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# Functional Outcomes Following Arthroscopic Versus Open Reduction of Mandibular Condylar Fractures

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## ABSTRACT

*Background: Surgical management of mandibular condylar fractures has traditionally relied on open reduction and internal fixation (ORIF) through retromandibular, submandibular, preauricular, or transparotid incisions, which provide direct fracture visualization at the cost of dissection near the facial nerve. Endoscope-assisted transoral fixation and arthroscopically guided reduction have emerged as minimally invasive alternatives intended to preserve the biomechanical benefits of rigid fixation while reducing this morbidity. Objective: This narrative review synthesizes the comparative literature on endoscopic- and arthroscopic-assisted versus conventional open reduction of mandibular condylar fractures to characterize their relative functional outcomes, operative morbidity, and evidentiary maturity. Methods: We reviewed randomized controlled trials, prospective comparative studies, case series, and systematic reviews and meta-analyses describing endoscope-assisted transoral fixation, arthroscopically guided condylar reduction, and their comparison with conventional open and closed treatment, drawing on the foundational technical literature on temporomandibular joint arthroscopy and the broader open-versus-closed condylar fracture evidence base. Findings: Endoscope-assisted transoral fixation achieves occlusal and functional outcomes essentially equivalent to conventional open reduction across randomized trials and pooled meta-analytic data, while consistently reducing the risk of facial nerve injury; this benefit is offset by substantially longer operative time and a demonstrable, center-dependent learning curve. Arthroscopically guided reduction, applicable chiefly to high condylar head and intracapsular fractures unsuited to plate fixation, remains supported largely by case-level evidence extrapolated from the mature general temporomandibular joint arthroscopy safety literature rather than by dedicated comparative fracture trials. Conclusions: Minimally invasive access techniques for mandibular condylar fracture surgery, particularly endoscope-assisted transoral fixation, now rest on a genuine comparative evidence base supporting a favorable morbidity profile without functional compromise, but their broader adoption is constrained by operative time and learning-curve considerations, and arthroscopically assisted reduction specifically warrants further prospective study.*

***Keywords:*** *mandibular condylar fracture; endoscope-assisted fixation; temporomandibular joint arthroscopy; open reduction internal fixation; facial nerve injury*

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## Introduction

Fractures of the mandibular condyle account for a substantial proportion of all mandibular trauma, and their surgical management continues to generate debate that is now shifting from a binary open-versus-closed framework, long characterized as a persistent treatment dilemma in the maxillofacial literature [1], toward a more granular question: among patients selected for surgical reduction, which access technique best balances anatomical restoration against surgical morbidity [2,3]. Conventional open reduction and internal fixation (ORIF) through retromandibular, submandibular, preauricular, or transparotid incisions provides direct visualization of the fracture but requires dissection through or near the facial nerve's branches, with attendant risks of transient or permanent weakness, sialocele, and visible scarring [4,5]. Over the past three decades, two related but distinct minimally invasive strategies have been developed to reduce this morbidity while preserving the biomechanical advantages of rigid fixation: endoscope-assisted transoral reduction, in which a rigid endoscope introduced through an intraoral incision provides visualization of the fracture site during reduction and plate

application without an external incision [6,7], and, less commonly, arthroscopically guided reduction of the TMJ itself, in which an arthroscope placed within the joint space is used to confirm condylar head position, disc relationship, and reduction adequacy, an approach first described for a high condylar process fracture by Anastassov and colleagues [8].

These two techniques are frequently discussed together in the oral and maxillofacial surgery literature because both substitute optical magnification and a minimally invasive portal for the wide surgical exposure of a traditional open approach, and both are compared against conventional ORIF using overlapping outcome measures: maximum interincisal opening, occlusal restoration, radiographic ramus height and condylar angulation, operative time, and facial nerve function [9,10]. The foundational technical literature on TMJ arthroscopy itself, most notably McCain and colleagues' six-year multicenter retrospective analysis of 4,831 arthroscopically treated joints, established both the safety profile and the functional benefit achievable through an intra-articular endoscopic approach to TMJ pathology, providing the technical and safety baseline against which arthroscopically assisted fracture applications are implicitly measured [11]. Endoscope-assisted transoral fixation has progressed considerably further along the clinical development pathway, having now been evaluated in randomized controlled trials, prospective comparative series, and multiple systematic reviews and meta-analyses directly comparing it with conventional extraoral open approaches [6,12,13,9].

