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Treatment of mandibular condyle impactation/dislocation into middle cranio fossa: a systematic review

Tratamiento de la impactación/dislocación del cóndilo mandibular dentro de la fosa craneana: una revisión sistemática

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ABSTRACT: Penetration of the mandibular condylar head into the middle cranial fossa is a rare event but can lead to serious complications, primarily due to the creation of a defect in the cranial base that poses a significant risk of hemorrhage from the middle meningeal artery. This systematic review aimed to identify the optimal treatment approach for mandibular condyle impaction or dislocation into the middle cranial fossa. We conducted a systematic review of the literature following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive search was performed across PubMed, Embase, ScienceDirect, Cochrane Library, and Google Scholar for relevant articles published between 1960 and 2023. Descriptive statistics were used to analyze the data. A total of 43 studies were included, encompassing 48 reported cases. The findings revealed a notable predominance of female patients and the following outcomes.

KEY WORDS: Temporomandibular joint, TMJ, condyle, fracture, fossa, algorithms.

INTRODUCTION

The temporomandibular joint is a hinge, arthrodial, synovial, and composite joint. It is considered complex because it contains two separate synovial cavities that must function in coordination (Alomar *et al*., 2007). The articular capsule defines the anatomical and functional boundaries: at the level of the condylar neck, it fuses with the periosteum; in the temporal region, it inserts 4 mm anterior to the articular eminence; laterally, it adheres to the edge of the mandibular fossa and the articular eminence; posteriorly, it attaches to the anterior slope of the petrotympanic fissure; and medially, it anchors to the sphenosquamosal suture. Medially and laterally, the capsule is reinforced by two ligaments that stabilize mandibular movement: the medial and lateral temporomandibular ligaments. Superiorly, the roof of the mandibular fossa is present, measuring only 0.08 mm in thickness, making it the thinnest anatomical region of the joint (Alomar *et al*., 2007; Romero *et al*., 2015).

It has been demonstrated that, due to its morphology, fractures in the roof of the glenoid fossa are uncommon; however, a small, circular-shaped condyle may more easily penetrate this region. This results in a scenario where a force applied in a caudal-to-cephalic direction can drive the condyle through the thinnest portion of the cavity, which is the medial aspect (Ribeiro *et al*., 2015). For 2012 only 49

cases were presented in the literature, representing only the 17.5% and 52% of all the mandibular fractures. Furthermore, in the current reported articles the complete information is not detailed, associated to clinical and surgical attention protocols, reason why, the comparison between published cases becomes necessary (Moher *et al*., 2009).

The objective of this study is to evaluate all types of treatments applied for mandibular condyle impaction or dislocation into the middle cranial fossa, along with their main complications, etiology, and the advantages and disadvantages of the different treatment approaches, through a systematic review.

MATERIAL AND METHOD

The framework of this systematic review was established to evaluate the topic by following the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and based on the PICO question (Moher *et al*., 2009). The main objective of this review is to answer the question: What is the most appropriate treatment for mandibular condyle impaction or dislocation into the middle cranial fossa? The PICO question is: "What is the most appropriate treatment for mandibular condyle impaction/ dislocation in the middle cranial fossa?"

PRISMA includes a checklist of 27 items and a four-phase flow diagram covering the title, abstract, introduction, methods, results, discussion, and funding. It was developed to provide precise and complete reporting of systematic reviews and meta-analyses. The systematic review covered studies published between 1960 and July 2023.

Search strategies

The systematic literature review was designed by an independent researcher and conducted independently by two calibrated evaluators following the same search strategy and applying predefined inclusion and exclusion criteria. In cases of disagreement regarding article selection or search results, a third evaluatorwas designated to resolve conflicts. However, no disagreements arose between the primary evaluators, so the third evaluator was not required.

