Management of Mandibular Condyle Fractures in Paediatric Patients: a Systematic Review

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ABSTRACT

Objectives: This systematic review searched three of the most used databases to assess if current evidence suggested a difference between surgical and non-surgical management of mandibular condyle fractures in paediatric patients.
Material and Methods: An electronic literature search was conducted of three well known databases - Ovid, PubMed and Web of Science. Studies included were conducted paediatric patients, in humans, written in English and published from January 1st 1996 until April 1st 2022. Data collection was carried out by two independent reviewers. Data collated from studies without high risk of bias was pooled for surgical vs non-surgical management and total tallies of all outcomes presented. Presence or absence of complications was recorded in 4 x 4 tables for each outcome and compared using a Chi-Square test.
Results: After duplicate records were removed, 182 records were screened. After exclusion of unsuitable reports, 20 were included in the review. Further analysis showed the included studies had high risk of bias. Given this, comparison of this pooled data showed no significant difference between management methods.
Conclusions: Presently it appears conservative management is functionally adequate without risks associated with surgical management, even though incidence of these risks was shown to be low in the studies included in this review.

Keywords: pediatrics; trauma; review literature.

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INTRODUCTION

Systematic reviews are increasingly relied upon to inform clinical practice. In the last decade there have been many reviews focused on the role of open and conservative management of mandibular condyle fractures with good evidence that open reduction internal fixation (ORIF) leads to better outcomes, functional and patient reported, for displaced unilateral fractures [1]. However, in the paediatric cohort the role of surgical management of condyles is less clear. This is due to added considerations such as future growth, as well as a lack of evidence over the role of newer technology and techniques, such as resorbable plating systems and endoscopic access to the condyle.

Additionally, recent work published by Alyahya et al. [2] has shown that most systematic reviews regarding mandibular condylar fracture management are of poor quality. Therefore, this project provides further clarity on the roles of conservative and operative management of both unilateral and bilateral mandibular condyle fractures in a paediatric patient by performing a high-quality systematic review, as measured by the A Measurement Tool to Assess Systematic Reviews-2 (AMSTAR-2) criteria [3] and following the widely accepted Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement [4].

Controversy around mandibular condyle fractures is not limited to how to manage fractures but also includes how to define them with the proposal of multiple classifications. This review will refer to the AO Foundation classification [5]. Therefore, mandibular condyle fractures are those occurring within this region and can be subdivided into head, neck and subcondylar fractures relative to the condylar head reference line and the sigmoid notch line as shown in Figure 1.

This systematic review aims to assess the outcomes from surgical management in paediatric mandibular condyle fractures compared to non-surgical management.

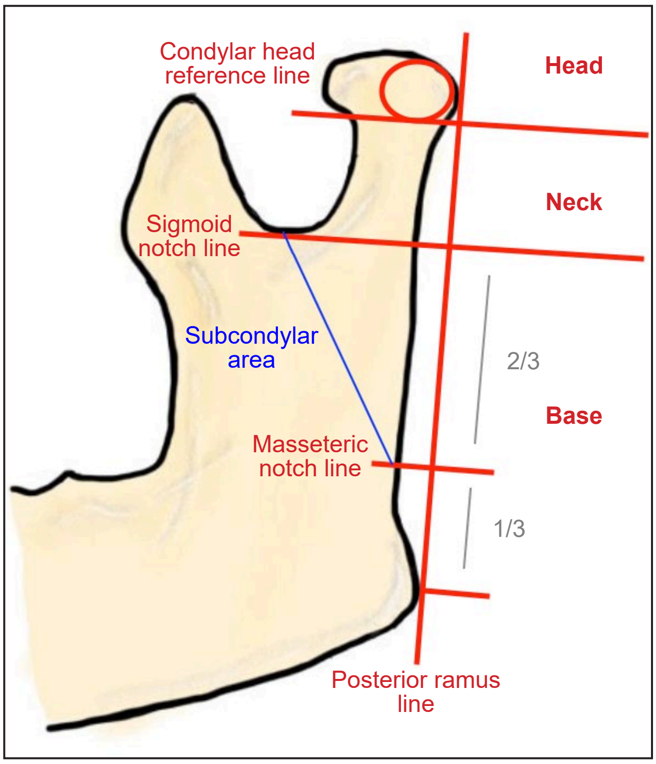

Figure 1. Diagram of classification of mandibular condyle.

MATERIAL AND METHODS

Protocol and registration

This study followed the guidelines of the PRISMA statement [4] and it was registered in the International Prospective Register of Systematic Reviews (PROSPERO).

Prospero registration number: CRD42022323176.

