

# Evaluation of Surgical Approaches to Condylar Fractures: A Systematic Review and Network Meta-Analysis



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**Background:** Condylar fractures are common maxillofacial injuries. Although both open and closed treatments are used, the optimal strategy remains debated due to variable functional outcomes and complication rates.

**Purpose:** This network meta-analysis compared the functional outcomes and complications of closed treatment versus various open approaches for mandibular condyle fractures. We evaluated and ranked 6 distinct open approaches: mandibular angle approach (MAA), retromandibular anteroparotid approach (RMAA), endoscopic transoral approach (ETOA), retromandibular through parotid approach (RMPA), preauricular approach (PAA), and submandibular approach (SMA).

**Data Sources:** PubMed, Embase, Web of Science, Cochrane Library, and China National Knowledge Infrastructure (CNKI) were systematically searched for randomized controlled trials (RCTs) published through March 2024, without language restrictions.

**Study Selection:** RCTs comparing closed treatment with at least one open approach and reporting relevant functional or safety outcomes were included. Two reviewers independently performed selection, resolving discrepancies by consensus.

**Data Extraction and Synthesis:** Data extraction followed the PRISMA guidelines. Methodological quality was assessed using the Cochrane risk of bias tool. Random-effects models were applied for both pairwise and network meta-analyses to estimate standardized mean differences (SMDs) and 95% confidence intervals (CIs).

**Main Outcomes and Measures:** Primary outcomes were mouth-opening capacity and lateral excursion. Secondary outcomes included deviation in mouth opening and incidence of facial nerve injury.

**Results:** Fourteen RCTs (3.2% of initial records) were included. Compared with the preauricular approach, RMAA, MAA, and ETOA significantly improved mouth opening [SMD, -2.31; 95% CI, -3.66 to -0.96], [SMD, 2.22; 95% CI, 0.66 to 3.97], and [SMD, 1.93; 95% CI, -0.14 to 3.72]. MAA, RMAA, and retromandibular through parotid approach achieved greater lateral excursion than closed treatment ([SMD, -2.13; 95% CI, -3.68 to -0.58], [SMD, -1.58; 95% CI, -2.91 to -0.25], and [SMD, -1.14; 95% CI, -1.94 to -0.34], respectively). MAA, RMAA, and ETOA were associated with fewer complications. No serious adverse events were reported.

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**Conclusions and Relevance:** Compared with closed treatment, specific open approaches—particularly RMAA, MAA, and ETOA—provided superior functional recovery and lower complication rates for condylar fractures. Further high-quality RCTs are warranted to confirm these findings.

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Mandibular condylar fractures account for 20 to 30% of all mandibular fractures, commonly resulting from trauma such as car accidents, falls, and assaults.<sup>1</sup> If left untreated, these fractures can lead to complications, including pain, malocclusion, facial asymmetry, limited jaw movement, and muscle spasms.<sup>2</sup> Consequently, appropriate treatment is crucial for restoring temporomandibular joint (TMJ) function and improving quality of life.

The main treatment options for condylar fractures are closed treatment and open management.<sup>3</sup> In this study, we define open treatment as surgical management involving direct visualization of the fracture site through an external incision for reduction and internal fixation, while closed treatment refers to conservative management such as closed reduction and intermaxillary fixation without an external surgical approach. Closed treatment avoids surgical risks, such as scarring, nerve injury, and infection. However, it has limitations, particularly in cases of displaced fractures, and carries a higher risk of long-term complications, including TMJ pain, joint ankylosis, and facial asymmetry.<sup>4,5</sup> In contrast, open management enables better anatomical reduction and restoration of joint and soft tissue function. Nevertheless, the optimal open approach remains debated, and further research is necessary to determine the optimal strategy.<sup>6,7</sup>

Traditional meta-analyses typically compare identical interventions, providing strong evidence for treatment decisions. Previous studies have primarily focused on comparing open reduction and internal fixation with closed treatment, without addressing the impact of different open approaches on outcomes and complications.<sup>8,9</sup> Common open techniques include the mandibular angle approach (MAA), retromandibular anteroparotid approach (RMAA), endoscopic transoral approach (ETOA), retromandibular through parotid approach (RMPA), preauricular approach (PAA), and submandibular approach (SMA).<sup>10</sup> These approaches vary in fracture exposure, facial nerve risks, and esthetic outcomes. Additionally, methodological limitations and the lack of randomized controlled trials (RCTs) have hindered efforts to determine the specific therapeutic efficacy of various open techniques for condylar fractures and to identify optimal interventions.<sup>11</sup> Researchers are increasingly using network meta-analysis, an innovative method that synthesizes both direct and indirect evidence to

comprehensively assess the relative efficacy of multiple interventions.<sup>12,13</sup>

This systematic review, incorporating a network meta-analysis, compared various open and closed interventions for condylar fractures. The aim was to assess the impact of these treatments on patients' mandibular function and complications. Based on our clinical observations and preliminary evidence, we hypothesized that RMAA would demonstrate superior functional outcomes, including mouth opening and lateral excursion, as well as lower complication rates compared to closed treatment and other open approaches. The specific aims were to perform a network meta-analysis comparing these approaches and to rank them based on functional outcomes and complications.

