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Systematic review

Does surgical treatment of mandibular condyle head (diacapitular) fractures provide better outcomes than closed treatment? – a systematic review and meta-analysis

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Abstract

The choices for managing a condylar head fracture (CHF) of the mandible are either open surgical or closed functional treatments (CFT) and the decision depends on various factors. The purpose of this systematic review was to ascertain from the available literature whether the open method or CFT yields better outcomes in managing CHF. We have systematically reviewed published articles according to the PRISMA statement. The search was conducted in PubMed, Google Scholar, Semantic Scholar, and the Cochrane Library database for comparative studies about both open and closed treatments from inception until April 2023. The outcomes of interest were mouth opening (MO), protrusion, laterotrusion, postoperative pain, and malocclusion. Eight studies met the inclusion criteria. The review comprised of 326 cases, among which 177 were managed by open methods and 149 were treated by CFT. The incidence of postoperative malocclusion and pain were significantly less in the open group. MO was better in the open treatment group although this was not statistically significant. Protrusion and laterotrusion occurred slightly more in CFT, although these were also statistically not significant. Overall, meta-analysis favoured open methods of managing CHF. Although enough evidence exists for the use of open methods for selected condylar head fractures, CFT still demonstrated favourable outcomes in undisplaced fractures. The selection of a particular treatment method should be individualised on the basis of each particular case considering the risk/benefits. Further high quality randomised trials are needed to establish a therapeutic guideline.

Keywords: Condylar fracture; Condylar head; Diacapitular; Intracapsular; Open treatment; Closed functional treatment

Introduction

Mandibular condyle process fractures account for 30%-40% of mandibular fractures.[1,2] Out of these, 65% are diacapitular or condylar head fractures (CHF).[3] The advent of multiplanar and three-dimensional volume-rendered imaging has aided in proper diagnosis, evaluation of displacement, and level of fracture, thereby contributing to their apparent increase in incidence.[4] There is no consensus regarding the management of condylar head fractures in adults. The choice between closed or open methods varies depending on the type of fracture, patient factors, and the treating surgeon's thoughts and expertise.

Closed reduction of condylar head fractures has been done traditionally for decades.[5] However, achieving exact anatomical reduction through closed functional treatment (CFT), particularly in adults, is questionable and rarely attained.[5] Hence, referring to it as a closed reduction is a mis-

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nomer, so we think 'closed treatment' would be a more appropriate expression. CFT has delivered acceptable outcomes, as the contralateral temporomandibular joint (TMJ) compensates for the function. However, CFT cannot negate long-term complications. The problems with CFT are the inability to achieve anatomical reduction, the fact that disc displacements have not been addressed, and the capsule, if injured, creates a propensity for ankylosis. TMJ-related complications such as pain, dysfunction, and osteoarthritis have also been reported.[5] Consequently, surgeons tend to favour the open method, and advancing technology has facilitated its successful accomplishment.[3,4,6–10]

Magnetic resonance tomographic studies have demonstrated soft tissue changes and disc and capsule injuries.[11] This finding has further endorsed the open method. Open reduction and internal fixation (ORIF) of CHF have been attempted with a plethora of techniques. The choice of ORIF is at the surgeon's discretion, availability and type of fracture, and it can be done with microplates, screws, lag screws, and resorbable pins.[12–17] On the whole, the idea of the open method is to restore the previous functional status of the TMJ, including the condyle and soft tissue components such as the disc, capsule, and associated ligaments.[6,15,18] However, scarring can impede the condyle's range of motion. Few authors have reported comparable outcomes when assessing multiple parameters such as restoration of form and function and the avoidance of long-term complications.[19] Hence, the discourse still persists regarding therapeutic decision-making in management. The purpose of this systematic review was to ascertain from the available literature whether the open method or CFT yields better functional outcomes in managing mandibular condylar head fractures.

Materials and methods

Search strategy and study selection

This systematic review was conducted in accordance with the guidelines established in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).[20] On April 2023, two reviewers (BL and A) searched the databases Pub Med, Google Scholar, Semantic Scholar, and Cochrane Library for papers published in English that used the term "Condylar head", "Mandibular condylar head", "diacapitular", "intracapsular", Mandible fracture, "treatment" , "management" , "Close" , "Open" , "Open reduction" , "Close reduction", "Osteosynthesis" and "fixation". The search was done using various permutations and combinations of these terms and then the abstracts and titles were screened. Studies were included in a database for detailed review if they met the following criteria: published in the English language; included all types of treatments for mandibular condylar head fractures; reported comparative outcomes about the treatment of both open and closed treatments (to exclude small case series and case reports). If the same study population was described in more than one paper, only the most recent or larger sample size was included for assessment.

Studies published in a language other than English, in vitro and animal studies, editorials, letters to the editor, reviews, book chapters, and studies with missing or insufficient data were excluded because of potential publication bias and duplication of results. The combined results of the databases were screened for duplicates. The reference lists of all final retrieved articles were reviewed for further identification of potentially relevant studies.

The studies were selected based on PICOST 1) Participants: Patients with mandibular condylar head fracture; 2) Intervention: patients who underwent closed treatment or open reduction and internal fixation; 3) Comparison: open versus closed treatment; 4) Outcomes: mouth opening, translational movement, pain score; 5) Study design - randomised controlled trial, prospective, retrospective, comparative; 6) Time frame - inception to April 2023.