This narrative review synthesizes the comparative literature on minimally invasive (endoscopic- and arthroscopic-assisted) versus conventional open reduction of mandibular condylar fractures across four domains: the surgical rationale, instrumentation, and technique variants that define these minimally invasive approaches; the comparative functional and occlusal outcome evidence, including randomized trials and pooled meta-analytic data; the operative morbidity profile, with particular attention to facial nerve injury, operative time, and the documented learning curve associated with endoscopic technique adoption; and the overall quality of the evidence base, patient selection considerations, and directions for future clinical research. Read together, this literature indicates that minimally invasive condylar fracture surgery has matured from isolated case reports into a technique supported by randomized comparative data, but one whose adoption remains constrained by a demanding learning curve and a persistently thin body of arthroscopy-specific outcome evidence relative to the endoscope-assisted transoral literature.

## Endoscopic and Arthroscopic-Assisted Techniques for Condylar Fracture Access and Fixation

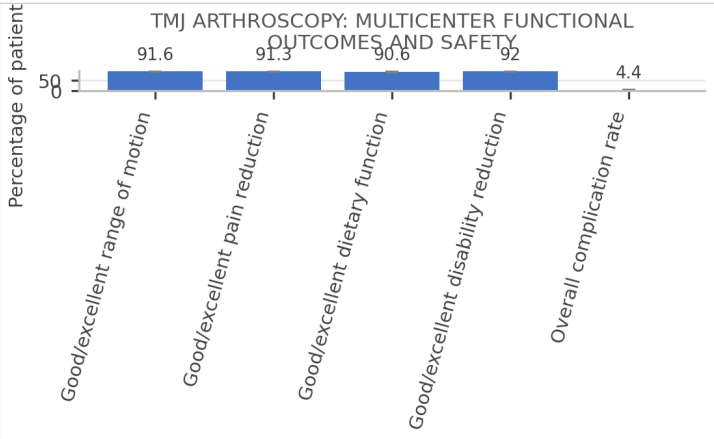
The unifying technical premise of minimally invasive condylar fracture surgery is that optical magnification delivered through a narrow portal can substitute for the wide surgical field of a conventional open approach, thereby permitting accurate reduction and rigid fixation while avoiding a facial-nerve-bearing extraoral dissection. Endoscope-assisted transoral fixation, the more extensively developed of the two strategies, uses a rigid 4-mm endoscope introduced through a small intraoral vestibular incision, together with specialized angled instrumentation, trocars, and percutaneous or transbuccal screwdrivers, to visualize the fracture line, achieve reduction, and place miniplates without an external incision [6,14]. Anehosur and colleagues' early series from a tertiary Indian maxillofacial center described this workflow in 15 patients with subcondylar and low condylar neck fractures, using a transbuccal trocar in the majority of cases to introduce the screwdriver at the angle required for plate fixation, and reported maximum intercuspation restored in all patients by six months, with a low complication rate limited to one transient facial nerve paresis and one draining sinus requiring plate removal [14]. Neuhaus and colleagues' larger single-institution series of 187 patients with 208 condylar base and neck fractures treated by an endoscopically assisted approach reported an early complication rate of 18.7% and a late (screw-loosening) complication rate of 2.1%, but, notably, zero cases of permanent facial nerve or parotid gland injury across the entire cohort, reinforcing that endoscopic visualization can be scaled beyond small pilot series while maintaining a favorable nerve-sparing profile [15]. Khiabani and colleagues directly compared this transoral endoscopic-assisted technique with closed treatment in a controlled series of 40 patients, finding that the endoscopic group achieved significantly greater restoration of posterior ramal height (a 5.8 ± 3.41 mm increase versus 1.45 ± 2.03 mm with closed treatment, p = 0.00) alongside modestly better mouth opening and lower occlusal disturbance, at the cost of a longer procedure (mean 80.35 minutes) [7].

