IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Advances In Endoscopic Assisted Repair Of Condylar Fractures: A Review

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Abstract

Mandibular condylar fractures account for a significant proportion of maxillofacial injuries and present complex diagnostic and therapeutic challenges due to their anatomical and functional importance. Traditional open reduction and internal fixation (ORIF) ensures anatomical restoration but is associated with facial nerve injury, scarring, and morbidity, whereas closed reduction may result in suboptimal alignment and dysfunction. Endoscopic-assisted repair has emerged as a minimally invasive alternative that combines improved visualization with reduced soft tissue trauma, offering excellent functional and esthetic outcomes. Advances such as rigid angled endoscopes, CAD/CAM-designed patient-specific plates, and navigation-assisted surgery have enhanced accuracy and fixation stability, particularly in complex fractures. Clinical evidence indicates lower complication rates, rapid restoration of temporomandibular joint function, and superior patient satisfaction. Despite limitations in comminuted or severely displaced fractures, ongoing technological innovations and improved surgeon training are positioning endoscopic-assisted repair as a preferred modality for condylar fracture management.

Keywords: Mandibular condyle, Endoscopic-assisted repair, Minimally invasive surgery, CAD/CAM implants, Maxillofacial fractures

Introduction

Mandibular condylar fractures are among the most common maxillofacial injuries, accounting for 16–56% of all mandibular fractures, and present unique diagnostic and therapeutic challenges due to their anatomical complexity and crucial role in mandibular function. They occur more frequently in males in their third decade of life and are commonly associated with interpersonal violence, falls, and traffic accidents.[1] These fractures may be unilateral in the majority of cases (approximately 75%) or bilateral in about 25%, often occurring alongside other mandibular fractures such as those in the symphysis or

parasymphysis regions. Clinically, patients may present with pain, malocclusion, restricted mouth opening, facial asymmetry, and an increased risk of temporomandibular joint (TMJ) dysfunction if not managed effectively, all of which significantly impact both function and aesthetics.[2] Management strategies traditionally include open reduction and internal fixation (ORIF) or closed reduction with intermaxillary fixation (IMF), each with distinct advantages and limitations. While ORIF allows for direct anatomical restoration, it carries risks such as facial nerve injury, scarring, infection, and morbidity from extraoral approaches; conversely, closed reduction avoids surgical complications but may result in imperfect anatomical alignment, functional deficits, or even ankylosis in complex cases, particularly in pediatric patients.[3] The ongoing debate regarding the optimal treatment modality largely depends on patient age, fracture type, displacement, and surgeon expertise, but visibility constraints and proximity to vital structures like the facial nerve continue to complicate surgical management. In this context, endoscopic-assisted repair has emerged as a minimally invasive alternative that combines improved visualization with reduced soft tissue trauma, aiming to preserve aesthetics while lowering the risk of complications. Utilizing intraoral or transoral incisions and specialized endoscopic instruments, this approach facilitates accurate reduction and fixation with minimal external scarring and nerve injury, representing a significant advancement in the management of condylar fractures and increasingly being adopted by maxillofacial surgeons as technology and surgical expertise continue to evolve.[4] The aim of the article is to review Advances in Endoscopic assisted repair of condylar fractures

Anatomical and Biomechanical Considerations in Condylar Fracture Repair

The mandibular condyle, a vital component of the temporomandibular joint (TMJ), plays a central role in jaw movements essential for mastication, speech, and facial expression. Structurally, it is a rounded projection at the superior end of the mandibular ramus that articulates with the mandibular fossa of the temporal bone through a synovial joint, separated by a fibrocartilaginous disc to facilitate both rotational and translational movements. These complex motions including elevation, depression, protrusion, retraction, and lateral deviation—are coordinated by the surrounding masticatory muscles that attach near the condyle. Because the condyle directly influences occlusion and TMJ dynamics, precise anatomical reduction and fixation are critical to restoring functional articulation, preventing malocclusion, and maintaining mandibular mobility.[5] Inadequate reduction may result in pain, restricted mouth opening, disc displacement, ankylosis, or long-term dysfunction that compromises quality of life. Conventional open surgical approaches, such as preauricular or submandibular access, provide direct visualization but remain limited by the condyle's deep anatomical position, the presence of intricate neurovascular structures, and the risk of facial nerve injury or visible scarring. These challenges highlight the limitations of traditional access and have driven the development of minimally invasive strategies designed to optimize visualization, minimize soft tissue trauma, and preserve both function and aesthetics. Understanding these anatomical and biomechanical principles underscores the importance of safe and accurate reduction methods, thereby supporting the clinical adoption of endoscopic-assisted repair in the management of condylar fractures.[6]

Review of Literature

Endoscopic-assisted surgical techniques have gained increasing attention as minimally invasive alternatives for condylar fracture repair, with several studies highlighting their advantages in visualization, fixation, and functional outcomes. The transoral endoscopic approach has been shown to facilitate direct access to the fracture site, improving anatomical alignment and fixation accuracy (Neuhaus et al., 2021; Paeng et al., 2005).[7,8] Comparative analyses suggest that transoral access offers lower complication risks than the transbuccal method, particularly in terms of facial nerve weakness, which was reported at 0.8% versus 1.24%, respectively (Roychoudhury, 2023). In addition, surgical efficiency appears to be enhanced with the transoral approach, as studies have demonstrated shorter operative durations compared to transbuccal techniques (Roychoudhury, 2023).[9] Regarding postoperative outcomes, Neuhaus et al. (2021) observed early complications in 18.7% of cases, with late complications reduced significantly to 2.1%, underscoring the potential for improved long-term prognosis. Patient selection remains a crucial determinant of success, with guidelines emphasizing fracture type, displacement, and patient age as key criteria for recommending endoscopic methods (Akdag et al., 2020).[10] Despite these positive reports, some

clinicians remain hesitant to adopt endoscopic techniques due to the steep learning curve and specialized equipment requirements (Martin & Lee, 2003).[11] Nonetheless, ongoing advancements in surgical technology, instrumentation, and surgeon training are progressively addressing these challenges, making endoscopic-assisted repair an increasingly viable and preferred option in the management of mandibular condylar fractures.