Collection of data and assessment of quality

Author, year of publication, study design (randomised control trial, prospective or retrospective), number of patients included, type of condylar head fracture, treatment method, fixation technique for ORIF, mouth opening, protrusion, laterotrusion, malocclusion, pain, complications, and follow-up were recorded. Two reviewers collected data. Standardised data forms were used to minimise variability. In case of conflicting evaluations, a final agreement was reached following a discussion with a third reviewer. (RA)

Risk of bias assessment and data synthesis

The generic data set from the risk of bias visualisation (robvis) tool was used to assess the risk of bias for both randomised and non-randomised comparative studies.[21] For meta-analysis of each available comparison, the weighted (standardised) difference in means (SMD) with 95% confidence interval (CI) were calculated using random-effect models for continuous outcome variables such as mouth opening, laterotrusion and protrusion, or Odd's Ratio (OR) with 95% confidence interval for frequency variables such as pain and malocculsion. Heterogeneity was assessed with the Q-statistic and Moran's I^2 and interpreted qualitatively as low (25%–50%), moderate (50%–75%), or high (75%–100%). All analyses were done in Stata version 17.0 using the "meta n" and "meta esize" packages.

Results

Study results

After the initial screening, a total of 141 pertinent publications were identified. Eight comparative studies were

included in the review. All the articles were included in the meta-analysis. The PRISMA flow chart is presented in Fig. 1.

Study characteristics

The studies were published between 2005 and 2023. Out of eight comparative clinical studies included in the review, two were randomised control trials, three were retrospective, and three were prospective. The follow-up ranged from a minimum of three months to a maximum of 70 months. Characteristics of the included studies are presented in Table 1.

The study comprised 326 cases, among which 177 were managed by open methods and 149 were treated by closed methods. The mean age of the patients included in the review ranged between 27-41 years. The condyle head fracture classification used were by Neff (n=2),[4,6] He (n=2),[15,22] Loukota (n=1),[23] Spiessel and Schroll (n=1)[19] and Ying (n=1).[18] Only five studies mentioned the associated fracture, and one excluded patients with associated fractures. Open treatments were performed via modified preauricular (n=3,) preauricular (n=3), retroauricular (n=1), with or without maxillomandibular fixation (MMF). The fixation was accomplished with microplates and screws (n=64), microscrew with 2/3 positional screws (n=26), compression screw (n=10), microscrews(n=9), titanium micromesh (n=4), resorbable polylactide screw (n=1) and sonic weld pins (n=9). Disc intervention was mentioned in five studies.[6,15,18,19,22]

Concerning the CFT for condylar head fractures, MMF with elastics was reported in six studies[6,15,19,23–24] and rigid MMF in two.[4,18] The duration of MMF implementation was not consistent. Studies have mentioned varied duration of physiotherapy following both open and closed treatments.