## Materials and Methods

This systematic review and network meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and A Measurement Tool to Assess Systematic Reviews 2 (AMSTAR 2) for web-based meta-analyses to ensure reporting integrity.<sup>14-16</sup> For transparency, the study was registered in the PROSPERO database (National Institute of Health and Nursing Research, CRD42024510780).

### SEARCH STRATEGY

We conducted a comprehensive search across 5 major databases: PubMed, Embase, Web of Science, the Cochrane Library, and China National Knowledge Infrastructure. The search included articles published in any language. Only RCTs were considered to ensure the inclusion of high-quality evidence. The primary search terms were "condylar" and "fracture," with the full search strategy provided in [Supplementary Table 1](#). To ensure the inclusion of the most current data, we also reviewed ongoing RCTs presented at major meetings hosted by the World Dental Federation, the American Dental Association, and the International Association of Oral and Maxillofacial Surgeons over the past 5 years. Additionally, we screened the reference lists of all the included studies to identify any relevant RCT not initially captured.

### INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for studies were as follows: RCT study design; completion of the incision, reduction, and fixation process for condylar fractures through any open approach; and research duration of  $\geq 12$  months or postoperative follow-up period of  $\geq 3$  months. The exclusion criteria encompassed case reports, observational studies (such as cross-sectional, case-control, and cohort designs), letters, personal opinions, book chapters, duplicate publications, studies with small sample sizes, unclear intervention measures, incomplete baseline or outcome data, improper endpoint reporting, and research involving patients with chronic condylar fractures or animal studies.

The participants, interventions, comparisons, and outcomes (PICO) criteria for this study were as follows:

P: Patients with a confirmed diagnosis of mandibular condylar fracture (regardless of site or whether unilateral or bilateral) based on clinical examination and imaging who underwent first-time surgery.

I: Different Surgical Approaches for Condylar Fractures

C: Any nonoperative intervention for condylar fractures, such as closed treatment.

O: The primary outcomes were mouth opening and lateral range of motion. Mouth opening was defined as the maximum vertical distance between the upper and lower central incisors during maximal voluntary opening, generally considered normal when exceeding 35 mm.<sup>17</sup> Lateral range of motion was defined as the maximum horizontal distance the mandible could be moved laterally from centric occlusion to one side, typically around 10 mm.<sup>18,19</sup> The secondary outcomes included the number of patients presenting with abnormal mouth-opening patterns and facial nerve injury during the follow-up period. Mouth-opening patterns were defined as the trajectory of mandibular movement during opening, which is normally straight and symmetrical in adults but may appear deviated or irregular in pathological cases.<sup>20</sup> Facial nerve injury was defined as damage or dysfunction of the facial nerve resulting in impaired facial muscle function, presenting with symptoms such as facial paralysis, deviation of the mouth angle, and incomplete eyelid closure.<sup>21</sup>

### DATA EXTRACTION

Two researchers (Yanan Ma and Yuxin Yang) independently extracted the following data from the selected studies: study title, lead author, region, sex (male/female) composition, sample size, mode of intervention, lesion characteristics (number and location), study and follow-up duration, and primary and secondary outcome measures. In the case of multiple

publications from the same trial, the most recent data were included. Any discrepancies during the data extraction process were resolved through discussions between Yanan Ma and Rui Luo. If needed, a third researcher, Yuxin Yang, was consulted to ensure consensus and data accuracy.

### QUALITY ASSESSMENT

Two researchers (Xinghua Yang and Ziang Zhao) independently assessed the quality of the included studies by using the Cochrane risk of bias tool.<sup>22</sup> Any disagreements were resolved by a third researcher (Ruimin Li) to ensure consensus and minimize risk of bias. A risk of bias map was then generated using Review Manager 5.3 to visually summarize the assessment results.

### DATA INTEGRATION AND ANALYSIS

The following 4 outcome measures were selected given their frequent reporting in the literature: postoperative mouth-opening, lateral range of motion, abnormal mouth-opening patterns, and facial nerve injury. Measures such as surgery duration and bleeding were excluded due to inconsistent data.

Classical meta-analysis (Stata 15.0, USA) was conducted for comparisons involving  $\geq 3$  studies. Continuous data (eg, mouth-opening, lateral range of motion) were summarized using standardized mean differences (SMDs) and 95% confidence intervals (CIs), calculated from reported means and standard deviations or derived from published data. Dichotomous outcomes (eg, postoperative abnormalities, nerve injury) were summarized using odds ratios (ORs) and 95% CIs based on patient group data. Statistical significance was set at  $P < .05$ .

Heterogeneity was assessed using Q tests and  $I^2$  values. A random-effects model was applied when  $I^2 > 50\%$ , indicating significant heterogeneity; otherwise, a fixed-effects model was used.