Surgical Approaches and Fixation in Endoscopic-Assisted Condylar Fracture Repair

Endoscopic-assisted repair of mandibular condylar fractures utilizes several surgical approaches and advanced instrumentation to optimize access, visualization, and fixation while minimizing morbidity. The intraoral or transoral approach, which involves an incision inside the mouth, is widely favored for its cosmetic advantage of avoiding external scars and reducing the risk of facial nerve injury, with visualization sometimes enhanced through a submandibular port that allows auxiliary instrumentation such as trocars or retractors particularly useful in managing medially displaced or high condylar fractures. Another less common option, the retroauricular approach, offers access from behind the ear with reduced visible scarring and limited direct facial nerve trauma, though it is less frequently employed in endoscopic procedures.[12] Visualization is most commonly achieved with rigid endoscopes, typically 4 mm in diameter, where 30° angled scopes provide a broad and clear operative field, while 45° scopes permit access to posteriorly or medially situated fractures but require higher technical proficiency. Flexible endoscopes, although less common, may aid in navigating the narrow, complex condylar anatomy. Fixation methods include titanium miniplates, often two per fracture site to ensure stability, resorbable plates that eliminate the need for secondary removal especially beneficial in pediatric cases and increasingly, 3D plates or CAD/CAM-designed patient-specific implants that offer superior anatomical fit and are advantageous in complex or comminuted fractures.[13] Specialized instrumentation such as endoscopic elevators, trocars, and retractors facilitates atraumatic manipulation and portal maintenance, while angled endoscopic drills and screwdrivers enable precise screw placement in confined spaces. In high-resource centers, navigation-assisted systems with 3D tracking further enhance accuracy in complex cases, showing how technological advancements have expanded the safety and effectiveness of endoscopic-assisted condylar fracture management.[14]

Clinical Outcomes of Endoscopic-Assisted Condylar Fracture Repair

Clinical evidence increasingly supports endoscopic-assisted techniques as a safe and effective alternative to traditional extraoral approaches for condylar fracture management, with studies consistently demonstrating lower complication rates, including reduced risks of facial nerve injury, hematoma formation, infection, and salivary fistulas. Functional outcomes are generally excellent, with most patients achieving rapid restoration of temporomandibular joint (TMJ) mobility, stable occlusion, and pain-free jaw function, while the absence of external scars contributes to superior esthetic results and high levels of patient satisfaction. Initially limited to subcondylar fractures, indications for endoscopic-assisted repair have expanded to include condylar neck and base fractures when adequate fragment size is present typically greater than 15 mm allowing for reliable fixation with one or two osteosynthesis plates depending on the complexity of the fracture.[15] Patient-specific factors, such as displacement and fracture pattern, guide the choice of fixation strategy, and the use of CAD/CAM-based plates has further improved clinical outcomes in complex cases. However, successful results remain strongly dependent on surgical expertise and access to specialized equipment, as the procedure requires advanced skills and entails a steep learning curve before mastery is achieved. Despite these advantages, limitations persist in the management of highly comminuted, severely displaced, or very high condylar fractures, where restricted access and visualization continue to pose challenges, often necessitating conventional open techniques. Nevertheless, with ongoing improvements in instrumentation, imaging, and surgeon training, endoscopic-assisted approaches are rapidly gaining prominence as a preferred modality, offering the dual benefits of functional restoration and superior esthetic outcomes.[16,17]

Recent Advances in Endoscopic-Assisted Condylar Fracture Repair

Recent innovations have significantly advanced the field of endoscopic-assisted repair for mandibular condylar fractures, particularly through the widespread adoption of transoral approaches that provide direct visualization, accurate reduction, and stable internal fixation while eliminating external incisions and thereby minimizing risks of facial nerve injury and visible scarring.[18] The integration of patient-specific, CAD/CAM-designed osteosynthesis plates has further enhanced anatomical precision and fixation stability, offering clear advantages in managing complex or significantly displaced subcondylar fractures. In addition, the refinement of specialized endoscopic instruments including rigid angled endoscopes, angled drills, and screwdrivers combined with 3D navigation and image-guided surgery, has improved intraoperative accuracy, reduced blood loss, shortened operative times, and lowered postoperative morbidity and hospital stays.[19] Emerging technologies such as endoscope-integrated ultrasonography and fluorescence-guided visualization provide real-time assessment of vascular and neural structures, enhancing surgical safety, while the development of minimally invasive fixation devices, including smaller titanium plates and bioresorbable materials, expands options for both adult and pediatric patients. Looking forward, hybrid techniques that combine endoscopy with robotic assistance are showing promise in further increasing precision and reducing surgeon fatigue, marking a new frontier in minimally invasive maxillofacial surgery.[20]

Conclusion

Endoscopic-assisted repair of mandibular condylar fractures offers a safe, minimally invasive technique that delivers excellent functional and esthetic results while reducing surgical morbidity. With ongoing advancements in navigation systems, robotics, and patient-specific implants, the approach is poised to become increasingly precise and effective. However, its broader adoption will depend on overcoming barriers such as the steep learning curve, equipment costs, and the need for robust long-term clinical evidence to validate outcomes.

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