The systematic search included the following databases: PubMed, Embase, ScienceDirect, Cochrane Library, and Google Scholar, covering literature published from 1960 to 2023. The search terms used were: TMJ impaction middle cranial fossa, TMJ dislocation middle cranial fossa, temporomandibular joint dislocation middle cranial fossa, and temporomandibular joint middle cranial fossa impaction. Results from all databases were combined, and duplicate articles were removed. All remaining references were collected and assessed for eligibility.

No search for unpublished literature was conducted. The focus was on published literature to identify previously reported cases. Additionally, the electronic search was supplemented by a manual iterative review of the reference lists of identified articles.

Study inclusion and exclusion criteria

During the initial selection stage of the study, titles and abstracts were reviewed and evaluated according to the inclusion criteria: articles written in English or Spanish; comparative clinical studies; literature reviews including case reports; case reports; cross-sectional studies; and cohort studies. During this process, pre-selected publications were further assessed using the following exclusion criteria: in vitro studies, animal studies, studies presenting only abstracts, and systematic reviews or meta-analyses.

The quality of the selected publications was evaluated based on the reporting of 12 key parameters for patients with mandibular condyle impaction or dislocation into the middle cranial fossa: reference and publication year, study design, number of patients, patient sex, mean patient age, etiology, laterality of the fracture (unilateral or bilateral), type of injury (impaction only or impaction plus fracture), medical treatment, postoperative follow-up, results, and conclusions. Each publication's quality was classified as good (9–12 variables reported), moderate (5–8 variables reported), or poor (1–4 variables reported).

RESULTS

A total of 43 articles were included in the review (Fig. 1), with a summary of variables presented in Table I. Forty-eight cases were analyzed, showing a significant predominance of female patients. When comparing open versus closed treatment approaches, among the 48 patients, 35.4% were male and 64.6 % female, with a mean age of 21.9 years for those undergoing surgery.

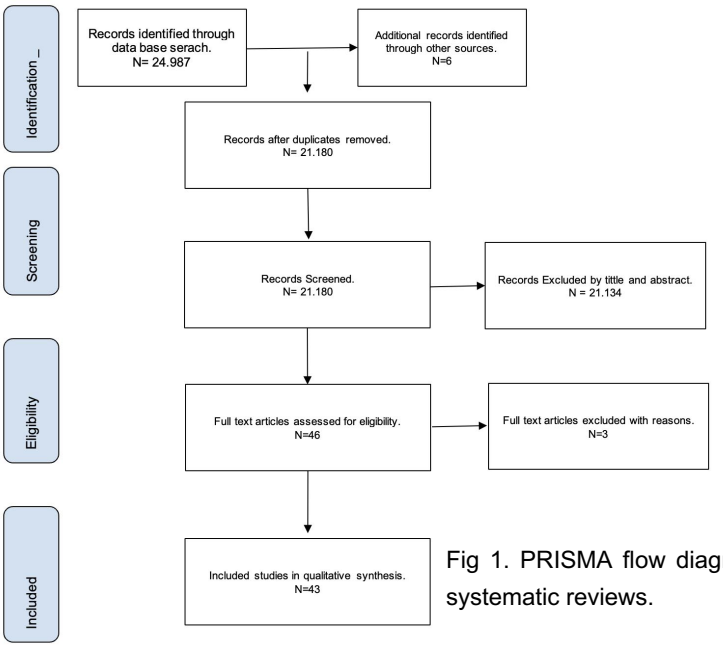

Fig 1. PRISMA flow diagram for systematic reviews.

Table I. Description of the variables associated with surgical intervention.

Variable	**Data**
Total, patients	48
Sex	17 male = 35.4 % 31 female = 64.6 %
Average age	21,9 years.
Etiology	Automobile accident vehicle 17 = 35.4 % Own feet fall 11 = 22.9 % Bicycle automobile accident 9 = 18.7 % Motorcycle automobile accident 7 = 14.5 % Blunt facial trauma (Punch) 1 = 2.08 % Unspecified 1 = 2.08 % Work accident 1 = 2.08 % Sport accident 1 = 2.08 %
Side of fracture	Right 28 = 58.3 % Left 19= 39.5 % Bilateral 1 = 2 %
Impaction/ Impaction plus condylar fracture.	Impaction was presented in 44 cases, representing 91.6 %, and impaction plus fracture only was presented in 4 cases, representing 8.3 %.
Open Vs. Close Treatment	Close 11 cases = 22.9 % Open 37cases = 77.1 %.