The protocol can be accessed at: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022323176.

Focus question

The focus question was developed according to the Patient, Intervention, Comparison, Outcome and Study Design (PICOS) framework as described in Table 1.

Table 1. PICOS guidelines

Population (P)	Patients aged < 18 years old with fractures of either one or both mandibular condyles, as defined by the AO classification.
Intervention (I)	Any surgical approach to reduction and fixation of the fracture.
Comparison (C)	Non-surgical management of the fracture.
Outcome (O)	Include occlusion/malocclusion, malunion, non-union, pain, sounds from temporomandibular joint, infection, wound dehiscence, nerve injury and mandibular movements subdivided into; protrusion, lateral excursion, maximal inter-incisal opening and lateral deviation of the chin during maximal opening.
Study design	Randomised controlled trials, controlled clinical trials and retrospective studies

The focus question: This systematic review aims to assess the outcomes from surgical management in paediatric mandibular condyle fractures compared to non-surgical management. This review aims to test the null hypothesis of no significant difference in the outcomes, as defined above, between surgical and non-surgical management of mandibular condyle fractures in paediatric patients.

Information sources

Three well known databases were used: Ovid, PubMed and Web of Science.

Search strategy

The following terms were searched: {(condyle fracture [Text Word]) AND (open OR surgical OR closed OR conservative OR nonsurgical [Text Word]) AND (pediatric OR paediatric OR children [Text Word]) AND (mandible OR mandibular [Text Word])}.

Selection of studies

Search results were merged and duplicate reports removed. The titles and abstracts from all reports highlighted from the searches were reviewed by 2 assessors (I.J. and R.B.) with obviously irrelevant reports being discarded. No disagreement existed between reviewers. Should disagreement between I.J. and R.B. have been encountered the other authors would have been consulted. Full text articles were obtained for studies appearing to meet the inclusion criteria or where there was uncertainty.

Types of publication, studies and population

Randomised controlled trials, controlled clinical trials and retrospective studies were selected for inclusion.

Inclusion and exclusion criteria

The inclusion criteria were set to include studies in humans written in English and published from January 1st 1996 until April 1st 2022. Study type allowed for randomised controlled trials, controlled clinical trials and retrospective studies. Both unilateral and bilateral mandibular condyle fractures were included. Only paediatric cases were included. Therefore, studies in adult cases were excluded as were those studies published before January 1st, 1996 and in languages other than English. Case reports, technical reports, animal studies, *in vitro* studies, reviews papers and conference papers were also excluded. Where the literature was unclear, e.g. paediatric data could not be separated from adult data, authors were contacted via email for clarification.

Sequential search strategy

A pilot search was made on PubMed (U.S. National Library of Medicine) about the management of mandibular condylar fractures to identify relevant keywords.

Ovid, PubMed and Web of Science were searched in April 1, 2022 using the terms above. This search included the following Ovid database field guides: Books@Ovid April 01, 2022; Journals@Ovid Full Text April 01, 2022; Embase 1996 to 2022 Week 14; Ovid MEDLINE® 1996 to April Week 1 2022.

Data extraction

Data items, as below, were recorded in an agreed upon table by two independent reviewers. This involved searching, screening, reviewing, and collecting data. There were no disagreements. No automation tools were utilised. Where data was missing or uncertainty existed, the authors of the study were contacted via email to ask for clarification.

Data items

To aid data extraction by reviewers (I.J. and R.B.) tables with the following fields were agreed upon and completed for each study. Data included: year of study publication, study design, patients per group, age of patients (range and mean), type of fractures per group, fixation method, length of intermaxillary fixation post treatment, frequency of follow-up and outcomes. Three pooled outcomes were decided upon for data collection: function, patient satisfaction and post-operative complications. Function included reports of malocclusion and mandibular movements. Patient satisfaction was measured by reports of pain, sounds from the temporomandibular joint (TMJ) and compliance with treatment. Complications included infection, wound dehiscence, nerve injury, malunion/non-union and ankylosis.

Risk of bias assessment

The Newcastle Ottawa Scale (NOS) [6] was selected for risk of bias and quality assessment due to the expected weighting towards observational studies as well as being a quick and adaptable assessment with easy to interpret results [7]. Each included paper was scored using the NOS by two independent authors.

Statistical analysis

Data collated from studies without high risk of bias was pooled for surgical vs non-surgical management and total tallies of all outcomes presented. Presence or absence of complications was recorded in 4 x 4 tables for each outcome. From this surgical vs non-surgical outcomes was compared using a Chi-Square (χ^2) test. The null hypothesis being there is no association between the method of management and the outcome specified. $P < 0.05$ was used to indicate significance.