***Representative endoscopic- and arthroscopic-assisted technique studies comparing minimally invasive access with conventional open reduction of mandibular condylar fractures cited in this review.***

| Study | Design | Technique compared | Principal finding |
|---|---|---|---|
| Anastassov et al. 2000 | Case report | Arthroscopically guided reduction, high condylar process fracture | Demonstrated technical feasibility of intra-articular arthroscopic guidance for reduction of a fragment unsuited to plate fixation |
| Anehosur et al. 2018 | Prospective case series (n=15) | Transoral endoscopic-assisted ORIF vs historical open approach | Maximum intercuspation restored in all patients by 6 months; 1 transient facial paresis, 1 draining sinus |
| Khiabani et al. 2015 | Comparative cohort (n=40) | Transoral endoscopic-assisted ORIF vs closed treatment | Posterior ramal height gain 5.8±3.41 mm (endoscopic) vs 1.45±2.03 mm (closed), p=0.00 |
| Neuhaus et al. 2021 | Retrospective single-institution series (n=187 patients, 208 fractures) | Endoscopically assisted ORIF | Early complication rate 18.7%, late complication rate 2.1%, zero permanent facial nerve injury |

| Study | Design | Technique compared | Principal finding |
|---|---|---|---|
| Sinha & Natarajan 2020 | Randomized comparative study (n=20) | Retromandibular transparotid vs transoral endoscopic-assisted ORIF | Comparable functional outcomes; endoscopic approach 3x longer operative time but fewer facial nerve injuries |

***Functional outcomes and overall complication rate from the largest available multicenter safety and outcome dataset for TMJ arthroscopy, the foundational technique underlying arthroscopically assisted condylar fracture reduction, across 4,831 arthroscopically treated joints in 3,146 patients over six years (McCain et al., 1992).***




Arthroscopically assisted reduction, by contrast, applies the instrumentation and portal technique of diagnostic and operative TMJ arthroscopy, established as a mature surgical discipline by McCain and colleagues' large multicenter safety and outcome analysis [11], to the different problem of visualizing and confirming reduction of a displaced or dislocated condylar fragment from within the joint space itself, rather than fixing the fragment through an external plate-and-screw construct. Anastassov, Lee, and Schneider's case report of arthroscopic reduction of a high condylar process fracture demonstrated the technical feasibility of using arthroscopic visualization to guide manipulation of the condylar fragment back into an anatomically acceptable position relative to the glenoid fossa and articular disc, an approach particularly suited to high condylar head fractures in which the fragment is too small or too intracapsular to support conventional screw fixation and for which an external approach carries a disproportionate risk relative to the limited fixation achievable [8]. Because arthroscopic guidance in this setting is generally paired with closed or percutaneous manipulation rather than rigid internal fixation, it occupies a narrower niche than endoscope-assisted transoral ORIF, applicable chiefly to fracture patterns for which open plate fixation is not feasible.

A further technical distinction relevant to outcome comparison is the choice between purely transoral endoscopic access and hybrid or alternative extraoral minimally invasive approaches. Sinha and Natarajan's randomized comparative study contrasted a retromandibular transparotid approach with a transoral endoscopic-assisted approach in twenty patients with subcondylar fractures, finding that although functional outcomes measured by the Helkimo dysfunction index did not differ significantly between groups, the endoscopic approach required roughly three times the operative time of the retromandibular approach (196.6 ± 48.9 minutes versus 63.5 ± 12.48 minutes) while producing substantially fewer temporary facial nerve injuries [13]. This trade-off between operative efficiency and nerve-sparing visualization recurs throughout the comparative literature and frames much of the clinical decision-making around whether to adopt a minimally invasive access technique for a given patient and fracture pattern [16,9].

