Mandibular condyle fractures: A diagnosis with controversial treatment

Fracturas del cóndilo mandibular: Un diagnóstico con tratamiento controversial

Ana L. Ortiz-Gutiérrez[1], Belinda Beltrán-Salinas[1] and Ricardo Cienfuegos[2,3]*

[1]Hospital Metropolitano "Dr. Bernardo Sepulveda" SSNL, Monterey; [2]Cirugía Plástica Reconstructiva, División de Educación, UMAE Traumatología and Ortopedia Lomas Verdes, IMSS, Ciudad de México; [3]Cirugía Plástica, Hospital ABC, Ciudad de México, México

Abstract

Background: *Over the years, the treatment to be chosen for the resolution of condylar fractures has been discussed with great concern. Treatment depends on the type and location of the fracture, as well as other associated factors such as facial injuries and concurrent diseases.* **Aim of the study:** *The aim of the study was to make a review of the different criteria to establish a diagnosis and treatment to resolve mandibular condyle fractures, according to the evolution of the years and what this entails.* **Discussion:** *Management of condylar fractures remains controversial among surgeons. However, as time goes by and as comparative and analytical studies are carried out within the issue, parameters and criteria are established to facilitate the decisions taken regarding the management and treatment of condylar fractures.* **Conclusion:** *Condylar fractures must be managed according to the clinical and case presentation.*

KEY WORDS: *Condyle. Fracture osteosynthesis. Mandibular fractures. Maxillofacial injuries. Maxillo-mandibular fixation.*

Resumen

Antecedentes: *A lo largo de los años se ha discutido con gran preocupación el tratamiento que hay que escoger para la resolución de las fracturas condilares. Este depende del tipo y la localización de la fractura, así como de otros factores asociados, como las lesiones faciales y las enfermedades concomitantes.* **Objetivo:** *Hacer una revisión de los diferentes criterios para establecer un diagnóstico y un tratamiento para la resolución de las fracturas del cóndilo mandibular, de acuerdo con la evolución de los años y lo que esto conlleva.* **Discusión:** *El manejo de las fracturas condilares sigue siendo controvertido entre los cirujanos. Sin embargo, a medida que pasa el tiempo y se realizan estudios comparativos y analíticos sobre el tema, se establecen parámetros y criterios para facilitar las decisiones tomadas en relación con el manejo y el tratamiento de las fracturas condilares.* **Conclusión:** *Las fracturas condilares deben ser manejadas según la clínica y la presentación del caso.*

PALABRAS CLAVE: *Cóndilo. Osteosíntesis de fractura. Fracturas mandibulares. Lesiones maxilofaciales. Fijación maxilomandibular.*

Correspondence:
*Belinda Beltrán Salinas
Adolfo López Mateos, 4600
C.P. 66480, San Nicolás de los Garza, N.L., México
E-mail: beltransa25@yahoo.es

Date of reception: 03-06-2018
Date of acceptance: 14-08-2018
DOI: 10.24875/CIRU.18000507

Cir Cir. 2018;87:587-594
Contents available at PubMed
www.cirugiaycirujanos.com

Introduction

Maxillofacial trauma involves various structures within the craniofacial skeleton, involving soft and bony parts of the facial region due to an acute or chronic energy action. Maxillofacial fractures are generally associated with high morbidity, loss of function, esthetic sequelae, and high financial costs; the consequence of the hospitalization and resources that it demands.

The condylar eminence is frequently involved in fractures of the maxillofacial complex constituting 25%-35% of mandibular fractures. Its frequency and fracture pattern depends on different causes, with the highest incidence being motor vehicle accidents (44.20%), cycling (24.61%), physical aggression (8.12%), and falls (23.07%)[1].

The mandibular condyle may be fractured by direct or indirect trauma, being displaced by the reaction of various factors such as direction, magnitude, point of application of force, state of the dentition, and occlusal position[2].

Within the study in relation to condylar fractures there are classifications for the denomination to the location of the same ones. According to Loukota, fractures are classified in diacapitular, neck, and base. Diacapitular fractures being those fractures compromising the head of the condyle, in which the line begins at the articular surface, being able to extend outside the capsule. Neck fractures of the condyle include fractures that begin above the sigmoid recess. And finally, the base fractures (subcondylar) are those whose fracture line is below the sigmoid recess[3-5] (Fig. 1).

