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# Computer-guided arthrocentesis of the temporomandibular joint: A narrative review

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**Abstract**
Temporomandibular joint (TMJ) arthrocentesis is a minimally invasive procedure widely used for the management of internal derangements and inflammatory disorders of the TMJ. Conventional arthrocentesis relies on anatomical landmarks and clinician experience, which may lead to variability in needle placement and outcomes. The integration of computer-guided technologies, including cone-beam computed tomography (CBCT), computer-aided design/computer-aided manufacturing (CAD/CAM), and three-dimensional (3D) printed surgical guides, has enhanced the precision, safety, and predictability of TMJ arthrocentesis. This narrative review aims to summarize the current evidence on computer-guided arthrocentesis of the TMJ, discussing indications, digital workflow, clinical outcomes, advantages, limitations, and future perspectives.

**Keywords:** Temporomandibular joint, arthrocentesis, computer-guided surgery, CAD/CAM, surgical guide, CBCT

## 1. Introduction
Temporomandibular disorders (TMDs) encompass a group of conditions affecting the TMJ, masticatory muscles, and associated structures. Arthrocentesis, first introduced by Nitzan *et al*., has become an established treatment modality for patients with closed lock, disc displacement without reduction, and inflammatory TMJ conditions refractory to conservative therapy. Despite its clinical success, conventional arthrocentesis is technique-sensitive and depends heavily on surface anatomical landmarks.
Advances in digital dentistry and maxillofacial surgery have enabled the development of computer-guided approaches for TMJ interventions. Computer-guided arthrocentesis utilizes patient-specific imaging and virtual planning to fabricate surgical guides that assist in accurate needle insertion into the superior joint space. This approach aims to reduce procedural errors, improve lavage efficiency, and minimize complications.

## 2. Rationale for Computer-Guided Arthrocentesis
Accurate access to the superior joint compartment is critical for the success of arthrocentesis. In conventional techniques, inaccurate needle placement may result in extra-articular fluid extravasation, inadequate lavage, facial nerve injury, or vascular complications. Computer-guided arthrocentesis addresses these challenges by:
- Enhancing precision of needle trajectory and depth
- Reducing operator-dependent variability
- Improving reproducibility and standardization
- Increasing safety, particularly in complex or anatomically compromised cases

## 3. Digital Workflow
The computer-guided arthrocentesis protocol typically follows a standardized digital workflow:

### 3.1 Imaging Acquisition
High-resolution CBCT scans are obtained to visualize osseous TMJ components. In some protocols, magnetic resonance imaging (MRI) data may be superimposed to assess disc position and soft tissues.

### 3.2 Virtual Planning
Dedicated software is used to identify the optimal entry points, angulation, and depth of needles into the superior joint space. Critical anatomical structures such as the facial nerve, superficial temporal vessels, and external auditory canal are considered during planning.

### 3.3 Surgical Guide Design and Fabrication
Patient-specific guides are designed using CAD software and fabricated via 3D printing. Guides may be tooth-supported, mucosa-supported, or bone-supported, depending on clinical requirements.

### 3.4 Clinical Procedure
The guide is positioned intraorally or extraorally, ensuring stable seating. Needles are inserted through guide sleeves according to the preplanned trajectory, followed by joint lavage and, when indicated, intra-articular injection of medications such as hyaluronic acid or corticosteroids.

## 4. Clinical Indications
Computer-guided arthrocentesis may be particularly beneficial in:
- Disc displacement without reduction (closed lock)
- Refractory inflammatory TMJ disorders
- Patients with altered anatomy or previous TMJ surgery
- Teaching and training environments
- Bilateral or repeated arthrocentesis procedures

## 5. Clinical Outcomes
Current literature reports favorable outcomes for computer-guided arthrocentesis, including:
- Significant reduction in pain intensity (VAS scores)
- Improvement in maximum mouth opening
- Decreased joint sounds
- High accuracy of needle placement confirmed radiographically

Comparative studies suggest that guided techniques may offer superior precision and reduced complication rates compared to conventional arthrocentesis, although long-term randomized controlled trials remain limited.

## 6. Advantages and Limitations
### 6.1 Advantages
- High precision and predictability
- Reduced risk of iatrogenic injury
- Shorter learning curve for less-experienced clinicians
- Improved patient confidence and acceptance

### 6.2 Limitations
- Increased cost and need for digital infrastructure
- Additional radiation exposure from CBCT
- Time required for planning and guide fabrication
- Limited availability of high-level evidence

## 7. Comparison with Conventional Arthrocentesis
While conventional arthrocentesis remains effective and widely practiced, computer-guided techniques represent an evolution toward precision-based TMJ interventions. The choice between approaches should consider clinician experience, case complexity, resource availability, and patient-specific factors.

## 8. Future Perspectives
Future developments may include dynamic navigation systems, integration of artificial intelligence for automated planning, and augmented reality-assisted TMJ procedures. These innovations have the potential to further enhance accuracy, efficiency, and clinical outcomes.

## 9. Conclusion
Computer-guided arthrocentesis of the TMJ is a promising advancement that enhances the accuracy and safety of a well-established minimally invasive procedure. Although preliminary results are encouraging, further high-quality clinical trials are required to validate its long-term benefits and cost-effectiveness.

## 10. Conflict of Interest
Not available.

## 11. Financial Support
Not available.

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