## Comparative Functional and Occlusal Outcomes: Minimally Invasive versus Conventional Open Reduction

The strongest evidence for functional equivalence or advantage of minimally invasive approaches over conventional open reduction comes from randomized and prospective comparative trials specifically designed around this comparison. Schmelzeisen and colleagues' multicenter randomized controlled trial, conducted between 2003 and 2006 across 74 patients with condylar fractures randomized to an endoscopically assisted transoral approach (n = 40) or a conventional nonendoscopic extraoral approach (n = 34), found comparable Helkimo dysfunction scores between groups at both 8-to-12-week and one-year follow-up, with no statistically significant difference in functional outcome, while the endoscopic group required longer operative time but experienced a lower rate of facial nerve injury [6]. Anehosur and colleagues' subsequent randomized clinical trial directly comparing an endoscopic approach with a conventional retromandibular approach reinforced this pattern of broadly comparable functional restoration between access techniques, with the principal differentiator again being the morbidity profile rather than the degree of functional recovery achieved [12].

Meta-analytic synthesis of this comparative literature has generally supported the conclusion that endoscope-assisted transoral treatment achieves outcomes at least equivalent to, and in some respects favoring, conventional open reduction. Cavalcanti and colleagues' meta-analysis pooling evidence across the endoscopic-versus-open comparative literature concluded that surgical treatment of adult mandibular condylar fractures, whether by endoscopic or conventional open technique, provides better outcomes than closed treatment, while highlighting that endoscopic-assisted surgery in particular offers a facial-nerve-sparing alternative without meaningfully compromising occlusal or functional recovery relative to conventional ORIF [9]. Bera and colleagues' three-arm meta-analysis comparing closed, open, and endoscopically assisted management reached a similar conclusion at a broader evidentiary scope, finding that outcome differences among the three modalities are real but modest and substantially influenced by fracture level, displacement, and surgeon experience, a caveat that applies with particular force to the technically demanding endoscopic and arthroscopic techniques [10]. Al-Moraissi and colleagues' more recent network meta-analysis of randomized clinical trials for adult condylar process fractures incorporated the endoscopic-versus-open comparative trials alongside the broader open-versus-closed literature, situating endoscope-assisted ORIF as a technique variant within the overall hierarchy of surgical options rather than a categorically distinct treatment, and reinforcing that fracture-level-specific and displacement-specific indications, rather than access technique alone, remain the dominant determinants of functional outcome [17,3].

Radiographic and biomechanical outcome measures add a further dimension to this functional picture. Khiabani and colleagues' finding of significantly greater restoration of posterior ramal

height with the transoral endoscopic-assisted technique compared with closed treatment suggests that endoscopic visualization may confer a specific advantage in achieving accurate three-dimensional reduction of the proximal fragment, an advantage that would be expected to translate into better long-term occlusal stability and reduced risk of secondary malocclusion or facial asymmetry, although this specific radiographic endpoint has not yet been directly compared between endoscopic and conventional open ORIF in a randomized design [7]. Taken together, the weight of comparative evidence indicates that where endoscope-assisted transoral fixation is technically feasible, it achieves functional and occlusal outcomes essentially equivalent to those of conventional open reduction, positioning the choice between techniques as primarily a question of morbidity and surgical resource allocation rather than a functional outcome trade-off [4,18].

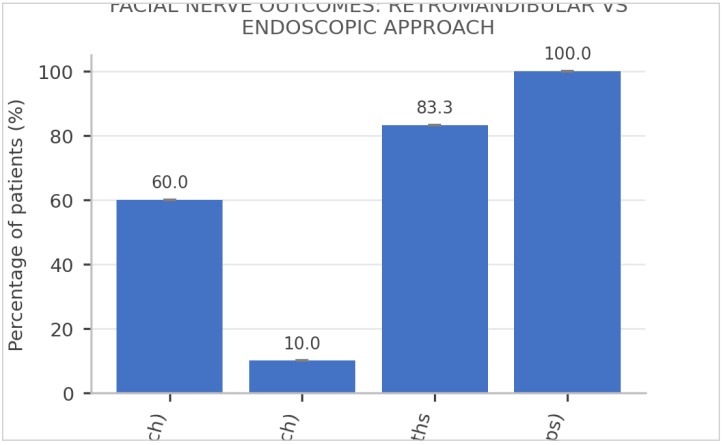
***Randomized and meta-analytic evidence comparing endoscopic-assisted with conventional open reduction of mandibular condylar fractures cited in this review.***