Regarding the etiology of mandibular condyle fractures and impactions in the middle cranial fossa, motor vehicle accidents accounted for the highest proportion at 35.4 % (17 cases), followed by falls from height (22.9 %), bicycle accidents (18.7 %), and motorcycle accidents (14.5 %). Sports-related accidents, work-related injuries, blunt facial trauma, and unspecified causes each represented 2.08% of cases. Laterality analysis showed a higher incidence on the right side (58.3 %) compared to the left side (39.5%), with only one patient (2 %) presenting bilateral fracture and/or impaction.

Table II details the treatments reported in the reviewed articles. The most performed interventions included extraoral (extra buccal) approaches, manual repositioning, glenoid fossa reconstruction (reported in five articles), closed manual repositioning, and maxillomandibular fixation (reported in 7 articles).

Table II. Author/year, type of investigation, types of treatments, post-surgical control, conclusions.

AUTHOR/YEAR	TYPE OF INVESTIGATION	SURGICAL TREATMENT	POST-TREATMENT CONTROL	CONCLUSIONS
Pirok DJ (1970)	Review + case	MMF 2 weeks; plug exercises	Stable at 18 months	Surgical treatment indicated when mechanical blockage or marked deviation exists.
Kallal & Gans (1977)	Case	MMF 2 weeks + elastics 3 months	No complications	Successful conservative management.
Aho AJ (1986)	Review + case	Manual repositioning; MMF not recommended in children	1.5 years, mild deviation	Manual repositioning in early cases; craniotomy in late cases.
AJ (1990)	Case	Guided opening + exercises + MMF 2 weeks	Monthly follow-ups for 2 years	Early rehabilitation favors functional repositioning.
Chuong (1994)	Review + case	Modified endoaural approach, repositioning, calvarial graft, disc fixation	2 months, 36 mm opening	Highlights importance of early diagnosis, anatomy, and multidisciplinary support.
Tornes (1995)	Review + case	Failed MMF 8 weeks; condylotomy/coronoidectomy + splint	5 years	Closed repositioning in recent trauma; avoid initial craniotomy.
Sandler *et al.* (1996)	Case	Hemicoronal approach, craniotomy, bone graft	2 weeks, 35 mm opening	Approach should depend on degree of penetration; direct visualization is safer.
Long *et al.* (1997)	Case	Preauricular + traction; arthroscopy; plate reconstruction	Not specified	Bone graft ideal; arthroscopy useful for assessment.
Melugin & Indresano (1997)	Review + case	Endoaural, condylotomy, costal graft	Not specified	Closed reduction in early injuries; craniotomy or condylotomy in late cases.
Defabianis (2001)	Review + case	Repositioning + bone reconstruction; disc replaced with Gore-Tex	3 months, 29 mm opening	Good prognosis; no complications.
Kroetsch *et al.* (2001)	Review + case	Manual repositioning + MMF 2 weeks	1 year, 48 mm opening	Aggressive surgery reserved for complications or failed closed treatment.
Barron *et al.* (2002)	Review + case	Manual repositioning + MMF 1 week	2 years, 35 mm opening	Good outcome with no complications.
Spanio *et al.* (2002)	Review + 2 cases	Case 1: craniotomy + graft; Case 2: repositioning + iliac crest graft	1 month / 8 months	Closed reduction only appropriate in very early cases.
WJ (2003)	Review + case	Preauricular + craniotomy; temporal fascia graft	1 month and up to 4.8 years	Importance of early detection and complete anatomical restoration.
Cillo & Sinn (2005)	Case	Preauricular + craniotomy; graft reconstruction; MMF 3 weeks	7 weeks	Goals: prevent recurrence, restore posterior height and function.
Harstall *et al.* (2005)	Review + case	Closed repositioning + MMF 1 week	2 months	Conservative treatment indicated in early cases without neurological compromise.
Soares (2005)	Case	Preauricular, repositioning + discectomy	2 weeks / 9 months	Good functional outcome.
Rosa & Guimarães (2006)	Review + case	Open reduction with condylotomy	Not specified	Consider trauma timing and ankylosis risk.
Ohura *et al.* (2006)	Review + case	Failed closed attempt; preauricular + traction + temporal fascia graft; MMF 3 weeks	2 years, 42 mm opening	Closed reduction useful in children <4 weeks; open if it fails.
Clauser *et al.* (2006)	Review + case	Submandibular + preauricular; osteotomy; temporal flap	2 weeks, 45 mm opening	Treatment tailored to fossa damage and ankylosis risk.
Magge *et al.* (2007)	Case	Craniotomy + calvarial graft	1 month / 1 year	Aims: restore function, symmetry, and prevent ankylosis.

