IL)-1, IL-2, IL-6, tumor necrosis factor (TNF)-alpha, and cytotoxins (53). Arthrocentesis distends the joint space and

disrupts adhesions in the disc (54). It eliminates negative pressure (55) and decreases intraarticular pressure (56). Also, arthrocentesis improves disc mobility, decreasing intraarticular surface friction (57,58). Although a relatively safe and less invasive procedure, pain, edema, transient facial nerve paralysis due to local anesthetic, injury to the superficial temporal artery, and bleeding into joint have been reported (59). As it is a blind needle insertion, difficulty in 2 needle insertion may be encountered. Literature reports 2–10% of arthrocentesis procedures have complications (17,57). However, this interventional procedure has low morbidity, is minimally invasive, economical, and remove synovial degradation products. Its reported success rate is 70–90% (59-61). Arthrocentesis is indicated in osteoarthritis (54), chronic joint pain (57), acute episodes of degenerative or rheumatoid arthritis (18), painful disc displacement with reduction (18), and post traumatic arthritis (62). Malachovsky *et al.* observed arthrocentesis reduces pain, need of analgesics, and improves mobility of joint (56). Arthrocentesis increased mouth opening and reduced pain without any complication and morbidity in 76 patients with internal derangement of TMJ (63).

A systematic review and meta-analysis comparing arthrocentesis and arthroscopy concluded that although high level evidence is lacking, arthroscopy may be slightly better that arthrocentesis for improving joint movement and reducing in pain in cases of internal derangement of TMJ while complications were similar in both procedures (25). Another systematic review had conflicting reports and suggested that there is lack of strong evidence and they should be advised with caution (30). Although insignificant clinically, they may have a better outcome in reducing pain in comparison to non-surgical modalities and they can be considered in patients refractory to conservative therapies (35,37,64). Among, different arthrocentesis techniques (single puncture and double puncture) both were equally effective in reducing pain and improving mouth opening (19,27). Most of the reported complications were temporary and resolved with no treatment (65).

Intracapsular or intraarticular injection is a therapeutic injection of a pharmaceutical agent into the TMJ. It is less invasive than surgery and can be performed with arthroscopy and arthrocentesis for better results (23). Various medications (*Table 4*), including corticosteroids, morphine, tramadol, sodium hyaluronate (low or high molecular weight), and platelet-rich plasma have been administered alone or in combination to treat acute synovitis, osteoarthritis, rheumatoid arthritis, gout, and psoriatic arthropathy. Liu *et al.* conducted a meta-analysis using various intraarticular injections for TMJ osteoarthritis and found effectiveness with tramadol, morphine and PDGF after arthrocentesis in reducing pain and improving mouth opening. While hyaluronic acid injection alone improves mouth opening, the combination of corticosteroid and hyaluronic acid injection reduces symptoms of both pain and improves mouth opening (24). Sakalys *et al.* found that subjects who received intraarticular injections of plasma rich in growth factors had statistically significant pain relief compared to hyaluronidase injections (23). Ok *et al.* used intra-articular injections of growth hormone in rat TMJs and found that growth hormone and insulin-like growth factor-1 concentrations were higher after local injections of growth hormone in comparison to controls, implying that growth hormone injections into the TMJ cartilage and subchondral bone reduced osteoarthritis scores in rats and that growth hormone injections for humans could be used in the future (66). Chandra *et al.* found that intraarticular injection of platelet rich plasma were more effective in symptom reduction and improving mouth opening than arthrocentesis in 52 patients who had refractory TMDs (67). De Sousa BM used various treatment modalities such as splint therapy, intraarticular injections with betamethasone, sodium hyaluronate, or platelet-rich plasma to treat TMDs and found long term success using combined treatment of splint and intraarticular injection of platelet rich plasma (22). A systematic review comparing various pharmacological agents including hyaluronic acid, morphine, dexamethasone, tramadol, placebo, platelet-derived growth factor (PDGF), prednisolone, betamethasone, betamethasone plus hyaluronic acid, arthrocentesis alone administered with intra articular injections concluded that injections of morphine, tramadol, PDGF after arthrocentesis improved pain and joint function in TMJ osteoarthritis. A combination of hyaluronic acid and corticosteroids was more effective in improving TMJ osteoarthritis symptoms than corticosteroids alone and hyaluronic acid alone was effective in improving mouth opening in short term (22). Corticosteroids may be indicated more for TMJ pain rather than for improving joint function and mouth opening Intra articular injections of non-steroidal anti-inflammatory drugs (NSAIDS) and opioids suggest low quality evidence that NSAIDS do not have any effect on pain and mouth opening related treatment outcomes while opioids may improve both in short term (34). Recent evidence also suggests that minimally invasive procedures with intra articular injections may be considered early in the short term (<5 months) and