| Study | Design | Comparison | Principal finding |
|---|---|---|---|
| Schmelzeisen et al. 2009 | Multicenter randomized controlled trial (n=74) | Endoscopic transoral (n=40) vs nonendoscopic extraoral (n=34) | Comparable Helkimo dysfunction scores at 8-12 weeks and 1 year; endoscopic group had lower facial nerve injury rate |
| Anehosur et al. 2019 | Randomized clinical trial | Endoscopic vs retromandibular approach | Comparable clinical outcomes between access techniques |
| Cavalcanti et al. 2021 | Meta-analysis | Endoscopic surgery vs open reduction | Surgical treatment (endoscopic or open) outperforms closed treatment; endoscopic approach nerve-sparing without compromising function |
| Bera et al. 2022 | Three-arm meta-analysis | Closed vs open vs endoscopically assisted management | Modest but real outcome differences, heavily influenced by fracture level, displacement, and surgeon experience |
| Al-Moraissi et al. 2023 | Network meta-analysis of RCTs | Multiple treatment modalities including endoscopic-assisted ORIF | Fracture-level and displacement-specific indications remain dominant determinants of outcome |

## Operative Morbidity: Facial Nerve Injury, Operative Time, and the Learning Curve

If functional and occlusal outcomes are broadly comparable across access techniques, the comparative literature is far more decisive on the question of operative morbidity, where minimally invasive approaches show a consistent and clinically meaningful advantage with respect to facial nerve injury, offset by consistently longer operative times and a documented learning curve. Sinha and Natarajan's head-to-head comparison found that six of ten patients treated by the retromandibular transparotid approach experienced temporary facial weakness compared with only one of ten in the transoral endoscopic-assisted group, even though five of the six affected retromandibular patients had recovered by six months, illustrating both the elevated nerve-injury risk of the direct extraoral approach and its predominantly transient, self-limited character [13]. Agier and colleagues' large series of 329 patients undergoing open rigid internal fixation via conventional extraoral approaches quantified this baseline risk at greater granularity, finding that just over half of patients (50.45%) showed some sign of postoperative facial nerve dysfunction, the great majority transient, with only 1.82% sustaining permanent injury and 98.16% of affected patients achieving complete functional restoration during follow-up [5]. This baseline risk profile from conventional ORIF provides the comparator against which the nerve-sparing benefit of endoscopic and arthroscopic access must be weighed.

***Facial nerve weakness incidence and recovery, and occlusal restoration, from a randomized comparative study of retromandibular transparotid (RMT, n=10) versus transoral endoscopic-assisted (ENDO, n=10) approaches for surgical management of mandibular subcondylar fractures (Sinha & Natarajan, 2020).***




The trade-off for this reduced nerve-injury risk is consistently longer operative time. Sinha and Natarajan documented a roughly three-fold increase in operative duration with the transoral endoscopic-assisted approach relative to the retromandibular transparotid approach (196.6 versus 63.5 minutes) [13], while Khiabani and colleagues' endoscopic series likewise reported a substantially longer procedure time than would be expected for closed treatment [7]. Schmelzeisen and colleagues' randomized trial similarly noted that the endoscopic approach required more operative time than the nonendoscopic comparator, even as it achieved a lower facial nerve complication rate, reinforcing that the time cost of endoscopic visualization is a robust and reproducible finding across independent study populations and surgical teams rather than an artifact of any single center's early experience [6].