RESULTS

Study selection

The selection process of studies for inclusion and justification of exclusion is outlined in Figure 2. After duplicate records were removed, 183 records were screened. After exclusion of unsuitable reports, 20 were included in the review. The level of agreement between the two authors (I.J. and R.B.) in selecting abstracts and studies to be read in full-text were measured at Cohen's κ = 1 due to agreement of 100%.

Exclusion of studies

The main reason for exclusion was incorrect study type: case reports (n = 30), adult study (n = 12), review article (n = 19), conference report (n = 1), not relating to fracture management (n = 2), incomplete article (n = 1), technical note (n = 3). After read through other studies were excluded as: unable to separate paediatric information from other ages (n = 17), outcomes not reported (n = 6) or unable to separate information for condyle fractures alone (n = 5).

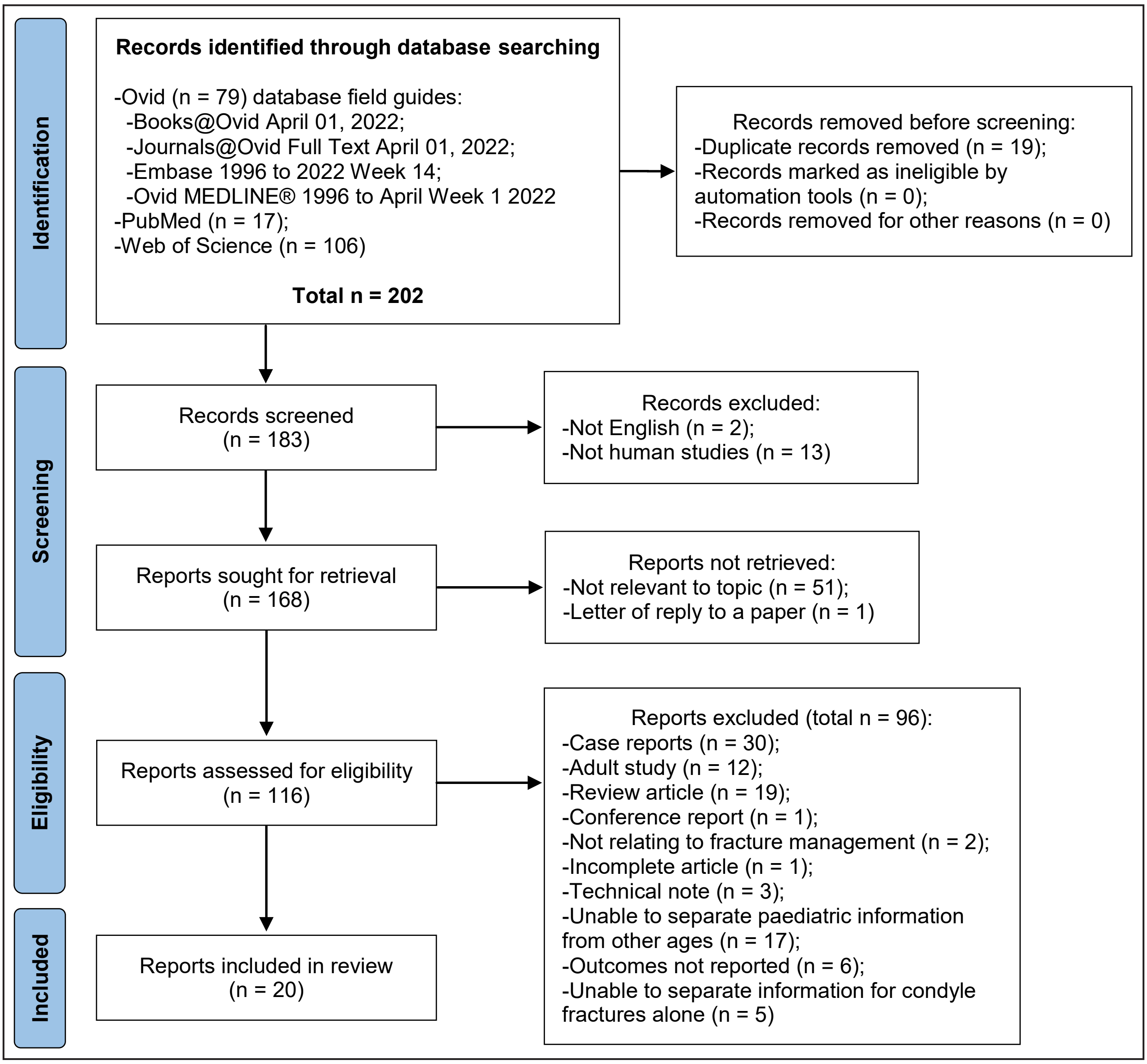

Figure 2. Flow diagram of studies selection according PRISMA guidelines.