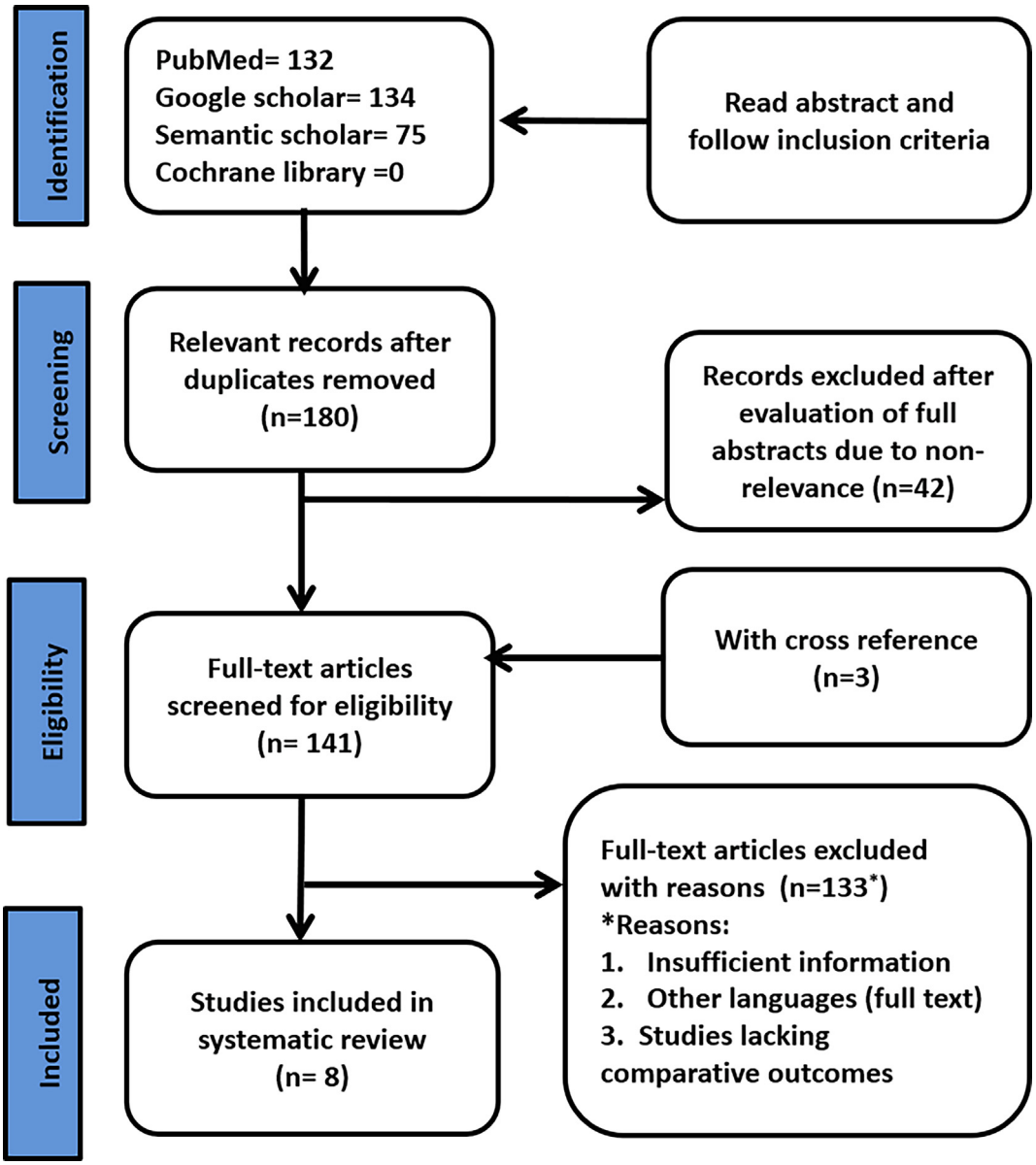

Fig. 1. PRISMA flow chart.

Table 1
Characteristics of the included studies.

Serial number	First author, year and reference	Study type	Open (O) / close (C)	Patients	Mean age (years)	Sex (M/F)	Type of fracture (classification by)	Associated facial fracture	Treatment	Mouth opening (mm) *	Protrusion (mm)*	Laterotrusion (mm)*	Malocclusion*	Pain*	Complications	Follow up (months)
1.	Hlawitschka 2005[4]	Retrospective comparison	O	14 b/l=5	30	13/1	Type B (Neff's)	Yes	Modified preauricular; Compression screw (n=10) Titanium micromesh (n=4) Absorbable polylactide screw (n=1)	39.1	4.7	6.3	No	Nm	Temporary FN paresis=1	11-20
			C	29 b/l=5	28	25/4	Type A (Neff's)		Rigid MMF-10 days followed by 6-8 weeks functional treatment Physiotherapy- yes (3 weeks) Orthodontic activator (n=8) cases	43.7	5.1	7.8	N=10	Nm		
2	Schneider 2008[23]	Prospective RCT	O	7 b/l=nm	Nm	Nm	Nm (Loukot's)	Nm	Nm	49	7	17	Nm	1.3 (VAS, 0-100)		6
			C	5 b/l=nm	Nm	Nm	Nm (Loukota's)		Elastic MMF - 10 days Physiotherapy-yes	45	5.4	16	Nm	7 (VAS.,0-100) (More)		
3	Landes 2008[19]	Prospective randomisation	O	9 b/l=2	27	Nm	Nm (Spiessl and Schroll)	Yes(5)	Preauricular; 1.2 mm H- and T-shape with 6-8 mm length and 1 mm diameter screws =9 Disc position inspected for correct position.	39±8.9	6.1±3.1	8.1±3.1	N=0	N=2	Temporary FN paresis=0 Brokenhardware =1	12
			C	8 b/l=2	31	Nm	Nm (Spiessl and Schroll)		Elastic MMF - 2 weeks Physiotherapy-yes	41±7.3	7.5±1.8	8±2.3	N=13	N=0		

4	Chen Ho 2015[22]	Retrospective comparison	O	20 b/l=20	32.7 ±13.5	12/8	Nm (He's)	Yes(33)	Preauricular; 1.3mm microscrew (n=9) , Microplate (n=11) Reduction of disc in few cases Elastic MMF-2-6 week	39.50 ±6.5	Nm	Nm	N=3	0.26 ±0.65 (VAS 0-10) N=3	Click=5 Tightness=4 Temporary FN paresis=1	25
			C	18 b/l=18	28.6 ±9.6	10/8	Nm (He's)		Elastic MMF - 4-8 week. Physiotherapy-yes	34.7 ±6.9	Nm	Nm	N=11	1.6±2.7 (VAS, 0-10) N=8	Click=9 Tightness=7 Fail to reduction=2	
5	Ying 2018[18]	Prospective comparison	O	48 b/l=Nm	35-39	33/15	Type B and Type C (Ying new classification)	Yes	Modified preauricular; Screw/plates or both Reduced/repaired disc if torn or displaced Small fragments removed MMF-2 week	Nm	6.925±1.4	9.49±1.23	N=0	10(VAS, 0-100) N=1	Temporary FN paresis=9	6
			C	7 B/l=Nm	41	3/4	Type A (Ying new classification)		MMF -2 week Physiotherapy- yes (4 weeks)	Nm	7.46±0.92	9.08±1.52	N=0	N=0		
6	Kolk 2020[6]	Prospective comparative	O	26 b/l=3	37.4	13/13	Nm (Neff's)	No	Retroauricular; Microplate with 2/3 titanium positional screws. (microplate removal in the majority of cases when sufficient stability achieved with screw alone. Disc displaced in some cases	47.93 ±6.53	Nm	Nm	N=12	N=8		9-70
			C	54 b/l=19	39.3	34/20	Nm (Neff's)		Semi-rigid MMF-1 week Elastics MMF -1 week Physiotherapy-yes (after 1st week)	46.08 +7.37			N=0	N=8		