This operative time penalty is closely tied to a well-documented learning curve, a factor identified as a specific limitation by Sinha and Natarajan, who noted that the endoscopic approach "demonstrates a steep learning curve requiring enhanced instrumentation development" even as it appeared safer with respect to facial nerve protection [13]. McCain and colleagues' foundational multicenter TMJ arthroscopy safety analysis is instructive on this point at a broader scale: across 4,831 arthroscopically treated joints, the overall complication rate was low (4.4%), with good-to-excellent functional outcomes achieved in over 90% of cases across range of motion, pain, diet, and disability domains, but the study explicitly attributed variation in these outcomes across the twelve participating centers to differences in surgeon experience with the arthroscopic

technique, a pattern directly analogous to the center- and surgeon-dependent variability reported in the smaller, more fracture-specific endoscopic and arthroscopic condylar literature [11,10]. Eckelt and colleagues' earlier prospective randomized multicenter study of open versus closed treatment of condylar process fractures, though not itself an endoscopic-technique trial, established the broader principle that fracture-level-specific outcome differences and technique-dependent morbidity are recurring features of the condylar fracture surgical literature that any newer access technique, endoscopic or arthroscopic, must be evaluated against [16].

## Evidence Quality, Patient Selection, and Future Directions

The overall quality of the evidence base must be interpreted against the backdrop set by the highest level of evidence synthesis available for condylar fracture surgery generally: the Cochrane systematic review of interventions for mandibular condyle fracture treatment concluded that the underlying trial evidence, even for the foundational open-versus-closed comparison, remains limited in quantity and methodological quality, with substantial uncertainty about which patients derive the greatest benefit from any surgical approach [19]. This caution applies with even greater force to the narrower endoscopic- and arthroscopic-assisted subset of the literature reviewed here, where trial numbers are smaller still. Synthesizing across the technical, functional, and morbidity literatures reviewed above yields a coherent but asymmetric picture of the evidence supporting minimally invasive condylar fracture surgery. Endoscope-assisted transoral fixation now rests on a genuinely comparative evidence base that includes at least two randomized controlled trials directly pitting it against conventional open reduction [6,12], multiple prospective comparative cohort studies [7,13], and several meta-analyses pooling this literature alongside the broader open-versus-closed and closed-versus-open-versus-endoscopic comparative trials [9,10,17]. This body of evidence supports a reasonably confident conclusion that, in centers and surgeons with adequate endoscopic experience, transoral endoscopic-assisted ORIF achieves occlusal and functional outcomes equivalent to conventional open reduction while substantially reducing the risk of facial nerve injury, at the cost of longer operative time and a demonstrable learning curve [6,13,9].

Arthroscopically guided reduction of the condyle, by contrast, remains supported chiefly by case-level and small-series evidence extrapolated from the much larger and more mature general TMJ arthroscopy literature rather than by dedicated comparative trials in fracture patients [8,11]. This asymmetry reflects the narrower anatomical niche in which arthroscopic guidance is most applicable, namely high condylar head and intracapsular fractures in which the fragment is too small to support external plate fixation and in which arthroscopic visualization of the joint space, disc, and articular surface offers information that neither an open approach nor blind closed manipulation can readily provide [8,2]. Because these fracture patterns are relatively uncommon and their surgical management highly individualized, accumulating trial-level evidence specifically for arthroscopic-assisted reduction is likely to remain difficult, and clinical practice in this domain will probably continue to be guided by case series, surgeon experience, and extrapolation from the broader TMJ arthroscopy safety and outcome literature for the foreseeable future [11].

Patient and fracture selection remains the dominant determinant of which access technique is appropriate, a conclusion echoed across the broader condylar fracture literature independent of the specific comparison under study. Youssef and colleagues' evidence-based indications review proposed that fracture level and degree of displacement or dislocation are the strongest predictors of which patients benefit from any form of open intervention, a framework that extends naturally to the choice between conventional and minimally invasive access once surgery is indicated [3]. Jazayeri and colleagues' broader systematic review and meta-analysis of open-versus-closed treatment similarly found that ORIF's functional benefits must be weighed against its infection and nerve-injury risks on a case-by-case basis, a calculus into which the nerve-sparing profile of endoscopic access technique now enters as an additional, increasingly evidence-supported variable [18]. Future research priorities that emerge clearly from this synthesis include larger multicenter randomized trials of endoscopic-assisted transoral fixation stratified by fracture level and displacement, standardized reporting of operative time and learning-curve metrics to allow cross-study comparison, and dedicated prospective case series or registries specifically evaluating arthroscopically guided reduction in condylar head fractures, an application that at present remains promising but evidentially thin relative to its transoral endoscopic counterpart [8,16,4].

