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Review article

Surgical Strategies for Temporomandibular Joint Disc Perforation: Current Approaches and Future Directions

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Abstract

Temporomandibular joint (TMJ) disc perforation-an end-stage manifestation of internal derangement – causes pain, dysfunction, and osteoarthritic changes. This review briefly covers its etiology, pathophysiology, diagnosis, and treatment. Chronic mechanical overload and inflammation degrade the disc's matrix, leading to perforation. While MRI can suggest perforation, arthroscopy remains the definitive diagnostic tool. After a trial of conservative therapy, small or moderate perforations may be addressed arthroscopically (lysis/lavage, margin debridement, or discopexy), with studies reporting significant pain relief and improved mouth opening. Larger or degenerative tears often require open surgery (disc repair, discectomy, interpositional grafts, or joint replacement). Emerging tissue-engineering techniques (e.g., stem cell–seeded scaffolds) show promise for regenerating irreparable discs. Future research should prioritize randomized trials, standardized outcomes measures, and biologic therapies to optimize long-term TMJ function.

Keywords： temporomandibular joint, disc perforation, arthroscopic surgery, open joint surgery, regenerative therapy.

Introduction

Temporomandibular disorders encompass a spectrum of joint and muscle conditions, among which internal derangement (ID) of the temporomandibular joint (TMJ) is common [1]. In late stages of ID (Wilkes stage III–V), progressive disc displacement can culminate in articular disc perforation, where a full-thickness defect

forms in the fibrocartilaginous disc [2]. Disc perforation compromises the disc's cushioning ability, allowing abnormal articulation between the mandibular condyle and the temporal bone, which accelerates cartilage wear and osteoarthritis. Histologically, perforated discs show disorganized collagen fibers and focal inflammation [3]. Clinical symptoms often include persistent joint pain, crepitus (a grinding noise), and limited mouth opening [4]. Given the potential for joint degeneration and ankylosis, effective management of disc perforation is critical. This review provides a comprehensive update on surgical treatments for TMJ disc perforation, comparing arthroscopic and open approaches, summarizing outcomes, and highlighting future directions.

Etiology and Pathophysiology

Disc perforation typically arises from chronic mechanical overload and inflammatory degeneration. Non-reducing anterior disc displacement subjects the disc to abnormal compression and shear forces, which, over time, thin and weaken the disc structure [5]. The biochemical milieu also changes: increased cytokines and matrix metalloproteinases degrade collagen and proteoglycans. In a recent histological case report, a perforated disc sample showed reduced collagen I and fibrillin-1, increased MMP-3/9 expression, and abundant macrophages around the lesion, indicating active extracellular matrix breakdown and inflammation. These factors compromise the disc's load-bearing capacity, making it susceptible to tearing. Clinically, co-factors like trauma and rheumatoid arthritis can contribute; one study found ~13% of perforation patients had trauma history and 13% had RA [6]. Dysfunctional habits (e.g., bruxism, unilateral chewing) may also accelerate wear. Importantly, longer symptom duration is strongly associated with perforation, as is advanced Wilkes stage with degenerative changes. In essence, disc perforation is an end-stage pathology of joint degeneration, where the protective disc fails and direct osseous contact leads to a vicious cycle of joint damage.

Diagnosis and Classification

Diagnosing TMJ disc perforation relies on imaging and arthroscopy. Magnetic resonance imaging (MRI) is widely used for TMJ evaluation, but its accuracy in detecting disc perforations is limited, with fair agreement between MRI findings and arthroscopic confirmation [7]. No standardized MRI criteria for perforation exist, and studies have shown only moderate sensitivity—thus, a negative MRI cannot reliably exclude a small perforation. Arthrography (contrast imaging) can occasionally reveal communication between joint compartments, but it is invasive and associated with potential discomfort and contrast-related risks [8]. In practice, diagnostic arthroscopy remains the gold standard because it allows direct visualization of the disc and any defects.

Clinically, certain signs can raise suspicion. Joint crepitus — a coarse "sand or glass"- like noise — is an advanced sign and often correlates with condylar cartilage roughening and probable perforation [9]. In contrast, a clicking sound tends to occur earlier in internal derangement and has been associated with lower perforation risk. Other risk factors identified include radiographic osteoarthritic changes and altered disc morphology on imaging [10]. Based on these patient features, predictive models have been proposed: one recent model combining symptom chronicity, MRI evidence of osteoarthritis, and joint crepitus achieved an area under the curve (AUC) of 0.836 for perforation prediction [11].