7	Yadav 2021[24]	Prospective RCT	O	9 b/l=1	38.9 ±17.07	8/1	Nm(AOCMF)	Nm	Modified preauricular; Passive insertion of 1–2 sonic weld pins (diameter of 2.1 and length 15 or 17 mm) Elastic MMF -for preventing exogenous stress.	31.56+-5.92	Nm	5.11±3.41	N=3	1.44±2	Temporary FN paresis=4 Infection and parotid fistula=2 Resorption=9	3
			C	10 b/l=1	29.11 ±9.64		Nm (AOCMF)		Elastic MMF until patients were able to close in normal occlusion without any guidance. Physiotherapy- Nm	31.65+-5.33	Nm	5.90±2.73	N=1	1.9±1.45 (More)	Resorption =less	
8	Lai 2023[15]	Retrospective cohort	O	44(61) b/l=17	30 ±12.6	27/17	NM (He's)	Yes(50)	Pre-auricular; two 3-hole microplates and four 8-12 mm screws Elastic MMF -2 weeks Dislocated disc pulled back	39.9 ±6.9	Nm	Nm	N=2	Nm	Wound infection =1 Screw malposition=1 Temporary FN paresis=0	1 year
			C	18(32) b/l=14	37.8 ±20.2	11/7	Nm (He's)		Elastic MMF-4 weeks Physiotherapy- Nm	34.3 ±7.0	Nm	Nm	N=3	Nm	TMJ osteoarthritis=1	

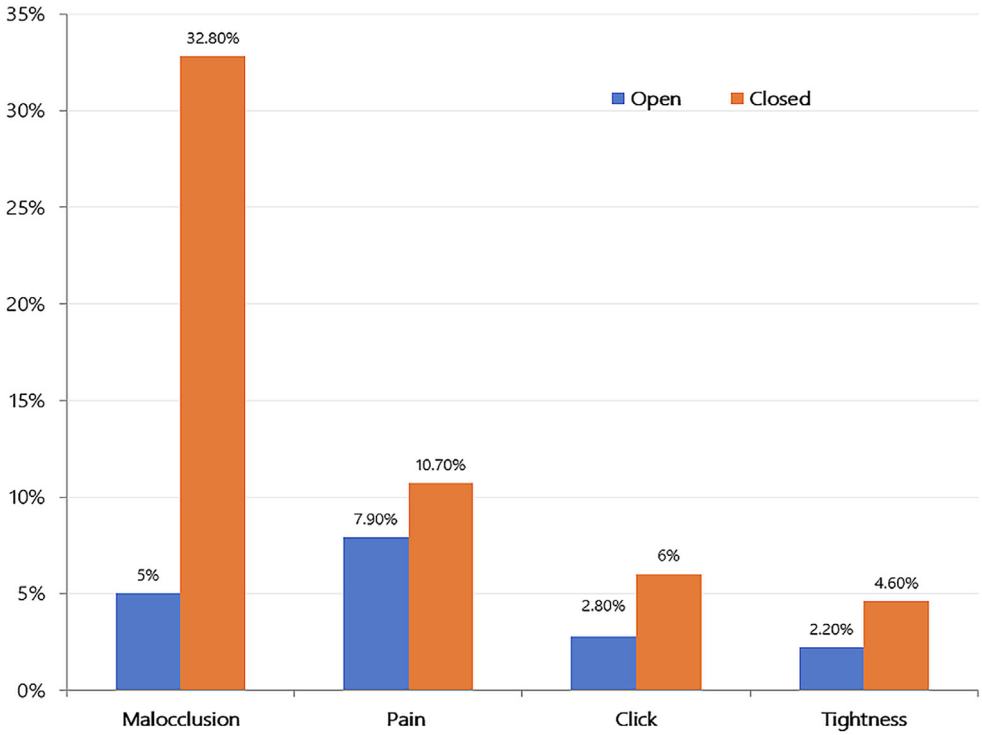

Fig. 2. Percentage comparison of complications in open and closed methods.

The comparative complications between open and CFT is illustrated in Fig. 2.

Risk of bias assessment

Two studies revealed low risk of bias (Schneider et al, Yadav et al) and the remaining six studies exhibited high risk of bias (Fig. 3).

Meta-analysis

Mouth opening (MO)

Seven studies included reported MO for both open and closed methods.[4,6,15,19,23–24] On comparing the standardised mean differences, MO was more in the open group than the closed method; however, it was not statistically significant (1.49, 95%CI = −1.47 to 4.45)(Fig. 4).