## Conclusion

The comparative literature on minimally invasive versus conventional open reduction of mandibular condylar fractures has matured substantially over the past two decades, particularly for endoscope-assisted transoral fixation, which now rests on randomized trial and meta-analytic evidence indicating functional and occlusal outcomes equivalent to conventional ORIF alongside a materially lower risk of facial nerve injury [6,12,9,10]. This benefit is consistently offset by longer operative time and a demonstrable learning curve that constrains the technique's generalizability outside high-volume, experienced centers [13,7]. Arthroscopically guided reduction occupies a narrower but clinically important niche, applicable chiefly to high condylar head and intracapsular fractures unsuited to conventional plate fixation, and draws its safety rationale from the mature general TMJ arthroscopy literature even as dedicated fracture-specific comparative data remain limited to case-level reports [8,11]. For both techniques, fracture level and displacement remain the primary determinants of surgical indication and expected outcome, and the choice of access technique should be understood as a question of morbidity mitigation and surgical resource allocation layered atop, rather than substituting for, the established indications for open reduction of the mandibular condyle [3,18,2]. Continued accumulation of multicenter randomized and registry-level data, particularly for arthroscopically assisted reduction, will be needed to place these minimally invasive techniques on the same evidentiary footing that endoscope-assisted transoral fixation has now achieved.

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## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

Doyle S conceived the review, conducted the literature search, and drafted the manuscript. Fischer U contributed to the literature screening and biomechanical framing and critically revised the manuscript for important intellectual content. Potocnik A contributed additional rehabilitation and functional-outcome context and approved the final version for submission.

## Ethics Statement

Not applicable. This is a narrative review of previously published literature and did not involve new experimental data, human participants, or animal subjects.

## Data Availability

No new data were generated or analyzed for this review. All sources synthesized are cited in the reference list and are available through their original publishers.

## References

1. Valiati R, Ibrahim D, Abreu MER, Heitz C, de Oliveira RB, Pagnoncelli RM, Silva DN (2008) The treatment of condylar fractures: to open or not to open? A critical review of this controversy. International Journal of Medical Sciences, 5(6):313-318, DOI:10.7150/ijms.5.313.

2. Boffano P, Benech R, Gallesio C, Arcuri F, Benech A (2014) Current opinions on surgical treatment of fractures of the condylar head. Craniomaxillofacial Trauma & Reconstruction, 7(2):92-100, DOI:10.1055/s-0034-1371772.

3. Youssef SALY, Raghoebar II, Helmers R, de Lange J, Dubois L (2025) Redefining and identifying evidence-based indications for open reduction and internal fixation in mandibular condylar fractures: a comprehensive systematic review and evidence analysis. Craniomaxillofacial Trauma & Reconstruction, 18(2):25, DOI:10.3390/cmtr18020025.

4. Singh V, Bhagol A, Goel M, Kumar I, Verma A (2010) Outcomes of open versus closed treatment of mandibular subcondylar fractures: a prospective randomized study. Journal of Oral and Maxillofacial Surgery, 68(6):1304-1309, DOI:10.1016/j.joms.2010.01.001.

5. Agier P, Kozakiewicz M, Tyszkiewicz S, Gabryelczak I (2025) Risk of permanent dysfunction of facial nerves after open rigid internal fixation in the treatment of mandibular condylar process fracture. Medical Sciences, 13(3):121, DOI:10.3390/medsci13030121.

6. Schmelzeisen R, Cienfuegos-Monroy R, Schön R, Chen CT, Cunningham LL, Goldhahn S (2009) Patient benefit from endoscopically assisted fixation of condylar neck fractures—a randomized controlled trial. Journal of Oral and Maxillofacial Surgery, 67(1):147-158, DOI:10.1016/j.joms.2008.09.019.

7. Khiabani KS, Raisian S, Khanian Mehmandoost M (2015) Comparison between two techniques for the treatment of mandibular subcondylar fractures: closed treatment technique and transoral endoscopic-assisted open reduction. Journal of Maxillofacial and Oral Surgery, 14(2):363-369, DOI:10.1007/s12663-014-0644-6.