Table 4 Pharmaceutical agents used for intraarticular injection

Type of pharmaceutical agent used in intraarticular injection	Mechanism of action	Dose
Corticosteroid	Powerful anti-inflammatory agent Inhibits pro inflammatory cytokine and enzyme expression Enhances IL-10, IL-1 receptor antagonists expression Activation of serotonin	Methyl prednisolone (20 mg in 0.5 to 1.0 mL suspension) Combination of betamethasone acetate and betamethasone phosphate (3 mg)—choice of drug for TMJ
Hyaluronidase	Maintains joint homeostasis Lubricates joint and balances distribution of stress, prostaglandin E2 and MMP synthesis is reduced, modulation of leukocyte function Anti-inflammatory Decreases mechanical wear and intraarticular fibrosis Hyaluronic acid maintains joint viscosity, and nutrition Hyaluronic acid is present in cartilaginous tissue and synovial fluid	High molecular weight (7×10^3 kD) sodium hyaluronate containing 8 mg/mL 2 injections at 1 week interval can be given Given in cases of inflammatory degenerative joint disease
Platelet concentrates	Contains growth factors in high concentration Contains cytokines Anti-inflammatory property Cell proliferation stimulation Accelerates cell differentiation Promotes healing process and cell repair	0.6 mL of PRP PRP is prepared by using citrated 10 mL of patient's venous blood and centrifugating for 15 min at 1,800 rpm followed by harvesting plasma rich layer at centrifuge at 3,500 rpm for 10 min Platelet concentrates—they are obtained from whole blood of patient; they can be 3 types: 1. plasma rich in growth factors; 2. platelet rich fibrin; or 3. platelet rich plasma
Morphine	Nociceptive neuron membrane becomes hyperpolarized, anti-inflammatory	0.1/1.0 mg
Tramadol	5-HT production is reduced Anti-inflammatory Decreased production of inflammatory cytokines Reduced leukocyte migration	50 mg/mL

IL, interleukin; TMJ, temporomandibular joint; MMP, matrix metalloproteinase; PRP, platelet rich plasma; 5-HT, 5-hydroxytryptamine.

intermediate period (up to 4 years) for relief of symptoms in TMJD patients who do not respond to conservative measures. or within a period of 3 months after conservative treatment (29).

Arthrocentesis or arthroscopy with injection of hyaluronic acid or Ringer's lactate solution or without an intra-articular injection in comparison to intra-articular platelet rich plasma (PRP) injections or platelet rich growth factors (PRGF) injections in patents with TMD simultaneously or after arthroscopy or arthrocentesis concluded that PRP or PGRP may be slightly better to reduce post-operative pain and improve TMJ function, but the results were not statistically significant and Type C recommendation may be given (25,26,68).

Another systematic review concluded that platelet concentrates may be slightly more effective than hyaluronic acid in improving pain in the initial 3 months but firm conclusion and evidence require further studies as there were variations in the methods of platelet concentrate preparation which may lead to varied results (27,28). Intra articular injections may also be used following arthroscopy and a systematic review suggests that PRP may be beneficial although there are limited studies (23). Limited evidence also suggests that splint therapy in conjunction with arthrocentesis may not confer additional benefits in comparison to arthrocentesis alone at 1 month. However, well designed studies with longer follow-up are essential to derive firm conclusions (27).