Protrusion and laterotrusion

Four studies reported protrusion in millimetres[4,18,19,23] and five reported laterotrusion.[4,18,19,23,24] Both protrusion (−0.37, 95% CI= −1.08 to 0.34) and laterotrusion (-0.17, 95% CI= −1.18 to 0.83) were slightly more in the CFT group than the open group but not statistically significant, on comparing the standardised mean differences (Fig. 4).

Malocclusion

Seven studies had reported malocclusion.[4,6,15,18,19,22,24] Pooled Odd's ratio (OR) revealed a statistically significant reduction in postoperative incidence of malocclusion in the open group (−2.12, 95% CI= −3.88 to −0.36)(Fig. 5).

Pain

Follow-up pain was mentioned in four studies.[6,18,19,22] The pooled OR (−0.91, 95%CI = −1.75 to −0.07) suggests that there was less pain perceived in the open method than closed, which was statistically significant (Fig. 5). I^2 analysis suggested moderate or low heterogeneity for the majority of comparisons.

As a limited number of studies were included in the meta-analysis, a funnel plot to assess the publication bias was not feasible.

Discussion

There is still ongoing controversy regarding the management of condylar head fractures of the mandible. Al-Moraissi et al conducted a systematic review and meta-analysis, which concluded that ORIF shows superior results in the management of condylar fractures. This study does not particularly report condylar head fractures, probably due to the lack of well-designed or comparative studies in the literature at that time.[25] Boffano et al (2016) published a systematic review of various opinions, including human and animal studies reporting the management of condylar head fractures.[26] Chrcavonic (2012) and Taneja et al (2022) published a review comparing open and closed methods; however, they were descriptive.[27,28] With all these reviews, there was still a lack of specific comparative review and meta-analysis on the superiority of open and closed methods in managing diacapitular or CHF of the mandible. The purpose of the present

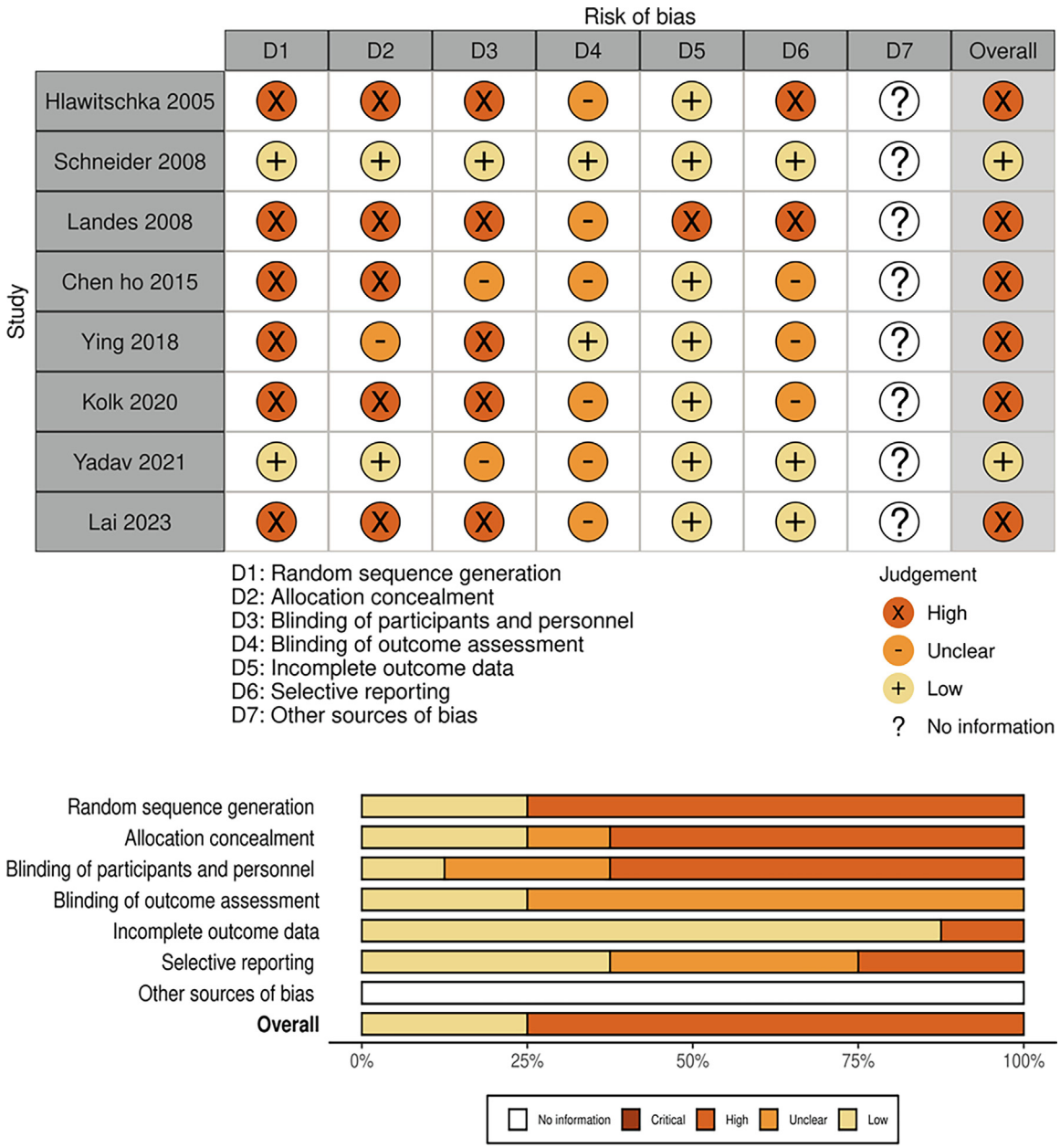

Fig. 3. Risk of bias assessment of included studies.

review was to determine the superiority of open versus closed treatment in the management of CHF of the mandible.