Likewise, MacLennan and Lindahl establish a classification with greater acceptance, defining fractures as condylar head, neck, and subcondylar fractures with the same parameters previously mentioned, as well as dislocation and displacement[6] (Fig. 2).

Background

Over the years, the treatment to be chosen for the resolution of condylar fractures has been discussed with great concern. Treatment depends on the type and location of the fracture, associated facial injuries, as well as concomitant diseases. It can range from functional therapy without maxillomandibular fixation (MMF), closed reduction with MMF, to open reductions with osteosynthesis plates[7].

Some authors establish that most condylar fractures are treated by closed reduction, due to the good results of the majority of the patients treated by this management[8]. The treatment for condylar fractures in children becomes more complicated due to the poor cooperation and difficulty when placing MMF and reduced space in mandible and maxillae with developing teeth. The methods of temporary immobilization involve arch bars, acrylic splints, MMF screws, and bonded brackets with the use of heavy elastics. The recommended period of immobilization oscillates from 1 to 2 weeks to allow early bone healing, followed by active mobilization of the mandible as an immediate indication to avoid ankylosis, aided with the use of elastics for 6-8 weeks to restore and obtain desirable occlusion. Studies establish good results in regard to masticatory function and patient satisfaction. In patients younger than 12 years, the adaptive mechanisms should restore function without immobilization, for which early mobilization is instructed. Patients with major disruption of occlusion and patients with risk of ankylosis or defective development, have to be the reason for alert and caution. Occlusal impairment, consisting of open bite and possible retropositioning of the mandible, may be a consequence of bilateral fracture dislocation. Treatment in these cases should be immobilization, as well as for an adult. In instances where unilateral condyle fracture with occlusal disruption is present, a period of 10-14 days should be assumed. In bilateral fractures immobilization of 3 weeks may be required. Young patients with a probability of ankylosis or defective development respond to either close proximity of the fractured condylar neck to the glenoid fossa or those who have multiple fractures with associated coronoid and zygomatic fractures. In these cases, it must be presumed that the meniscus and/or capsule is damaged, for which a conservative immobilization may be used in case the patient has minimal symptoms. Otherwise, in case of severe pain, MMF is recommended for no longer than 14 days, followed by active mobilization, due to the greater osteogenesis of condylar progress and remodeling capacity. In adolescent patients between 12 and 17 years old, if a malocclusion is present, the capability for spontaneous correction is less than in younger patients. Therefore, a malocclusion indicates MMF for 2-3 weeks. If the conservative treatment fails in this age group, the clinician would have to employ adult principles of treatment[9,10].

The protocol of closed reduction for adults includes mandibular exercises such as maximum opening, laterality, and protrusion, in which movements of 5-10 repetitions of 2-4 times a day during 3 months of rehabilitation must be done[11,12]. Arch bars are also

Figure 1. *Location of condylar fractures:* **A:** *Neck fractures;* **B:** *Subcondylar fractures;* **C:** *Diacapitular fractures.*

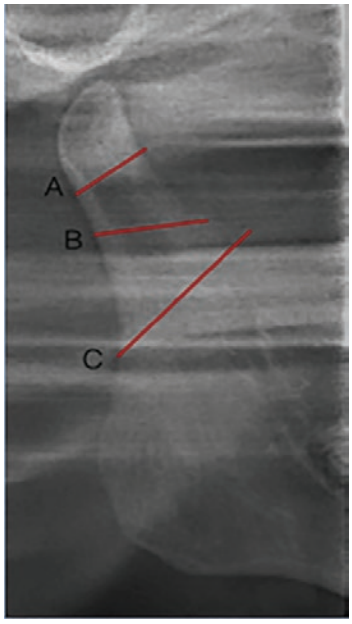

Figure 2. *Levels of condylar fractures.*

placed to guide the occlusion with elastics and achieve an optimal opening of 40 mm interincisal, using them from 1 to 4 weeks and kept under observation for 3 more months[12,13]. This protocol is carried out to mobilize the components early and restore physiological functions, avoiding some type of ankylosis[11].

It is considered that the temporomandibular joint is an area that can result in complications involving the VII cranial nerve, as well as other associated complications. Likewise, there may be technical problems at the moment of manipulation of the fractured segments toward their anatomical position, due to comminuted fractures, fragment size, or fracture characteristics. Finally, the necessary approach to open reduction may result in a scar[8,13].