Network meta-analysis was performed using Stata (version 15.0) with the network package, employing a frequency theory-based approach. Network diagrams were utilized to visualize treatment connections, and z-tests were performed to assess the consistency between direct and indirect comparisons by using inconsistency factor values and 95% CIs. Node splitting was utilized to assess agreement among evidence sources. Funnel plots were constructed to evaluate small-study effects and publication bias. Additionally, forest plots were constructed to display effect sizes with 95% CIs and prediction intervals. Surface under the cumulative ranking curve with area (SUCRA) values (0 to 100%) were used for ranking treatment efficacy, with high values indicating favorable outcomes.

## Results

### IDENTIFICATION OF STUDIES

The process for study selection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Fig 1). The initial database search identified 361 relevant studies. After removing duplicates and reviewing the abstracts, 32 studies were deemed eligible for further evaluation. A thorough review of the full texts resulted in the inclusion of 14 RCTs in the network meta-analysis.<sup>23-35</sup> The kappa consistency coefficient (k) between the 2 researchers of this study (Yanan Ma and Rui Luo) during data extraction was 0.91, indicating good agreement.

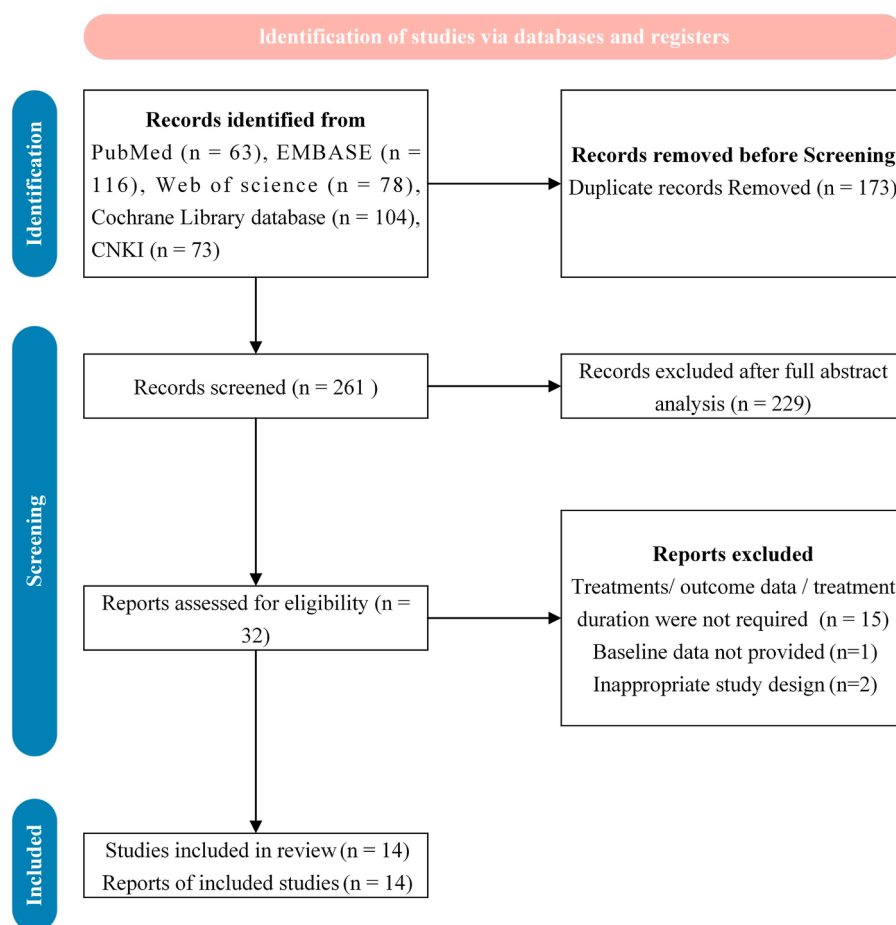
### STUDY CHARACTERISTICS

All the included studies focused on patients with condylar fractures diagnosed through clinical and radiographic examination. [Supplementary Table S2](#) provides a summary of the general characteristics of the studies. A total of 14 RCTs involving 816 patients

and 896 condylar fractures were included. The longest study duration was 59 months, and the minimum follow-up duration was 12 months, with an average follow-up period of 33 months. Fracture types included mid-condylar (51%), subcondylar (18%), and high condylar (1.6%), with 3 studies not specifying fracture type. Seven different interventions were assessed, and their distribution is shown in [Table 1](#).