The proponents of closed treatment adhere to this approach due to concerns associated with the surgical technique, including potential nerve and blood vessel injuries, difficulty in reduction, and scar formation. CFT only facilitates adaptive mechanisms that counterbalance for alteration in the direction of pterygoid pull and disc displacement. CFT does not restore the anatomy of displaced CHF and surrounding tissue complex, such as the disco-condylar unit.[12] Consequently, this results in limited condyle translation, which may introduce contralateral excessive lateral deviation during opening, associated pain, and malocclusion. In patients with non-compliance with physiotherapy, there could be permanent reduction in the range of motion due to capsule constriction and muscle contraction.[6] Conversely, open treatment addresses the bone and joint components, resulting in an earlier return to function. Anatomical reduction assists restoration of the disc and lateral pterygoid to a pre-injury state; however, surgical scarring might limit the rotational component between the disc and condyle.

The current meta-analysis evaluated the outcomes between closed and open methods. The outcome of treatment modality depends on the clinical and radiological parameters. Clinical parameters like MO, protrusion, laterotrusion, pain, and malocclusion were consistently reported and therefore included to assess the superiority of either method. Radiological outcomes were not reported consistently in all the

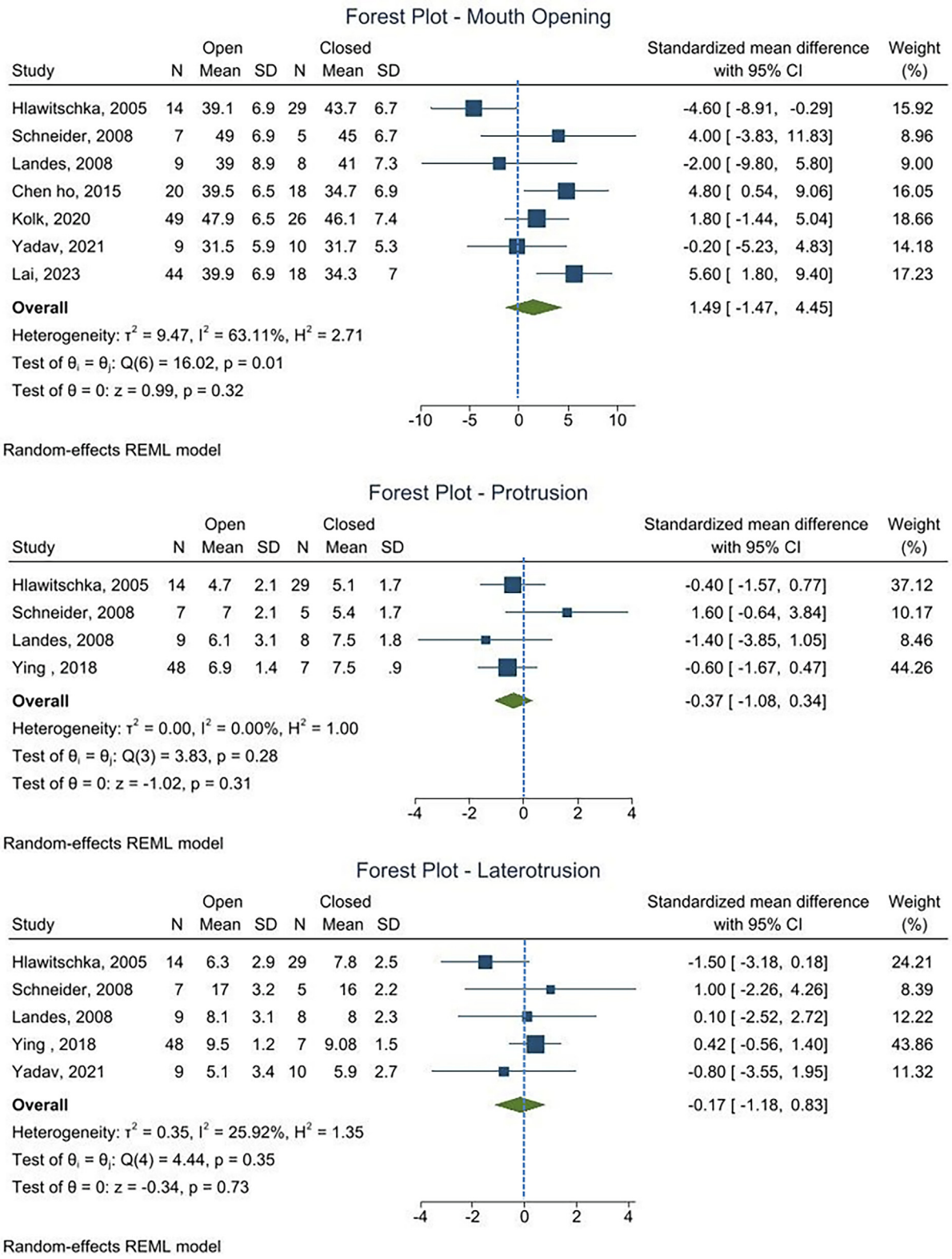

Fig. 4. Forest plot for postoperative mouth opening, protrusion and laterotrusion.

studies; thus, the comparison was not feasible. Overall, the results of the present review showed that the open method led to superior results in terms of MO, pain reduction, and occlusion. Laterotrusion and protrusion were slightly better in CFT, nevertheless they were not statistically significant.