AUTHOR/YEAR	TYPE OF INVESTIGATION	SURGICAL TREATMENT	POST-TREATMENT CONTROL	CONCLUSIONS
Taglialatela Scafati *et al.* (2008)	Review + case	Condylotomy + local graft	Not specified	Treatment depends on age, timing, and imaging findings.
Menon & Sinha (2008)	Review + case	Preauricular, condylotomy + temporal fascia; MMF 1 week	Not specified	Goals: restore function and avoid neurological injury.
Lloyd & Sivarajasingam (2010)	Case	Open reduction + craniotomy	1 year, 30 mm opening	Intensive physiotherapy is key to avoid ankylosis.
Man *et al.* (2011)	Review + case	Failed closed; multiple approaches; fossa repair with mesh and fascia	12 months	Closed reduction if no fracture; open if late or failed.
Hayashi *et al.* (2011)	Case	Right reduction + left TMJ prosthesis	Not specified	TMJ prosthesis useful in extensive reconstructions.
Struewer *et al.* (2012)	Review + case	Craniotomy + fossa reconstruction with temporal fascia	6 months	Treatment individualized based on damage and neurological risk.
Lee & Green (2013)	Case	Craniotomy + partial mandibulectomy	4 months	Careful planning required to avoid neurovascular injury.
Mannion *et al.* (2013)	Case	Open reduction + temporal flap; MMF 2 weeks	Not specified	Good functional and aesthetic outcome.
Jiao *et al.* (2013)	Case	Elastic traction; spontaneous repositioning; MMF + physiotherapy	2 years	Early repositioning is key; rule out associated injuries.
García-Guevara *et al.* (2013)	Case	Preauricular + TMJ prosthesis	2 years	Prosthesis reduces morbidity and operative time.
Vaezi *et al.* (2014)	Case	Craniotomy + reconstruction with miniplate; MMF + elastics	6 months	Treatment must be individualized; aim: restore function without neurological damage.
Zhang *et al.* (2014)	2 cases	Craniotomy + graft / Preauricular + titanium mesh	1 year	Advanced imaging and interdisciplinary management essential.
Oberman *et al.* (2014)	Case	Closed reduction + MMF 7 days	37 days	Closed reduction is the safest initial method.
Temiz *et al.* (2015)	2 cases	Case 1: closed; Case 2: open + fibrous release	6 months / 1 year	Closed in early stages; open if it fails.
He *et al.* (2015)	3 cases	Closed/open reduction + fossa reconstruction	1 year	Algorithm proposed based on timing, injuries, and CT findings.
Kanno *et al.* (2016)	Review + case	Craniotomy + miniplate reconstruction; MMF 28 days	18 months	Timely diagnosis essential; requires neuro–maxillofacial collaboration.
Zamorano *et al.* (2016)	Case	Craniotomy + condylectomy + temporal flap	1 year	Late diagnosis common; craniotomy reserved for sequelae or neurological risk.
Rikhotso & Bobat (2016)	Case	Arthroplasty + TMJ prosthesis	3 years	Open approach indicated in delayed or failed closed treatment.
De Mol (2017)	Case	No treatment	Not specified	CT and MRI are the most reliable diagnostic tools.
Liu *et al.* (2017)	Case	Condylectomy + temporal flap	6 months	Open reduction indicated in late lesions or intracranial damage.
Monteiro *et al.* (2019)	Review + case	Preauricular + craniotomy; fossa reconstruction	12 months	Management requires multidisciplinary team.
Díez-Suárez & Paredes (2021)	Review + case	Preauricular + craniotomy; condylectomy; resorbable mesh	Postoperative orthodontics	Should be suspected in high-energy trauma; CT is gold standard; interdisciplinary surgical management recommended.