### PAIRWISE META-ANALYSIS

Seven direct pairwise comparisons were identified, encompassing RMPA versus RMAA and RMPA versus closed treatment across 4 major outcomes (Fig S1). In terms of maximum mouth opening, only RMPA and RMAA were directly compared, and the analysis revealed no statistically significant difference between these 2 surgical approaches (SMD = 0.21, 95% CI: -0.05 to 0.47). For lateral excursion, patients treated with RMPA demonstrated significantly better functional recovery than those who received closed treatment (SMD = 0.27, 95% CI: 0.05 to 0.49), whereas no meaningful difference was observed between



**FIGURE 1.** Flow diagram of included studies.

**Table 1. DISTRIBUTION OF TREATMENTS**

Interventions	n (%)
RMPA	367 (46%)
RMAA	164 (20%)
PAA	54 (7%)
ETOA	16 (2%)
SMA	40 (5%)
MAA	34 (4%)
Closed treatment	127 (16%)

Abbreviations: ETOA, endoscopic transoral approach; MAA, mandibular angle approach; PAA, preauricular approach; RMAA, retromandibular anteroparotid approach; RMPA, retromandibular through parotid approach; SMA, submandibular approach.

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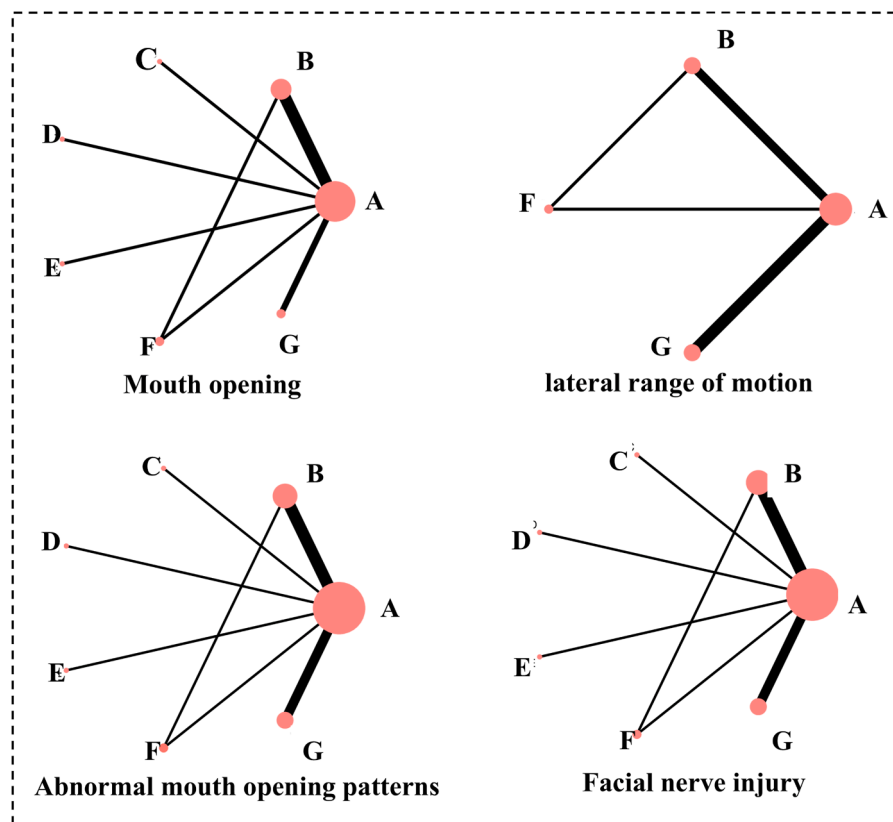
RMPA and RMAA (SMD = 0.22, 95% CI: -0.10 to 0.53). With regard to abnormal mouth-opening patterns during follow-up, RMPA was associated with a markedly lower risk compared with closed treatment (OR = 0.11, 95% CI: 0.04 to 0.31), while its performance did not significantly differ from that of RMAA

(OR = 0.19, 95% CI: 0.03 to 1.11). For facial nerve injury, both RMAA (OR = 0.20, 95% CI: 0.07 to 0.60) and closed treatment (OR = 17.24, 95% CI: 2.21 to 134.60) were linked to substantially lower complication rates relative to RMPA, suggesting a higher risk of nerve damage when using the RMPA approach. All comparisons were conducted using a random-effects model, and heterogeneity across studies remained consistently low ( $I^2 < 30\%$ ).

#### NETWORK META-ANALYSIS

A network meta-analysis was performed to evaluate outcomes for mouth-opening capacity and abnormalities, lateral movement amplitude, and facial nerve injuries during follow-up. Consistency analysis showed no significant global or local inconsistency (Tables S3 to S6), supporting the consistency assumption.

Figure 2 illustrates network plots, where node sizes reflect subject numbers and line thickness corresponds to study counts. All the networks formed closed loops with closely connected studies. Loop inconsistency tests (Fig S2) revealed inconsistency factor values close to zero, with 95% CIs including zero, indicating no inconsistency between the direct and indirect comparisons.



**FIGURE 2.** Network map for all outcomes. The size of each node represents the total number of participants receiving that intervention, while the thickness of the lines indicates the number of included studies. A: RMPA; B: RMAA; C: PAA; D: ETOA; E: SMA; F: MAA; G: closed treatment.