Study characteristics

Data from extraction of the included 20 reports is displayed in Table 2 [8-27]. Of these 20 papers, all were retrospective case series with the exception of [14], a retrospective cohort study, and one prospective cohort study [27]. The upper age limit set by different papers varied from < 12 years [9,11,13,14,17,18,22,24] compared to the remainder which extended up to 16 years. All papers included unilateral condylar fractures, information regarding bilateral condylar fractures was less clear with [8,12,14,15,17-22] explicitly mentioning them. Certain papers only included displaced [10,11,18,25] or dislocated [11,18,23,26] condylar fractures. Non-surgical management was used in papers [8,9, 12-22,24,26,27] and surgical management in [10,11, 13-15,20,23,25,27]. Non-surgical management involved conservative management with soft diet, and/or physiotherapy, and/or intermaxillary fixation for varying lengths of time as per Table 2 and occlusal splints [17,18,19,22]. Surgical management involved a variety of techniques including open reduction internal fixation of the condyle with titanium plates [10,13-15,20,25,27], Kirschner wire (K-wire) fixation [11] and bioabsorbable plate fixation [23]. Clinical and radiographic follow-up was carried out in all cases with only [8,16,27] having < 100% follow-up.

Risk of bias assessment

Given the best available level of evidence were cohort studies, the NOS was carried out as showing, with the exception of two studies [14,27], all the included studies have high risk of bias. Key limitations of each study and outcome of the NOS are displayed in Table 3, but key contributing factors were study design (case series) and small number of cases.

Results of individual studies

Occlusal splint therapy

Several different authors advocated the use of occlusal splints in managing condylar fractures [17,18,19,22]. These created a slightly open mouth position which caused the condyle and the articular disc to separate so that the condyle would have adequate time to heal, and to avoid further damage to the disc. The regime in which they were utilised varied however. Liu et al. [17] reduced the height of the occlusal splint from the second month after treatment, which caused regular contact between the condyle and the articular disc for functional stimulation, condylar remodelling and rehabilitation. Whereas, Wu et al. [18] and Zhao et al. [22] removed the splint after 4 weeks and 1 to 3 months respectively.

Intermaxillary fixation duration

Across all studies this ranged from 1 to 6 weeks. Some authors argued against intermaxillary fixation (IMF) in combination with ORIF due to concerns over development of intraarticular fibrosis [15]. Elastic IMF was used uniformly with archbars or IMF screws.

Open reduction

Where open reduction was required [10, 13-15,20,23,25,27], a variety of approaches were used. Preauricular was the most common, with transoral and endoscopic also being utilised. In a study of Landes et al. [27] a preauricular approach was chosen in all cases of high condylar fractures, and the fixation was performed with 1.2 mm titanium microplates and 1 mm screws, whereas condyle fractures at the lower condylar neck, at or below the sigmoid notch were surgically treated via the retromandibular approach. The use of video fluoroscopy was described to aid the confirmation of reduction and avoid further fixation to minimise risk of possible TMJ ankylosis [10]. Fluoroscopy was also utilised in the closed surgical reduction technique using K-wires [11] in order to confirm adequate reduction. The one study which utilised bioabsorbable plates used the GRAND FIX™ (Gunze; Kyoto, Japan) system made of poly-L-lactic acid [23]. These plates have been reported to resorb slowly within 3 to 5 years. In this study the main criteria for performing an open reduction using bioabsorbable miniplate fixation was the condyle dislocated from the glenoid fossa with the comminuted fractures of parasymphysis or mental foramen.

Function

All included reports were unanimous in portraying good functional outcomes for patients at varying stages of follow-up despite objective differences in outcome such as TMJ clicking, condylar growth (as measured radiographically), malocclusion and mandibular movements. Several papers demonstrated radiological evidence of high proportions, up to 50%, of abnormal condylar remodelling after mandibular condyle fracture [9,11,15,18,20]. However, this only rarely required intervention, e.g. removal of plate and screws [20], and where very long term follow-up was performed persistent growth changes were still shown to have no functional limitations [21].