Within the problems that could be presented in cases of articular fractures treated with a closed reduction, not only are early dysfunctions but also late joint changes in the next 10-50 years in the joint not found in an adequate anatomical position. There are also short-term problems, such as pain, dysfunction, limitation of opening, and deformities such as retrognathia, asymmetry, or open bite. On the other hand, long-term sequelae associated with the technique used for closed reduction, such as pain, arthritis, and movement limitation, could also present with open reduction. That is why the surgeon must perform an analysis based on specific criteria of the case in question to determine the treatment and management of the fracture to be treated[8].

To determine and provide the best treatment when performing the analysis of the patient in question, there are criteria that support the specific conditions in which condylar fractures occur. These criteria are established by means of absolute and relative indications to perform open reduction with internal fixation that will help the surgeon make a more accurate decision regarding the treatment to be performed.

The indications for open reduction are: (1) Displacement toward the middle cranial fossa, (2) failure to obtain adequate occlusion by means of closed reduction, (3) lateral extracapsular displacement of the condyle, (4) intrusion of a foreign object, (5) loss of posterior facial height, (6) loss of vertical height greater than 4 mm, and (7) angulations of 30° or greater. Likewise, indications for open reduction refer to condyles displaced outside the fossa and associated with malocclusions. These include (8) bilateral condylar fractures in edentulous patients where MMF is impossible due to alveolar atrophy present, (9) unilateral or bilateral condylar fractures where MMF is not recommended for medical reasons or problems in which physiotherapy is impossible (patients with seizures, psychiatric problems, alcoholism, reluctant behavior, mental retardation, or delayed neurological trauma), (10) bilateral condylar fractures associated with comminuted fractures of the middle third of the face, and

(11) bilateral condylar fractures associated to gnathological problems such as retrognathia, prognathism, open bite with periodontal problems or non-existent posterior support, absence of multiple dental organs and bilateral condylar fractures with unstable occlusion due to orthodontics and unilateral fractures with an unstable fracture base. An additional indication was any condylar process fracture in which a bony union and immediate function were desired[8,14-16].

The displacement toward the middle cranial fossa is not very frequent in incidence; however, it has been reported. Similarly, the lateral displacement is not very incident; however, it has been presented. Foreign bodies should be removed from the joint; however, a period of approximately 1-2 weeks is recommended to allow the edema to diminish so that fibrosis forms around the foreign body and allows it to be isolated and easier to handle at the time of removal[8,13].

Intracapsular fractures of the mandibular condyle head are mostly treated in a closed manner in most institutions since good results have been demonstrated. The type of fracture and its intracapsular location determine the prognosis after a closed functional treatment of condylar head fractures; the worst being those that are found comminuted[17,18]. However, nowadays, reports have been published about benefits of surgical treatment in these type of fractures, taking into consideration the advances in surgical techniques and imaging, such as the computerized tomography (scan)[18]. The keys for successful open reduction and rigid fixation of intracapsular fractures are: good exposure, anatomic reduction without damaging the cartilage surface of the condyle and lateral pterygoid muscle, stable fixation, and disc reposition[19-21].

There are several factors to evaluate and to determine the method to be used for open reduction, in which the following stand out: (1) position of the condyle, (2) location of the fracture, (3) time of evolution of the fracture, personality of the patient, edema volume, place of approach, and type of fixation. It is preferable to determine if the condyle is in the fossa, and if so, the fracture will heal under acceptable conditions in proper position and function after the restoration of occlusion and physiotherapy[8].