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COMPARISON OF MOUTH OPENING

Figures 3 and S3 present pairwise comparisons of postoperative mouth opening across 22 interventions, with 6 interventions showing significant differences. Patients undergoing PAA exhibited significantly reduced mouth opening compared to those treated with RMAA (SMD, 2.31; 95% CI, -3.66 to -0.96), MAA (SMD, 2.22; 95% CI, 0.66 to 3.97), ETOA (SMD, 1.93; 95% CI, 0.14 to 3.72), RMPA (SMD, -1.92; 95% CI, -3.13 to -0.7), SMA (SMD, 1.72; 95% CI, 0.01 to 3.43), and closed treatment (SMD, 1.55; 95% CI, 0.04 to 3.06).

SUCRA rankings placed RMAA as the most effective intervention (79.7%), followed by MAA (67.8%), ETOA (61.2%), RMPA (54.5%), SMA (49.8%), and closed treatment (36.3%), whereas PAA ranked lowest at 0.7% (Table S7 and Fig S4).

COMPARISON OF LATERAL RANGE OF MOTION

Figures 3 and S5 present comparisons of lateral range of motion across 6 interventions, with 3 showing significant differences. Patients who underwent MAA (SMD, -2.13; 95% CI, -3.68 to -0.58), RMAA (SMD, -1.58; 95% CI, -2.91 to -0.25), and RMPA (SMD, -1.14; 95% CI, -1.94 to -0.34) demonstrated significantly greater lateral excursion than those receiving closed treatment.

Probability rankings (Table S8 and Fig S6) and SUCRA values (Table S9 and Fig S7) indicated MAA as the most effective intervention (88.7%), followed by RMAA (66.7%) and RMPA (44%), whereas closed treatment ranked lowest (0.7%).

COMPARISON OF ABNORMAL MOUTH-OPENING PATTERNS AND FACIAL NERVE INJURY

Figure S8 and Table S10 show ORs for abnormal mouth-opening patterns across 21 comparisons, with 9 significant differences. Compared with MAA, RMAA (OR, 0.02; 95% CI, 0.00 to 0.42), SMA (OR, 0.03; 95% CI, 0.00 to 0.33), and closed treatment (OR, 63.81; 95% CI, 8.04 to 506.61) significantly increased abnormalities. Similarly, RMAA (OR, 16.40; 95% CI, 1.27 to 211.97), SMA (OR, 12.02; 95% CI, 1.76 to 81.96), and closed treatment (OR, 26.02; 95% CI, 4.86 to 139.36) were associated with higher incidences of abnormalities than RMPA.

SUCRA rankings indicated MAA as the most effective intervention (93.8%), followed by RMAA (79.9%), RMPA (59.3%), ETOA (56.0%), SMA (28.1%), and PAA (22.3%), with closed treatment being the least effective (11.6%) (Table S11 and Fig S9).

Facial nerve injury comparisons (Fig S10 and Table S12) across 21 pairwise analyses revealed 11 significant differences. Compared with SMA, interventions such as RMAA (OR, 38.41; 95% CI, 3.55 to 415.83) and ETOA (OR, 188.04; 95% CI, 8.47 to 4176.26) significantly reduced the incidence of injuries. Additionally, ETOA (OR, 0.01; 95% CI, 0.00 to 0.21) and MAA (OR, 0.03; 95% CI, 0.00 to 0.27) had lower incidences of injury than PAA.

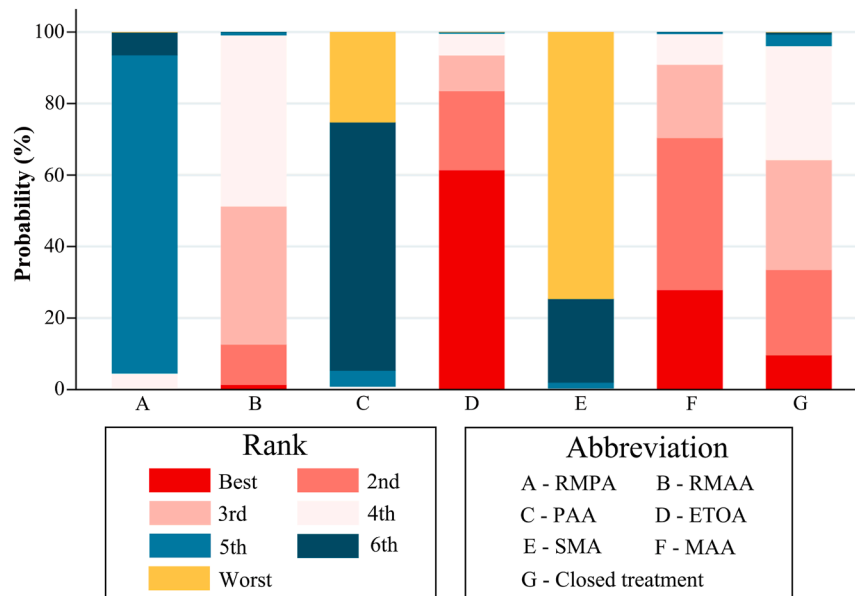
ETOA ranked highest in SUCRA values for reducing nerve injury (89.5%), followed by MAA (81.0%), closed treatment (68.1%), RMAA (60.4%), RMPA (32.9%), PAA (13.4%), and SMA, which ranked lowest (4.6%) (Table S13 and Figs 4 and S11).