Table 2. Summary of data extraction

Study	Year of publication	Study design	Age of patients (years)	Patients per group	Fixation method	Length of IMF post treatment	Frequency of follow-up
McGoldrick et al. [8]	2019	Retrospective case series	3 - 15	44	Conservative (32) or IMF (12)	7 - 10 days	The median follow-up period was 196 days (89% completed follow-up)
Strobl et al. [9]	1999	Retrospective case series	2.5 - 9.75	55	Conservative		At 6, 12, 24, 48 and 72 weeks post-traumatically and then yearly until the growth period is complete (100%)
Aksoyler et al. [10]	2021	Retrospective case series	6 - 16	6	Elastic IMF + open reduction	10 to 14 days	12 to 18 months (100%)
Kim and Nam [11]	2015	Retrospective case series	4 - 12	11	Percutaneous K - wire and elastic IMF. Closed reduction using threaded Kirschner wire inserted percutaneously under C - arm fluoroscopy and the use of external rubber traction)	3 weeks and physiotherapy was initiated. The external rubber traction and threaded Kirschner wire were removed within 3 to 4 weeks. All patients received a liquid diet for 3 weeks and then a soft diet for at least 2 weeks	24 to 42 months (mean 29.3 months) (100%)
Choi et al. [12]	2005	Retrospective case series	3 - 15	11	Conservative		1 to 6 years (mean 3.27 years) (100%)
Yadav et al. [13]	2021	Retrospective case series	≤ 12	41	Conservative (28), IMF (5), ORIF + IMF (8)	1 - 2 weeks	1 year (100%)
Li et al. [14]	2021	Retrospective cohort	< 12	84	ORIF or IMF alone	4 - 6 weeks	1, 3, and 6 months (clinical and CT assessment) (100%)
Vesnaver et al. [15]	2020	Retrospective case series	1.5 - 14	7	ORIF (6) or conservative (1 - no fixation was performed because the greenstick fracture was completely stable after open reduction)	IMF was never used	1 week, 1 month, 3 months, and 6 months, and then yearly thereafter. Completed follow-up ranged from 15 months to 6 years after surgery (100%)
Cooney et al. [16]	2020	Retrospective case series	2 - 15	49	Conservative or MMF	Unspecified ('short period')	The median follow-up time was 12 weeks (range 1 to 133 weeks) (88%)
Liu et al. [17]	2014	Retrospective case series	4 - 8	30	Occlusal splints	Occlusal splint worn for 3 to 6 months	1 to 6 years (mean 3.5) (100%)
Wu et al. [18]	2012	Retrospective case series	3.5 - 11	13	IMF + occlusal splints	After 4 weeks, the screws and occlusal splint were removed	3, 6, 12, 24 months, and more (mean period of 28.6 months) (100%)
Theologie - Lygidakis et al. [19]	2016	Retrospective cohort[a]	2 - 16	84	Conservative (22), IMF (39), IMF and occlusal splint (19) and ORIF (4)	IMF for 1 week in children up to 10 years of age and for a maximum of 2 weeks in older children	Initially, every 15 days for 2 months, every month for 4 months, and every 3 months afterward for 6 to 12 months. Then late follow-up for 14 months to 11 years post op. 46.57% attended with a mean follow-up period of 4.4 years. The mean age of patients at follow-up was 14.1 years
Zhang et al. [20]	2021	Retrospective case series	4 - 16	9	ORIF (9)	No IMF. Soft diet for > 1 month and functional jaw exercises daily	> 5 years with mean follow-up time 69.3 months (100%)
Hovinga et al. [21]	1999	Retrospective case series	3 - 16	25	IMF (5) or conservative (20, of which 4 required subsequent corrective orthodontics). In 4 patients, subsequent orthodontic treatment was required	2 weeks	> 5 years (100%). Max follow-up 24.5 years postoperatively
Zhao et al. [22]	2014	Retrospective case series	3 - 16	40	Occlusal splints	Removable occlusal splint worn for 1 to 3 months, accompanied by functional exercises	1, 3, and 6 months after treatment, and then once a year (100%). Range: 14 months to 4 years post splint removal
Güven and Keskin [24]	2001	Retrospective case series	4 - 11	8	IMF with custom made archbars	12 - 17 days IMF	3 to 6 years. Mean follow-up was 4.7 years. (100%)
Schiel et al. [25]	2013	Retrospective case series	7 - 15	6	ORIF (5 endoscopic transoral, 1 preauricular access)	-	Follow-up computed tomograms were obtained 6 and 18 months postoperatively. 100% completed follow-up of 18 to 35 months (median, 24.5 months)
Thorén et al. [26]	2001	Retrospective case series	3.1 - 15.6	26	Conservative (11) or IMF (7)	IMF for 10 to 24 days (mean, 17 days)	4.8 to 16.4 years (mean, 8.6 years). 18 patients (69%) completed follow-up
Landes et al. [27]	2008	Retrospective cohort	< 14	24	Conservative (13) or ORIF (11)	2 weeks IMF with 4 IMF screws and 1.5 mm elastics. Patients requiring conservative treatment younger than 12 years had guided occlusion by a removable orthodontic appliance for an average of 3 months to spare the tooth buds a traumatization by set screw insertion	Follow-up was intended at 12, 24, and 60 months. 19 (79%) patients presented for follow-up immediately. After 1 year, 11 patients (58%) presented for follow-up; after 2 years, 4 (21%) patients, and after 5 years, 4 (21%) patients presented for follow-up