Disc perforations are also classified by location and size. One categorization divides perforations into five types: type I (posterior perforation), type II (anterior), type III (lateral), composite (multifocal), and destruction (extensive). This classification guides surgical planning: e.g., posterior-type defects may be approached with posterior disc anchoring, whereas anterior perforations might require anterior fixation or grafting. Additionally, correlation exists with Wilkes staging: stage IV joints (non-reducing displacement with OA) frequently have perforations, reflecting severe joint degeneration [12].

In summary, a combination of clinical assessment, MRI (to rule in/out other pathology), and arthroscopic confirmation is used to diagnose and classify disc perforation, which then informs treatment choice.

Treatment Strategies

Treatment of TMJ disc perforation typically follows a stepwise approach. Initially, conservative therapies—such as anti-inflammatory medications, occlusal splints, physical therapy, and joint injections—are attempted. A recent retrospective study reported that comprehensive conservative management significantly improved pain and range of motion in patients with disc perforation or retrodiscal rupture [13]. Approximately three-quarters of such patients experienced partial symptom relief, suggesting that non-surgical measures should generally be tried first. However, prolonged nonoperative treatment can delay definitive care. Current opinion is shifting toward not delaying surgical intervention excessively: recommendations suggest limiting conservative management to about 3 months and proceeding to intra-articular procedures (e.g. arthrocentesis or arthroscopy) if symptoms persist [14]. This reflects a balancing act—avoiding unnecessary surgery while preventing advanced joint damage from chronic dysfunction.

Once surgery is indicated, two broad strategies are considered: minimally invasive (arthroscopic) and open. Surveys of TMJ specialists indicate that most favor disc removal (discectomy) for symptomatic perforations, with many reserving total joint replacement for salvage situations. Nonetheless, opinions vary. Emerging evidence supports arthroscopic approaches as effective, especially in early or moderate cases [15]. In practice, the treatment plan is individualized. Generally, if the perforation is small and the remaining disc can potentially be salvaged, arthroscopy for lavage, debridement, and repair is attempted first. If the perforation is large, the disc irreparable, or there is advanced osteoarthritis, open arthrotomy with discectomy (and possibly interpositional grafting or joint replacement) may be chosen immediately [16]. Other factors influencing the choice include patient age, comorbidities, and surgeon expertise.

In summary, the treatment paradigm is first trying conservative care; if inadequate, proceed to minimally invasive surgery for moderate disease; and reserve open techniques for severe, refractory cases. This approach maximizes the chance of symptom relief while minimizing morbidity.

Surgical Techniques

Arthroscopic Procedures: TMJ arthroscopy allows diagnosis and simultaneous treatment. Level I arthroscopy (arthrolysis and lavage) is used to break adhesions and flush inflammatory mediators. In perforation cases, arthroscopic ablation (e.g. with shaver or laser) can smooth the perforation margin. Quinn et al. reported treating 44 perforated joints with arthroscopic lysis and abrasion (some using Holmium laser); patients showed significant mouth-opening improvements and pain reduction, leading the authors to suggest that arthroscopy might replace open discectomy in selected perforations [17].

Level II (interventional) arthroscopy includes disc suturing (discopexy) or resection. In Yang's arthroscopic repair technique, sutures are placed to re-anchor the disc. Liu et al. applied this to 112 patients (135 joints) with perforations, achieving a 90.4% success rate at 12 months [18]. The technique is biomechanically robust but technically demanding it often requires specialized cannulas and instruments, limiting its widespread use. Recent modifications aim to simplify the procedure without custom tools.

Arthroscopic discectomy (complete removal of the torn disc) is also described. Novel two-portal arthroscopic discectomy techniques using coblation or shavers have been reported, enabling complete excision of nonfunctional disc tissue with minimal invasiveness. Indications for arthroscopic discectomy include cases

where the disc is irreparable but degenerative changes are not so severe as to preclude minimally invasive management [19]. Advantages of arthroscopy include smaller incisions, less postoperative pain, and faster recovery. It also allows direct joint evaluation and osteoplasty if needed. Limitations are the learning curve and potential difficulty in advanced arthritis or ankylosis.

Open Joint Surgery: Open arthrotomy remains a cornerstone for many perforation cases. Procedures include open disc repair, disc excision, and possibly joint reconstruction. Disc Repair: When the perforation is moderate and the remaining disc tissue of good quality, open suturing or anchoring can be done. One technique ("modified disc anchorage") fixes the disc edges to the condylar neck with anchors and sutures. In a clinical series of 31 patients, this method achieved a 96.8% effective reposition rate and significant pain relief at 6 months [20]. This suggests that, for select perforations (e.g. type I, III from earlier classification), open repair can restore joint anatomy effectively.