B 0.55 (-0.74,1.84)			0.44 (-0.62,1.50)		1.58 (0.25,2.91)	
0.09 (-0.89,1.06)	F		0.99 (-0.33,2.32)		2.13 (0.58,3.68)	
0.38 (-1.07,1.83)	0.29 (-1.36,1.94)	D				
0.39 (-0.20,0.99)	0.31 (-0.68,1.30)	0.01 (-1.31,1.34)	A		1.14 (0.34, 1.94)	
0.59 (-0.76,1.94)	0.50 (-1.06,2.06)	0.21 (-1.58,2.00)	0.19 (-1.01,1.40)	E		
0.76 (-0.32,1.84)	0.67 (-0.67,2.01)	0.38 (-1.22,1.98)	0.37 (-0.54,1.27)	0.17 (-1.34,1.68)	G	
2.31 (0.96,3.66)	2.22 (0.66,3.79)	1.93 (0.14,3.72)	1.92 (0.70,3.13)	1.72 (0.01,3.43)	1.55 (0.04,3.06)	C

Mouth opening
  Treatment
  Lateral range of motion

**FIGURE 3.** Results of the network meta-analysis of the differences in mouth opening and lateral range of motion after different interventions.

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**FIGURE 4.** Ranking diagrams regarding network meta-analysis of facial nerve injury after different interventions.

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#### PUBLICATION BIAS

Funnel plots (Figs S12 to S15) revealed no evident asymmetry for mouth opening, lateral movement amplitude, mouth-opening abnormalities, or facial nerve injuries, indicating a low likelihood of publication bias.

#### QUALITY ASSESSMENT

Study quality was assessed using the Cochrane risk of bias tool (Fig 5). Among the 14 studies, 4 had a low risk of bias, whereas 2 had a high risk due to incomplete outcome data and selective reporting. The remaining 8 studies were classified as having an unclear risk due to insufficient information on allocation sequence generation and concealment.