[a]However, not really a comparative and more of a large case series as late follow-up excludes those condyle fractures requiring surgery, so only records for non-surgical management.
IMF = intermaxillary fixation; ORIF = open reduction internal fixation; CT = computed tomography; MMF = maxillomandibular fixation.

Table 3. Risk of bias assessment

Study	Limitations	NOS score	Risk of bias
McGoldrick et al. [8]	- Retrospective data with possibility of missed data. Factors such as range of motion, deviation and opening measurements were not uniformly recorded in patient notes. - Small sample limits the applicability of statistical analysis and comparisons between groups. - Unable to assess potential long-term complications with length of follow-up.	5/9	High
Strobl et al. [9]	- Prospective case series. - In a randomized clinical trial, patients should be assigned to various treatment groups, including active physiotherapy with and without preceding IMF and myofunctional activator therapy with and without preceding IMF. - Strengths: Long term follow-up through the complete growth period. Sample size of 55 relatively large for this type of fracture.	6/9	High
Aksoyler et al. [10]	- Prospective but not comparative, i.e. case series. - Small sample (6 cases). - Relatively short follow-up (18 months). - Specific sub-cohort of condylar fractures.	5/9	High
Kim and Nam [11]	- Case series. - Small sample (11 cases).	5/9	High
Choi et al. [12]	- Case series. - Small sample (11 cases). - Wide range of follow-up from short (1 year) to adequate. - Strength – more accurate assessment of condylar remodelling with CT as opposed to OPG alone (however higher radiation dose to paediatric patients).	5/9	High
Yadav et al. [13]	- Short follow-up (1 year). - Case series.	5/9	High
Li et al. [14]	- Did not separate bilateral fractures and unilateral fractures. - Better grouping should lead to a more convincing conclusion. - However, based on the data volume, sub-grouping the cases into bilateral fractures and unilateral fractures would further decrease the data size and lead to insufficient case numbers for each group.	8/9	Low
Vesnaver et al. [15]	- Case series. - Small sample. - Good length of follow-up.	5/9	High
Cooney et al. [16]	- Short follow-up. - Retrospective and case series. - Loss to follow-up. - Compared to other studies. - Modest/good sample size.	5/9	High
Liu et al. [17]	- Case series. - Retrospective. - Small to modest sample size.	5/9	High
Wu et al. [18]	- Case series. - Retrospective. - Specific sub-cohort of condylar fractures. - Small sample size.	5/9	High
Theologie-Lygidakis et al. [19]	- Late follow-up excludes those condyle fractures requiring surgery so only records for non-surgical management. - Therefore not truly comparative and more of a large case series. - Retrospective. - Good sample size.	7/9	High
Zhang et al. [20]	- Retrospective. - Small sample size.	6/9	High
Hovinga et al. [21]	- Retrospective. - Case series. - Small to modest sample size. - Very long follow-up compared to most studies so truly able to assess long term implications on growth.	6/9	High
Zhao et al. [22]	- Insufficient length to identify long term effects on growth. - Modest sample size. - Wide age range so accounts for different 'remodelling/growth potential' due to of condyle/patient. - Retrospective. - Case series.	5/9	High
Zhang et al. [23]	- Small sample size. - Case series. - Good long term follow-up.	5/9	High
Güven and Keskin [24]	- Retrospective. - Case series. - Small sample.	5/9	High
Schiel et al. [25]	- Retrospective. - Case series. - Small sample.	5/9	High
Thorén et al. [26]	- Retrospective. - Case series. - Small sample.	6/9	High
Landes et al. [27]	- Patient number is limited. - Full randomization of closed vs open treatment was originally planned, however, not judged ethically acceptable after the literature had been reviewed.	8/9	Low

NOS = The Newcastle Ottawa Scale; IMF = intermaxillary fixation; CT = computed tomography; OPG = orthopantograms.