Disc Excision and Interposition: If the disc is severely damaged or non-salvageable, it may be resected. This leaves a gap that is often filled with interpositional material to prevent bone-on-bone contact. A wide array of grafts have been used: autologous fat (abdominal or septal), temporalis muscle/fascia, dermal-fat grafts, auricular cartilage, and even alloplastic spacers. In surveys, 46% of surgeons report using abdominal fat as an interpositional implant after discectomy, and 10% use temporalis fascia [21]. Early animal studies demonstrated that autologous dermal grafts into disc perforations result in fibrous tissue growth across the defect, whereas untreated controls did not heal. Clinical reports similarly describe successful reconstruction with autologous cartilage or fascial-fat flaps. Open discectomy is especially indicated when perforation coexists with crepitus and condylar degeneration; it effectively relieves mechanical obstruction and can be combined with condylar shave, eminectomy or total joint replacement as needed. Downsides of open surgery include larger incisions, risk to facial nerve, longer recovery, and potential for postoperative joint noises and fibrosis [22]. Importantly, advocates of disc preservation argue that joint replacement should be postponed when possible, to allow for condylar remodeling and to avoid lifelong implant issues.

Comparative Analysis and Indications: In general, arthroscopic methods are preferred for younger patients or earlier-stage disease (Wilkes III–IV) because they preserve native structures and have good mid-term outcomes. Open approaches are often reserved for late-stage cases. In practice, many surgeons tailor their approach: for symptomatic perforations without severe osteoarthritis, arthroscopy (with or without repair) is attempted; if this fails or in the presence of ankylosis, open discectomy and reconstruction are performed. A recent international survey found that 66% of TMJ surgeons would choose discectomy for persistent symptomatic disc perforation, while about 31% would instead opt for alloplastic joint replacement, especially if deterioration is advanced [23]. This reflects the wide range of practice. Ultimately, success depends on careful case selection: small perforations with good disc mobility may do well with arthroscopy, whereas large, chronic perforations often need open solutions.

Emerging Therapies and Future Directions

Recent advances in regenerative medicine offer promising avenues for disc perforation repair. A 2024 review emphasized that only about 75% of TMJ disc perforations are currently repairable with existing surgical techniques, highlighting the need for novel solutions [24]. Tissue engineering strategies aim to heal or replace severely damaged discs. These include seeding stem cells (e.g., autologous TMJ-derived mesenchymal stem cells) onto biodegradable scaffolds shaped like the native disc. In a rabbit model, synovial MSCs seeded into a fibrin scaffold demonstrated hyaline-like fibrocartilaginous tissue formation at perforation sites after 12 weeks, suggesting potential for disc regeneration [25]. Three-dimensional (3D) printing and custom

bioreactors have also been investigated: polycaprolactone (PCL) scaffolds fabricated via 3D printing, when seeded with adipose-derived stem cells and cultured under dynamic loading, achieved integrated tissue formation resembling the native disc in vitro and prevented degeneration when implanted in vivo. Additionally, growth factor delivery systems—such as transforming growth factor-β (TGF-β)-loaded nanoparticles—and gene therapy approaches targeting proinflammatory cytokines (e.g., IL-1β antisense constructs) are under exploration to modulate joint inflammation and promote matrix synthesis [26]. Although still experimental, such approaches could one day regenerate a functional disc.

Biological treatments have also been studied. Autologous platelet-rich plasma (PRP) injections into the joint have shown symptomatic relief in TMJ disorders, although specific data for perforated discs remains limited; a recent systematic review reported significant improvements in pain and maximal interincisal opening, but heterogeneity in protocols precludes definitive conclusions [27]. Allogeneic collagen matrices (derived from bovine or porcine sources) have been used as disc implants in small clinical series, demonstrating satisfactory functional outcomes and low immunogenicity at one-year follow-up. There is also interest in chondroprogenitor cell transplantation: in a minipig model, implantation of nasal chondroprogenitor cells on a hyaluronic acid–gelatin scaffold into TMJ disc defects resulted in durable fibrocartilage regeneration after six months [28]. Overall, current regenerative therapies are in early stages; rigorous clinical trials are needed to assess safety, efficacy, and long-term integration.

From a clinical research standpoint, the field lacks high-quality evidence. Most outcome data come from retrospective series. Future priorities include randomized controlled trials comparing arthroscopic versus open treatments for disc perforation repair, standardized scoring of pain and function (e.g., use of the Research Diagnostic Criteria for TMD [RDC/TMD] and visual analog scales), and long-term follow-up (≥5 years) to assess joint health (e.g., progression of arthrosis, need for reoperation) [29]. Imaging advances, such as MRI arthrography with intra-articular gadolinium and novel molecular biomarkers detectable via positron emission tomography (PET), may improve perforation detection and patient selection [30]. Understanding which patients benefit most from repair versus replacement—accounting for factors like age, systemic disease (e.g., diabetes, rheumatoid arthritis), and parafunctional habits (e.g., bruxism) - remains a critical research challenge.