DISCUSSION

Condylar dislocation through the glenoid fossa into the middle cranial fossa is an uncommon event. The mandibular anatomy facilitates force dissipation, typically resulting in fractures at the weakest part of the condylar neck, thereby preventing the transmission of forces to the cranial base. This mechanism explains the high incidence of condylar fractures. The smaller, more rounded condylar neck observed in children predisposes them to this condition. Conversely, the adult condyle, with its greater medial-lateral length, is less likely to penetrate the glenoid fossa; however, cases have also been reported in adults (Long *et al*., 1997; Barron *et al*., 2002; Menon & Sinha, 2008; Oberman *et al*., 2014; Arya & Chigurupati, 2016; Díez-Suárez & Paredes-Farrera, 2021).

Clinical presentations may vary. Initial examinations can reveal signs suggestive of a sub-condylar fracture and/or intracranial injury. Common symptoms include preauricular pain, trismus, unilateral hearing loss, and other intracranial manifestations such as bleeding caused by injury to the middle meningeal artery, facial nerve paralysis, otorrhea, and drowsiness. Extra-cranial signs may include premature posterior occlusion due to shortening of the mandibular ramus, lateral deviation of the mandible, anterior open bite, and laceration of the external auditory canal (Mannion *et al*., 2013; Oberman *et al*., 2014; Arya & Chigurupati, 2016; Díez-Suárez & Paredes-Farrera, 2021).

The treatment of this injury must be individualized, taking into consideration factors such as the patient's age, growth potential, degree of glenoid fossa destruction, risk of ankylosis, and likelihood of associated head injuries. The complex nature of this condition has led to the development of multiple treatment options, guided by clinical signs and symptoms, duration of the injury, and patient-specific characteristics. The primary objective of treatment should be to restore mandibular function and occlusion while minimizing the risk of neurological complications (Man *et al*., 2011; Yoshida, 2023).

Multiple treatment modalities are described in the literature for managing mandibular condyle dislocation into the middle cranial fossa. Broadly, two main approaches are recognized: closed reduction and open surgical reduction, the latter often combined with glenoid fossa reconstruction. Closed reduction is generally indicated within the first four weeks post-trauma and is particularly suitable for pediatric patients (Harstall *et al*., 2005; Liu *et al*., 2017). This approach can be subdivided into reduction with or without manipulation. Closed reduction without manipulation may be achieved using two techniques: the "handle method" with a bite device, and the "traction method," employing instruments such as hooks or wires. This procedure must be performed under general anesthesia due to the risk of secondary injury to the middle meningeal artery and should be carried out in collaboration with a neurosurgeon (Aho *et al*., 1986; Man *et al*., 2011; Mannion *et al*., 2013).