Patient satisfaction

Initial joint pain was reported in several studies [9-12,14-16,18,19,21-24,27] however in all studies except [18,26] this had resolved long term. Several patients required subsequent corrective procedures due to poor outcomes. Hovinga et al. [21] where one patient (low condylar neck fracture) showed obvious malocclusion and facial asymmetry, which needed to be corrected by orthognathic surgery. Facial scarring was reported in [15,20,27] and was satisfactory. TMJ clicking was found in a number of studies [12,16,18-22,24,26]. It was more commonly reported by patients but less reproducible by clinicians on examination e.g. 44.4% vs 22.2% [26] and 2 cases vs 0 [21].

Postoperative complications

No cases of infection, malunion, or nerve injury were reported in any of the studies. Condylar growth was noted to be abnormal in [9,11,12,15,18,20,26]. Of these [9,11,12] reported this was not clinically relevant and of no function or aesthetic limitation to patients. No cases of ankylosis were reported except in Theologie-Lygidakis et al. [19] were 2 cases were noted and required surgical correction due to limitations to mouth opening and function.

Synthesis of results

Data from each study was extracted and pooled. The results of statistical analysis are displayed in Table 4. Even with pooling the total numbers for each group was limited with 463 non-surgical cases vs 57 surgical cases. This pooled analysis showed no statistically significant difference in outcomes of surgical vs non-surgical management.

DISCUSSION

The most important finding from this review was of the quality of current available evidence. Available published material regarding management of paediatric mandibular condyle fractures is almost exclusively in the format of case series. From the "Levels of Evidence" [28], this is level 4 evidence and so is fraught with a host of limitations which affect this review. Although potential biases are likely to be significantly higher than if randomised control trials had been available, the case series were still reviewed as the best available evidence that could be found. To account for the lack of available papers directly comparing outcomes for surgical and non-surgical management options, collected data from all the available studies was pooled to for statistical assessment. However, the significant heterogeneity in the content of each study results in large drawbacks to this analysis and limit its usefulness.
Another principal limitation is the small sample sizes seen across all studies. Zhang et al. [20] illustrated how rare surgical management of paediatric condyle

Table 4. Pooled results for outcomes of surgical vs non-surgical management

Type of management		Non-surgical		Surgical		P-value[a]
		N	%	N	%	
Negative functional outcomes	Malocclusion	21	5	0	0	0.1
	Mandibular movements	56	12	6	11	0.73
	Total	77	17	6	11	-
Negative satisfaction outcomes	Pain	3	1	1	2	0.37
	TMJ clicking	17	4	1	2	0.45
	Aesthetics	7	1	0	0	0.35
	Total	27	6	2	4	-
Negative postoperative outcomes	Infection	0	0	0	0	-
	Nerve injury	0	0	0	0	-
	Malunion/non-union	0	0	0	0	-
	Ankylosis	2	0	0	0	0.61
	Condylar growth	27	6	2	4	0.47
	Total	29	6	2	4	-
Total number of cases		463	100	57	100	-

[a]Significant at level $P < 0.05$ (Chi-Square test).
TMJ = temporomandibular joint; N = number.

fracture is as during a 12 years period only 9 children satisfied the criteria and were enrolled in this study. Unanimously, in all 9 cases, parents preferred the option of conservative treatment, even though their children had been advised to treat surgically As a result, it is no surprise that the pooled sample size for non-surgical management was just over 8 times as large as that for surgical. There is also likely to be significant publication bias towards surgical or innovative non-surgical approaches to paediatric condyle fractures compared to outcomes for standard duration IMF of these injuries. It is also unsurprising that most of these fractures are managed with conservative measures (soft diet +/- short-term IMF +/- functional therapy) given the lack high level evidence for improved results with surgical management coupled with the known risks of surgical management (nerve injury, potential growth complications, multiple general anaesthetics, and scarring) [29]. However, future work on the actual impact of these risks is required as findings from case series included in this review suggest fears of negative surgical outcomes may be overestimated [15,20].

When reporting collected data on outcomes, not every included paper specifically mentioned each group of outcomes. Non-surgical management case series often did not report on post-operative complications like infection or nerve injury. Therefore, they were assumed to have not occurred, but this is a potential source of significant bias in the results. The way in which included outcomes were presented in reports is also high risk for bias. For example, Vesnaver et al. [15] reports 0 negative aesthetic outcomes but this is justified as scars being ‘very discrete and none of the patients or parents complained about them’ [15]. Whether this is truly the same as a non-surgical management option leaving no scar at all is debatable. Although Landes et al. [27] improved reproducibility of by setting a quantitative threshold for scar measurements being considered significant, this did not factor in patient’s views on their scar [27]. Given the paediatric cohort, the social and mental implications of self-perceived negative aesthetic outcome need to be considered as well. Similarly some papers reported normal mandibular movements for deviations < 3 mm e.g. Zhao et al. [22], whereas others simply listed mandibular opening deviations as present or absent [12,16,18,19]. This further limits direct comparison of data between different reports.