8. Anastassov GE, Lee H, Schneider R (2000) Arthroscopic reduction of a high condylar process fracture: a case report. Journal of Oral and Maxillofacial Surgery, 58(9):1048-1051, DOI:10.1053/joms.2000.8750.

9. Cavalcanti SCSXB, Taufer B, Rodrigues AF, Luz JGC (2021) Endoscopic surgery versus open reduction treatment of mandibular condyle fractures: a meta-analysis. Journal of Cranio-Maxillofacial Surgery, 49(8):749-757, DOI:10.1016/j.jcms.2021.02.019.

10. Bera RN, Kumar JA, Kanojia S, Boojar FMA, Chauhan N, Hirani MS (2022) How far we have come with the management of condylar fractures? A meta-analysis of closed versus open versus endoscopic management. Journal of Maxillofacial and Oral Surgery, 21(3):888-903, DOI:10.1007/s12663-021-01587-0.

11. McCain JP, Sanders B, Koslin MG, Quinn JD, Peters PB, Indresano AT (1992) Temporomandibular joint arthroscopy: a 6-year multicenter retrospective study of 4,831 joints. Journal of Oral and Maxillofacial Surgery, 50(9):926-930, DOI:10.1016/0278-2391(92)90047-4.

12. Anehosur V, Kulkarni K, Shetty S, Kumar N (2019) Clinical outcomes of endoscopic vs retromandibular approach for the treatment of condylar fractures—a randomized clinical trial. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology, 128(5):479-484, DOI:10.1016/j.oooo.2018.12.007.

13. Sinha A, Natarajan S (2020) Comparative evaluation of clinical and radiological outcomes of retromandibular transparotid and transoral endoscopic-assisted approach for surgical management of mandibular subcondylar fractures. Craniomaxillofacial Trauma & Reconstruction, 14(2):90-99, DOI:10.1177/1943387520949099.

14. Anehosur V, Joshi A, Rajendiran S (2018) Endoscopic-assisted intraoral open reduction internal fixation of mandibular subcondylar fractures: initial experiences from a tertiary-care maxillofacial center in India. Craniomaxillofacial Trauma & Reconstruction, 11(3):183-191, DOI:10.1055/s-0037-1603457.

15. Neuhaus MT, Zeller AN, Desch L, Dhawan A, Jehn P, Gellrich NC, Zimmerer R (2021) Endoscopically assisted treatment of condylar base and neck fractures: a single institution analysis of outcomes and complications. Journal of Maxillofacial and Oral Surgery, 20(4):665-673, DOI:10.1007/s12663-020-01398-9.

16. Eckelt U, Schneider M, Erasmus F, Gerlach KL, Kuhlisch E, Loukota R, Rasse M, Schubert J, Terheyden H (2006) Open versus closed treatment of fractures of the mandibular condylar process—a prospective randomized multi-centre study. Journal of Cranio-Maxillofacial Surgery, 34(5):306-314, DOI:10.1016/j.jcms.2006.03.003.

17. Al-Moraissi EA, Neff A, Kaur A, Falci SGM, de Souza GM, Ellis E (2023) Treatment for adult mandibular condylar process fractures: a network meta-analysis of randomized clinical trials. Journal of Oral and Maxillofacial Surgery, 81(10):1252-1269, DOI:10.1016/j.joms.2023.06.006.

18. Jazayeri HE, Lopez J, Khavanin N, Xun H, Lee UK, Best DL,

Reategui A, Urata MM, Dorafshar AH (2023) Comparative benefits of open versus closed reduction of condylar fractures: a systematic review and meta-analysis. Plastic and Reconstructive Surgery, 151(4):664e-672e, DOI:10.1097/prs.0000000000010009.

19. Sharif MO, Fedorowicz Z, Drews P, Nasser M, Dorri M, Newton T, Oliver R (2010) Interventions for the treatment of fractures of the mandibular condyle. Cochrane Database of Systematic Reviews, Issue 4:CD006538, DOI:10.1002/14651858.CD006538.pub2.