## Discussion

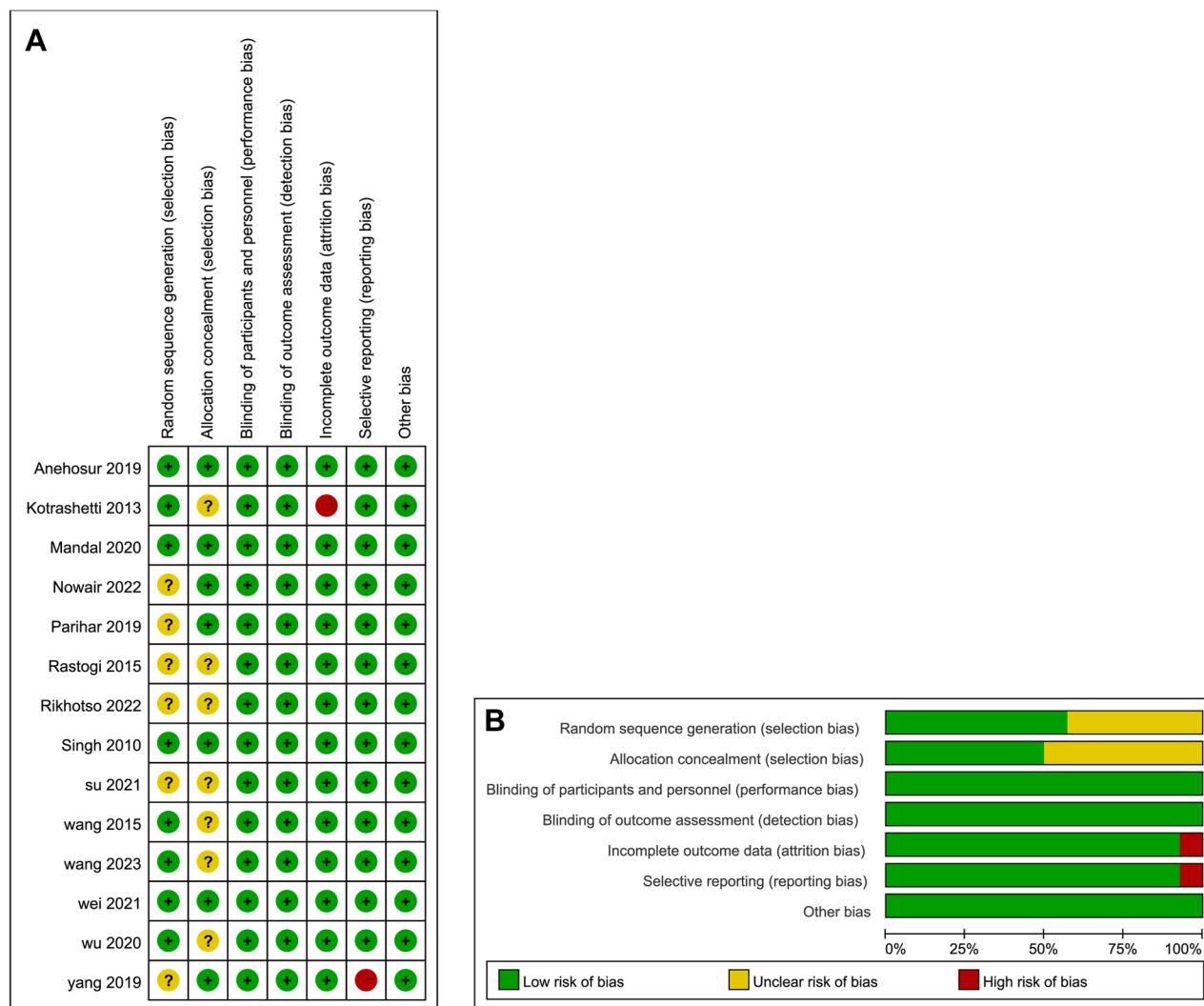
#### SUMMARY OF FINDINGS

This systematic review and network meta-analysis, which included 896 condylar fractures in 816 patients, compared various open approaches with closed treatment. Based on our clinical observations and preliminary evidence, we hypothesized that RMAA would demonstrate superior functional outcomes, including mouth opening and lateral excursion, as well as lower complication rates compared to closed treatment and other open approaches. The results of the analysis supported our hypothesis. The study evaluated outcomes such as interincisal opening, lateral excursion, lateral open bite, and facial nerve injury during follow-up. The results

showed that RMAA and MAA significantly improved mouth opening compared with PAA. Furthermore, RMAA, MAA, and RMPA improved lateral movement and reduced lateral open bite compared with closed treatment. Additionally, ETOA and MAA significantly reduced the incidence of facial nerve injury during follow-up compared with closed treatment. However, not all open approaches led to improved mouth opening or reduced facial nerve injury.

The retromandibular approach is subdivided into 2 primary variants, namely RMPA and RMAA. The critical distinction involves their relationship with the parotid gland. RMPA traverses parotid parenchyma, increasing invasiveness and facial nerve injury risk. Conversely, RMAA avoids direct parotid dissection, minimizing these complications.<sup>36,37</sup> This anatomical advantage corresponds with our network meta-analysis findings, wherein RMAA demonstrated significantly lower facial nerve injury incidence versus RMPA. Previous meta-analyses have also shown that RMAA is more effective than RMPA in reducing facial nerve injuries when treating condylar fractures via the submandibular posterior approach, supporting the findings of our study.<sup>38</sup>

MAA is another open option for treating condylar fractures. The procedure begins with a 5-cm skin incision below the mandible, posterior to the ascending ramus. The incision passes through the skin, subcutaneous tissue, and platysma, with careful dissection to protect the marginal mandibular branch of the facial nerve. The parotid gland is retracted, and subperiosteal dissection exposes the posterior border of the ascending ramus. This approach avoids the main trunk of the facial nerve, minimizes interference with the



**FIGURE 5.** Results of risk bias. (A) Study quality assessment summary. (B) Study quality assessment graph.

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surrounding soft tissues and ligaments of the TMJ, and reduces the risk of complications such as facial paralysis. Additionally, it promotes better recovery of mandibular function after surgery. Although MAA is primarily used for low condylar fractures, it may not be suitable for condylar neck fractures. In these cases, MAA can cause tissue overextension, hindering vertical screw placement into the plate and increasing stress concentration, making it less effective for condylar neck and higher fractures.<sup>39</sup>

With the advent of new technologies and surgical innovations, there has been increasing interest in minimally invasive open strategies, with ETOA emerging as a promising approach for treating mandibular condylar fractures. Endoscopes play a crucial role throughout the procedure, aiding in fracture identification, visualization, position assessment, evaluation of displacement and overlap, fracture reduction, and

alignment confirmation and assisting with the control of posterior margin repositioning.<sup>40</sup>

ETOA, developed by surgeons and gynecologists, was first used in 1997 to improve visualization during mandibular angle osteotomy for patients with hypertrophic masseter muscles. The following year, it was applied to treat mandibular condylar fractures in 20 patients. Over the past 2 decades, numerous studies have shown the success of the intraoral endoscopic approach in repairing these fractures.<sup>41</sup> ETOA involves making an S-shaped incision in the buccal mucosa along the anterior border of the ramus of the mandible. The incision is deepened to the periosteum, generating an optical cavity under the periosteum on the lateral surface of the ramus. A retractor with an adjustable endoscope is inserted into the surgical field, and surrounding soft tissue attachments are fully dissected to fix and reduce the fracture ends.<sup>42</sup>