The results regarding functional outcomes support earlier work suggesting little correlation between radiographically observed condylar changes and mandibular dysfunction [30]. Some papers suggested better remodelling outcomes in younger children [9,19] although in one worse growth outcomes were observed for the youngest patient but this could have been confounded by different fracture management compared to the rest of the case series [15]. Most studies utilised radiography for follow-up. There was a regular use of computed tomography (CT) imaging in more recent studies, with older studies favouring orthopantograms (OPG) reflecting advancements in technology. Although CT is a non-invasive medical examination, exposure to ionising radiation is of particular concern in paediatric patients. In certain papers the increased radiation exposure was justified as “the protocol used is in line with the country’s medical regulations and ethics” [14].

Many of the studies included in this review identified and discussed the degree of displacement as a key factor influencing requirement for surgical management, e.g. [27]. Although mandibular condyle fractures in paediatric patients have been shown to be more common than in adult cohorts [30], displacement of the fractured condyle is uncommon and paediatric fractures are often greenstick fractures. This has been attributed to the different anatomy of a child’s condyle compared to an adults including the; thick overlying soft tissues, more elastic properties of the bone, presence of a large amount of immature trabecular bone and thin cortical bone [29].

The length of follow-up varied greatly across the included studies. The longest follow-up was 15 years [21] and the shortest was 6 months [14]. The impact of this on the risk of bias was considered as part of the Newcastle Ottawa Scale (NOS). Many of the papers included discuss the importance of long enough follow-up to allow monitoring of changes which may occur over the course of the child’s growth period [19,21,22]. The standard of 5 years for follow-up was chosen for the NOS as the mean age of children included was 8.5 years. Five years gave adequate length to observe any changes in the pubertal growth phase whilst still being practical for most researchers. Ideally duration of follow-up should extend to adulthood after remodelling of the mandible is complete but this would be very difficult for any future prospective studies to achieve. The adequacy of follow-up standards selected for the NOS were 100%, 80 to 99% and < 80%. Given the small sample sizes it was important cases were retained and 80% has been demonstrated to be an achievable level for mandibular fracture follow-up [31]. A 100% follow-up was achieved in all but three of the cases, although these still did manage follow-up rates of 89% and 88% unlike Landes et al. [27] where very low follow-up rates were seen even at 1 year [8,16,27]. Unsurprisingly, the longer the follow-up the greater the number of cases that were lost, Theologie-Lygidakis et al. [19] demonstrated a drop in engagement from 100% to 46% from initial too long term follow-up. The cause of dropouts was reported as either lack of communication or lack of interest on the part of the parents and the patients, and was mainly among patients treated the first 5 years of the study. Similar findings were seen with Landes et al. [27] at the 5 year mark.

In addition to the limitations of the available data, there were several limitations of this systematic review itself. Certain reports had to be excluded as they could not be accessed. Authors were contacted but no response obtained. Similarly, where reports had to be excluded as 'Unable to separate paediatric information from other ages' (n = 17) or 'Outcomes not reported' (n = 9) authors were contacted via email. Where responses were obtained, the requested information was not able to be shared. This review did include studies from a range of different nationalities and cultures and so is not limited by local environmental factors influencing treatment decisions or outcomes.

This topic is fraught with heterogeneity at every level and this review has been unable to provide convincing evidence for superiority or inferiority of surgical management of paediatric mandibular condyle fractures from the current available evidence. Historical arguments for and against surgical and non-surgical management cannot be disproved from this review. Open reduction is thought to be beneficial to obtain anatomical reduction in severely displaced cases, minimise risk of facial asymmetry with significant injuries and give a rapid return to function. Non-surgical management is argued to obtain acceptable/equivalent occlusal results with significantly reduced morbidity or complications (e.g. scarring, infection, avascular necrosis and ankylosis).

To address the limitations highlighted in this review, future work must be directed in two areas. Firstly, an agreed international consensus is required to define the measurable outcomes paediatric mandibular condyle fractures. This will then allow consistent comparison between future trials. Secondly, high-quality prospective trials are required directly comparing surgical and non-surgical methods.

CONCLUSIONS

This review found that the current literature consists of two distinct schools of thought management, each being presented with poor quality evidence and high levels of bias. Although this review pooled current available data no clear evidence was found for or against surgical or non-surgical management. Presently it appears conservative is functionally adequate without risks associated with surgical management, even though incidence of these risks was shown to be low. Therefore, the argument for non-surgical as first line with surgical being reserved for specific types of condylar fracture is still supported.

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