When closed reduction is unsuccessful, several surgical strategies are available. Open surgical reduction can be performed using either a preauricular or a temporocranial approach, and typically includes one of three techniques: direct open manipulation, condylotomy, or intracranial condylectomy. Following dislocation, in the absence of the condyle, the glenoid fossa often becomes occupied by fibrous tissue. If a condylotomy or intracranial condylectomy is performed, glenoid fossa reconstruction is usually required, using a bone graft, titanium mesh, or a combination of both. The preauricular approach provides a more direct and extensive surgical field, facilitating both TMJ reconstruction and condylotomy more effectively than other approaches (Tornes & Lind, 1995; Ohura *et al*., 2006; Mannion *et al*., 2013).

The use of post-operatory CT is a mandatory requirement to show the condyle position and to make sure that there are no iatrogenic injuries (Menon & Sinha, 2008). Postoperative follow-up should be maintained for up to two years. Most patients reported in the scientific literature presented deviation of the oral opening toward the affected joint side. Physiotherapy including the use of maxillomandibular elastics and guided mouth-opening exercises is recommended to improve function and reestablish proper occlusal mechanics (Murad *et al*., 2018).

Various postoperative treatment protocols have been described in the literature. Several reports recommend maxillomandibular fixation for a period of 7 to 28 days to maintain occlusion and prevent recurrence of condylar displacement, followed by physiotherapy (Jiao *et al*., 2013; Kanno *et al*., 2016; Monteiro *et al*., 2019). Jiao *et al*. (2013)

proposed the use of maxillomandibular elastics for traction in three patients over a one-month period, with follow-up extending to one year. Stable postoperative occlusion was achieved, and the patients presented oral opening ranges between 35 and 38 mm. However, all three cases exhibited varying degrees of mandibular deviation during mouth opening. The aim of physiotherapy is to reduce deviation during mouth opening and closing. It is typically initiated during the first postoperative week, with monthly follow-ups for up to one year to evaluate functional outcomes (van der Linden, 2003; Hayashi *et al*., 2011). In patients with temporomandibular joint prostheses, physiotherapy is generally recommended 48 hours after surgery. During the first two postoperative weeks, exercises consist of maximal sustained opening and closing. Starting in the third week, forced mouth-opening exercises are introduced using wooden spatulas placed bilaterally between the posterior teeth, performed either alternately or simultaneously for 2–3 minutes. This therapeutic protocol includes weekly supervised sessions for a period of two months, with the patient continuing the exercise routine at home 3–5 times per day for 12 weeks (Moher *et al*., 2009; Lee & Green, 2013).

CONCLUSION

Treatment decisions depend on patient age, clinical presentation, and neurological involvement. In cases with neurological symptoms, open reduction with craniotomy may be required. When there is severe bone loss, reconstruction with a custom temporomandibular joint prosthesis is recommended.

Postoperative physiotherapy includes monthly monitoring, elastic guidance, and exercises to achieve at least 30?mm of oral opening. The main goals are to restore mandibular function, recover pre-injury occlusion, and ensure long-term stability.

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RESUMEN: La penetración de la cabeza condilar mandibular en la fosa craneal media es un evento poco frecuente, pero puede provocar complicaciones graves, principalmente debido a la creación de un defecto en la base del cráneo que representa un riesgo significativo de hemorragia por la arteria meníngea media. El objetivo de esta revisión sistemática fue identificar el enfoque terapéutico óptimo para la impactación o luxación del cóndilo mandibular en la fosa craneal media. Realizamos una revisión sistemática de la literatura siguiendo las directrices PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Se llevó a cabo una búsqueda exhaustiva en PubMed, Embase, ScienceDirect, Cochrane Library y Google Scholar para encontrar artículos relevantes publicados entre 1960 y 2023. Se aplicaron estadísticas descriptivas para analizar los datos. Finalmente, se incluyeron 43 estudios, que abarcaron 48 casos reportados. Los hallazgos revelaron una notable predominancia del sexo femenino y los siguientes resultados.

PALABRAS CLAVE: Articulación temporomandibular, ATM, cóndilo, fractura, fosa, algoritmos.

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