Considering mouth opening, only two studies[22,23] were statistically significant out of four studies which reported increased MO in the open group. Studies by Landes et al and Yadav et al revealed a slight increase in the closed group, however were not statistically significant.[19,24] Overall, the

mouth opening was superior in open, although not significant. Various factors, including type of CHF, bilateral involvement, severity of disc injury, the duration of IMF, choice of osteosynthesis material, postoperative scarring, accompanied pain, associated fracture, and the follow-up duration, influence the mouth opening. In the open method, the size of osteosynthesis material and the resultant scarring can impede MO.[29] On the other hand, muscle spasms can hinder MO in the closed method.[6] The compensation by a healthy TMJ can contribute to increased rotational movement in either method.[8]

Discussing the protrusion and laterotrusion, the meta-analysis favoured the closed treatment method; however statistically not significant. For protrusion, out of four studies included for pooled analysis, Ying et al contributed to most weight (44.26%) towards CFT, followed by Hlawitschka et al. Likewise, for laterotrusion, out of five studies included for meta-analysis, Ying et al (43.86%) and Hlawitschka et al (24.21%) contributed the most weight. Protrusion and laterotrusion, being highest in closed reduction from meta-analysis results, could be misleading as the case selection for closed and open treatment was biased. Fractures with no decrease in vertical height and undisplaced discs were treated by the CFT in the study by Ying et al.[18] This substantiates that the disco-condylar unit is undisturbed and causes limitation in the range of motion. Hence, the protrusion values would obviously be higher in the closed method as the muscle-bound fragment is in place, and the lateral pterygoid expected to function normally without limitation. Similarly, Hlawitschka et al discussed the restriction of excursion movements in closed reduction; however, the values on the graph are contradictory.[4] Hence, reduced protrusion values in the open method would be superfluous, according to the present meta-analysis. The study by Schneider et al is a randomised controlled trial with no bias, and it reported better protrusion with open treatment; however, the weighting is