Conclusions

TMJ disc perforation represents a complex surgical problem at the interface of joint mechanics and biology. Both arthroscopic and open surgical approaches can be effective when appropriately applied, but neither is universally superior. Key surgical techniques—arthroscopic lavage, disc discopexy, open repair, discectomy with grafting—each have specific indications, advantages, and limitations. According to recent surveys, most experts favor discectomy (with or without interpositional graft) for symptomatic perforation, although minimally invasive approaches are increasingly used first-line. Critically, long-term outcomes depend on early intervention and appropriate technique selection. Currently, a portion of perforations remains unrepairable by conventional means, underscoring the need for advanced therapies. Future research should focus on evidence-based protocols, better diagnostic criteria, and regenerative treatments aimed at restoring disc integrity. By integrating surgical innovation with biologic repair strategies, the goal is to improve patient outcomes and preserve TMJ function over the long term.

Conflict of interests. The authors declare no conflicts of interest.

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Темпоромандибулярлы буын дискінің перфорациясының хирургиялық стратегиялары: Ағымдағы тәсілдер және болашақ бағыттары

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Түйіндеме

Темпоромандибулярлы буын (ТМЖ) дискінің перфорациясы - ішкі бұзылыстың соңғы сатыдағы көрінісі - ауырсынуды, дисфункцияны және остеоартриттік өзгерістерді тудырады. Бұл шолуда оның этиологиясы, патофизиологиясы, диагностикасы және емі қысқаша қарастырылады. Созылмалы механикалық жүктеме және қабыну диск матрицасын бұзады, бұл перфорацияға әкеледі. МРТ перфорацияны болжаса да, артроскопия түпкілікті диагностикалық құрал болып қала береді. Консервативті емді сынаудан кейін шағын немесе орташа перфорацияларды артроскопиялық жолмен шешуге болады (лизис/шаю, жиектерді тазарту немесе дископексия), зерттеулерде ауырсынудың айтарлықтай басылуын және ауыздың ашылуының жақсарғанын хабарлады. Үлкен немесе дегенеративті көз жасы жиі ашық операцияны қажет етеді (дискіні жөндеу, дискэктомия, интерпозициялық трансплантация немесе буындарды ауыстыру). Жаңадан дамып келе жатқан тіндік инженерия әдістері (мысалы, дің жасушаларының тұқымдары) қалпына келмейтін дискілерді қалпына келтіруге үміт береді. Болашақ зерттеулер рандомизацияланған сынақтарға, стандартталған нәтижелерге және TMJ функциясын ұзақ мерзімді оңтайландыру үшін биологиялық терапияға басымдық беруі керек.

Түйін сөздер: темпоромандибулярлы буын, дискінің перфорациясы, артроскопиялық хирургия, ашық буын хирургиясы, регенеративті терапия.

Хирургические стратегии при перфорации диска височно-нижнечелюстного сустава: Современные подходы и будущие направления

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Резюме

Перфорация диска височно-нижнечелюстного сустава (ВНЧС) - конечная стадия проявления внутреннего расстройства, которая вызывает боль, дисфункцию и остеоартрозные изменения. В данном обзоре кратко описаны этиология, патофизиология, диагностика и лечение перфорации диска ВНЧС. Хроническая механическая перегрузка и воспаление разрушают матрицу диска, что приводит к перфорации. Хотя МРТ может предположить перфорацию, артроскопия остается окончательным диагностическим инструментом. После попытки консервативной терапии небольшие или умеренные перфорации можно устранить артроскопически (лизис/промывание, краевая обработка или дископексия), при этом исследования сообщают о значительном облегчении боли и улучшении открывания рта. Более крупные или дегенеративные разрывы часто требуют открытой операции (восстановление диска, дискэктомия, интерпозиционные трансплантаты или замена сустава). Новые методы тканевой инженерии (например, каркасы, засеянные стволовыми клетками) обещают регенерировать невосстановимые диски. В будущих исследованиях приоритет следует отдать рандомизированным испытаниям, стандартизированным результатам и биологическим методам лечения для оптимизации долгосрочной функции ВНЧС.

Ключевые слова: височно-нижнечелюстной сустав, перфорация диска, артроскопическая хирургия, открытая хирургия суставов, регенеративная терапия.