Because the optical cavity is entirely beneath the periosteum and deeper than the facial nerve plane, ETOA avoids facial nerve injury. Additionally, compared to RMPA, SMA, and closed treatment, ETOA provides an excellent operative field through a small incision, minimizes tissue dissection to reduce scarring, and leads to fewer postoperative complications. This approach results in faster recovery, shorter hospital stays, and quicker restoration of TMJ function,<sup>43</sup> contributing to increased mouth opening during follow-up. These findings align with earlier meta-analyses.<sup>44</sup> However, ETOA is less effective than external approaches, such as MAA and RMAA, in improving lateral movement and correcting abnormal bite patterns. The intraoral path of ETOA limits exposure to condylar fractures, especially high-positioned fractures, providing less visibility than external approaches. This limitation may result in less precise repositioning of the fracture segments, potentially impacting the recovery of joint motion, particularly lateral excursion and incisal guidance, compared to MAA and RMAA.

Overall, studies show that RMAA, MAA, and ETOA offer several advantages over other open approaches and closed treatments, including increased mouth opening, improved lateral movement, reduced facial nerve injuries, and better functional recovery during follow-up. However, condylar fractures are a heterogeneous group, ranging from high condylar neck to low sub condylar types, and vary in displacement, comminution, and dislocation.<sup>45</sup> This heterogeneity is clinically meaningful and should not be regarded solely as a statistical confounder. The choice of open approach is highly dependent on fracture characteristics, particularly the location in relation to adjacent neurovascular structures. High condylar fractures, situated near the joint capsule and the main trunk of the facial nerve, present considerable challenges in exposure and fixation.<sup>46</sup> Approaches such as the PAA or ETOA are often employed to enhance visualization, although the risk of facial nerve injury may vary. In contrast, low sub condylar fractures, located inferior to the mandibular notch, provide more favorable access. Approaches such as RMPA, MAA, and RMAA aim to balance adequate exposure with minimized risk to the marginal mandibular nerve.

This network meta-analysis pooled data across diverse fracture types. While this offers a generalized overview of comparative intervention performance, it may mask important differences in efficacy and safety among specific subtypes. Accordingly, interpretation of the results should acknowledge that the optimal approach is contingent on individual fracture anatomy. The SUCRA rankings represent average effects across the included population and should not be construed as universal recommendations. Clinical decision-making should instead prioritize patient-

specific factors, such as fracture location, degree of displacement, comorbidities, and the surgeon's experience and technical expertise. Further research is warranted to validate these findings; large-scale randomized clinical trials and direct head-to-head comparisons are needed to assess the relative effectiveness and cost-efficiency of various open approaches and to determine the most appropriate treatment strategies for condylar fractures.

#### STRENGTHS AND LIMITATIONS

This network meta-analysis is the first to compare different open approaches comprehensively for management of condylar fractures. A rigorous search strategy spanning 5 major databases and incorporating recent RCTs ensured a robust evidence base. Unlike previous meta-analyses, which focused solely on open reduction and internal fixation versus closed treatment, this study evaluated treatment outcomes and complications across various open approaches. The closed-loop structure enabled both direct and indirect comparisons, offering a hierarchical ranking of interventions to guide clinical decision-making.

Although this study employed rigorous methodology and included recent randomized clinical trials, several limitations remain. Fundamental differences in fracture location represent the primary constraint. Despite anticipating the clinical relevance of these variables, the limited number of included studies and the lack of patient-level or outcome data stratified by specific fracture characteristics in the original trials hindered further analysis. As a result, the findings reflect pooled effects across a broad spectrum of injury types, introducing clinical heterogeneity and potential bias into the effect estimates and comparative rankings. This limits the precision and direct applicability of the conclusions to specific clinical scenarios. Additionally, variability in follow-up duration across studies may have affected the assessment of long-term functional outcomes and complications. Other limitations include the absence of reported data on economic costs, operative duration, and the substantial learning curve associated with certain techniques such as the ETOA.<sup>47</sup> Moreover, several included studies had an unclear or high risk of bias. Interpretation of the results should therefore be undertaken with careful consideration of these limitations.

RMAA and MAA outperform other open approaches and closed treatment in enhancing mouth opening and lateral excursion as well as in reducing mouth-opening abnormalities in patients with condylar fractures. ETOA and MAA are particularly effective in minimizing the incidence of facial nerve injuries, thereby improving functional outcomes. Overall, MAA, RMAA, and ETOA yield superior outcomes

compared to closed treatment and other approaches. Nonetheless, future high-quality RCTs must prospectively stratify patients by fracture location and report stratified outcomes. Only such rigorously stratified data will enable future meta-analyses to generate subtype-specific evidence essential for precise surgical decision-making.

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### Supplementary Data

Supplementary data associated with this article can be found in the online version, at <https://doi.org/10.1016/j.joms.2025.09.013>.

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