A systematic review and meta-analysis by Nogueira *et al.* comparing arthroscopy and arthrocentesis reported

that there was no significant increase in adverse effects between the two procedures and the adverse effects when present were temporary (65). Complications may include nerve injuries, optical injuries, breakage of the intra-articular instruments, otological injuries, vagal alteration, leakage of fluid into deep cervical tissues, vascular injuries and vertigo (69). Complications of arthroscopy were reported in 4% and most important ones included temporary frontal paralysis, prolonged cervical edema, and arthrocentesis complications (3%) included severe bradycardias, prolonged cervical edema. Complications were often related to the surgeon experience and most of the reported complications were temporary that resolved with no treatment (31).

Limitations of this review

Only PubMed, Scopus, and Google Scholar were used in this review. Furthermore, the articles included in this review were selected by manually that fulfilled inclusion and exclusion criteria. As a result, even if a comprehensive search was conducted, many articles may have been overlooked. Although this research includes descriptive analysis, no clear conclusions can be drawn because metanalysis was not included.

Conclusions

Diagnosis and management of TMDs are often challenging. Conservative methods are often accepted by patients, while surgical modalities are invasive and involve higher risks for more serious adverse outcomes. Hence TMJ injections are useful, economical, and less invasive methods of joint treatment with good success rates and should be performed in resistant cases with failure of conservative modalities before invasive surgical procedures are considered. If carefully performed by a skilled operator with knowledge of the local anatomy, these interventions are relatively safe. Intraarticular injections with or without arthroscopy and arthrocentesis for better results may be considered for immediate and long-term benefits in cases not responding to conservative modalities.

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Supplementary

Appendix 1

DATA BASE: PUBMED; Filters applied: Clinical trial, Metanalysis, Randomized controlled trial, Review, Systematic review			
Sl no	Search words	Number of articles	
1	Temporomandibular Joint Disorders or TMDs	3,485	
2	Temporomandibular Joint Disorders and Arthrocentesis	126	
3	Temporomandibular Joint Disorders and Arthroscopy	139	
4	Temporomandibular Joint Disorders and Intraarticular injections	126	
5	Temporomandibular Joint Disorders and Nerve blocks	14	
6	Auriculotemporal nerve block or ATN block	457	
7	Twin block	180	
8	masseteric nerve block	446	
9	Temporomandibular Joint Disorders and Auriculotemporal nerve block	6	
10	Temporomandibular Joint Disorders and twin block	3	
11	Temporomandibular Joint Disorders and masseteric nerve block	5	
Total articles: 4,987			
Data base: Scopus; Filters applied: review articles, research articles and others			
1	Temporomandibular Joint Disorders and Arthrocentesis	469	
2	Temporomandibular Joint Disorders and Arthroscopy	737	
3	Temporomandibular Joint Disorders and Intraarticular injections	369	
4	Temporomandibular Joint Disorders and Nerve blocks	88	
5	Auriculotemporal nerve block or ATN block	95	
6	Twin block and nerve block	47	
7	masseteric nerve block	20	
8	Temporomandibular Joint Disorders and Auriculotemporal nerve block	12	
9	Temporomandibular Joint Disorders and twin block	11	
10	Temporomandibular Joint Disorders and masseteric nerve block	1	
Total articles: 1,849			
Data base: Google Scholar; Filter applied: review articles; Year of search 2015 onwards first 20 pages of google scholar were considered (in case pages of google scholar search were more than 20).			
		Total articles	Screened articles from first 20 pages
1	Temporomandibular Joint Disorders or TMDs	2,650	200
2	Temporomandibular Joint Disorders and Arthrocentesis	627	200
3	Temporomandibular Joint Disorders and Arthroscopy	18,200	200
4	Temporomandibular Joint Disorders and Intraarticular injections	3920	200
5	Temporomandibular Joint Disorders and Nerve blocks	11,600	200
6	Auriculotemporal nerve block or ATN block	26	26
7	Twin block	12,100	200
8	masseteric nerve block	941	200
9	Temporomandibular Joint Disorders or TMDs and ATN block	39	39
10	Temporomandibular Joint Disorders or TMDs and twin block	83	83
11	Temporomandibular Joint Disorders or TMDs and masseteric nerve block	183	183
Total articles: 50,369; total articles screened: 1,731			

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