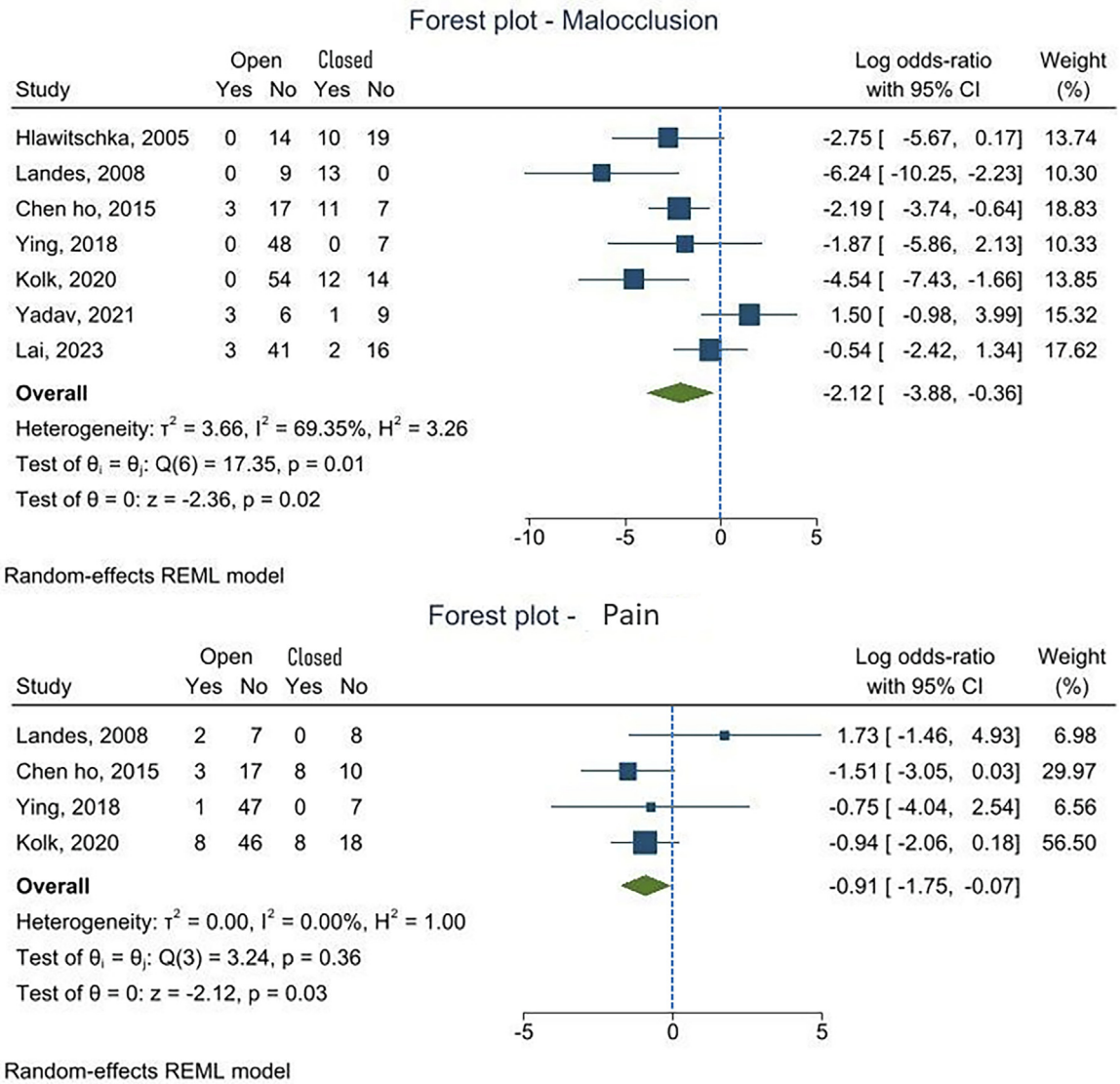

Fig. 5. Forest plot for malocclusion and pain.

less (10.17%).[8] Hence, further well-designed randomised controlled trials of exclusive CHFs can settle the contention.

Malocclusion following CHFs varies on the fracture type, depending on the displacement of the fracture fragment, which further results in ramus height reduction. In closed reduction, MMF does not aid in regaining the normal anatomy in case of displaced or dislocated condyle fragments, further restricting the range of motion. Nevertheless, open treatment restores the pre-traumatic anatomical presentation of the condyle, henceforth the pre-traumatic occlusion. Post-treatment malocclusion was significantly less in the open group from the pooled meta-analysis of seven studies. Except for the study by Yadav et al, all studies were in line with open reduction to prevent malocclusion.[24] The reason is attributed to the technique sensitive osteosynthesis material used for open treatment in the former study and the subsequent improper reduction in those three cases in the open group. Hence with meticulous technique and optimal osteosynthesis material, open treatment provides better outcomes regarding malocclusion in the case of CHF.[6]

TMJ pain can be due to the change in the harmony of the disc condyle relationship and a change in muscle pull in displaced fractures. Although compensation for deranged function and adaptations happens, pain persists in patients debilitating the chewing function. Hence, the open method proves to be a better option to avoid pain, although it cannot be completely negated. The presence of post-treatment pain was reported in four studies,[6,18,19,23] and meta-analysis revealed better outcomes in the open group. In the present review, out of eight included studies, only three had reported pain VAS scores. The lack of consistent data limited the meta-analysis of VAS scores.[8,23,24] As it is subjective and the degree of pain perceived cannot be measured with dichotomous data, further RCTs elucidating VAS scores can better facilitate the outcomes.

Both treatment methods come with inbound complications. Nevertheless, the types of complications vary between the two treatment methods. Open methods carry surgical risks such as facial nerve paresis, surgical site infection, and potential compromise to capsule integrity, which is absent in closed fracture. Studies have documented temporary facial nerve paresis[4,18,23,24] in the open group and hardware issues,[15,19] which were subsequently removed. Hence, surgeons should be aware of plausible complications and communicate to patients beforehand. Comparing TMJ-related complications between two groups, the open method is superior in reducing postoperative TMJ symptoms such as tightness, clicking, and pain.[23] The percentages were comparatively less in open methods (Fig. 2). This is because the open method not only restores the bony anatomy but also addresses the surrounding tissue concerns and provides the opportunity to access and correct disc problems.[6,12]

The primary goal for managing CHFs is to achieve a stable occlusion and a pain-free TMJ, which negates the impediments to mastication. The function is of prime importance for patient satisfaction in the long term. However, a certain range of motion parameters like MO, protrusion, and laterotrusion may not initially elucidate higher values following the open method. The restoration of the range of motion is time-dependent.[15] In this regard, meta-analysis favours open reduction and internal fixation, which includes addressing the disc. Factors such as additional expenditure incurred to the patient, operation theatre time, general anaesthesia requirement, and complications should be considered. The risk-benefit assessment plays a crucial role before selecting a treatment modality.

The limitation of the present review is the small number of studies of which many lacked proper randomisation of cases. The lack of information on associated fracture and bilateral involvement further increases the confounding bias. To establish standardised therapeutic guidelines, it is imperative to have further randomised controlled trials with well-described methods that minimise the confounding factors.

Conclusion

The open method can achieve stable occlusion, reduced postoperative TMJ pain, and better mouth opening than closed, thus, an earlier return to function. Protrusion and laterotrusion were slightly better in closed treatment, nevertheless statistically insignificant. However, restoration of the range of motion is time dependent. Although enough evidence exists for open methods for selected condylar head fractures, CFT still demonstrate favourable outcomes in undisplaced fractures. The selection of a particular treatment method should be individualised for each case case considering risk-benefit. Further, high-quality RCTs of strict design are needed.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patient permission

Exempt. Patient permission not applicable.

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