The choice of approach to be performed depends on the location of the fracture line. The submandibular approach, occasionally referred to as the Risdon approach, can be used for access to the mandibular region, angle and body fractures, and condylar fractures. It is precise to recognize very important structures that associate to the region, such as the marginal mandibular branch of the facial nerve, facial artery, and facial vein to proceed with the incision and dissection. The incision in the submandibular approach is carried through skin and subcutaneous tissues to the level of the platysma muscle. The superior portion of the incision is undermined approximately 1 cm, and the inferior portion is undermined approximately 2 cm or more. The retromandibular approach exposes the entire ramus from behind the posterior border; therefore, it is useful for exposure of the condyle neck. The anatomical structures that have to be taken into consideration in this area correspond to the facial nerve and the retromandibular vein. The incision for this approach begins 0.5 cm below the earlobe and continues inferiorly 3-3.5 cm, and it is placed just behind the posterior border of the mandible and may or not extend below the level of the mandibular angle. The preauricular approach is a standard to access the TMJ, and it comprehends several important anatomical structures in the area such as the parotid gland, superficial temporal vessels, auriculotemporal nerve, facial nerve, and the temporomandibular joint itself. The incision is held at the junction of the facial skin with the helix of the ear. A natural skin fold line along the junction may be used to minimize the scar. The incision extends superiorly to the top of the helix and may include an anterior extension[22]. The periangular approach, also referred to as high submandibular, or modified Risdon's approach, has been used to approach fractures of the condylar base. This approach provides good esthetics and drastically reduces the chance of facial nerve paraesthesia. The periangular approach involves a 3-5 cm curved incision, marked 1 cm from the angle of the mandible[23].

Diacapitular fractures are accessed by means of a preauricular approach or only by means of a preauricular approach. A subcondylar or neck fracture is accessed by means of a retromandibular or submandibular approach. Furthermore, the option of an intraoral approach is available (now with endoscopic assistance), which can only be used for neck fractures and fractures of the subcondylar type, since the access is limited and it hinders the direct visibility toward the site to be treated, it is an approach for surgeons with experience, however it avoids facial scars, facial nerve affection and provides constant visualization of the occlusion during the procedure. A fracture with the evolution of 2-3 weeks, is the maximum time to operate, is accessed by means of a combined submandibular and preauricular approach[8,24-28].

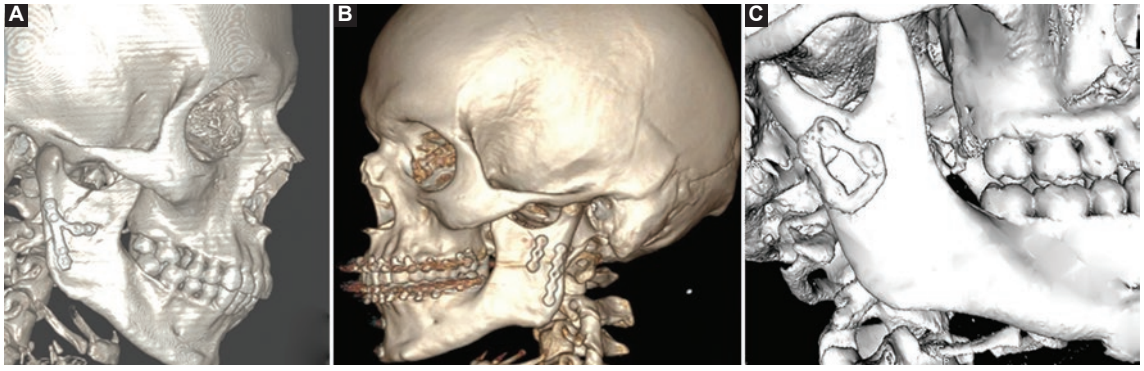

Figure 3. A-C: *Design of different osteosynthesis plates.*

There are various designs of plates as osteosynthesis material used to perform the internal fixation. The five main designs for performing osteosynthesis, as required on a case-by-case basis, are: (1) straight standard plate, (2) inverted Y plate, (3) delta plate, (4) trapezoidal plate, and (5) rectangular plate. The use of each of them depends on the fracture to be reduced, being the straight plate the most used, due to its high resistance[29,30] (Fig. 3). Strut plates are also a three-dimensional plate option for transoral endoscopically assisted approaches, providing intraoperative handling and fitting accuracy, precluding complications such as plate fatigue fractures[31].

The term and concept of rigid internal fixation are used to determine the application of an internal system to prevent movements at the fracture site when normal function forces are exerted. Within the above mentioned, reconstruction plates, high profile plates, and multiple screws are included. It is important to mention, to determine a good treatment plan, with a fixation system that maintains the fracture in question[32,33]. Open reduction and internal fixation of the condyle are irrational if the internal fixation is not sufficiently stable to resist physiological strains, becoming necessary numerous plating techniques. Trapezoidal condylar plates are a good option to stabilize subcondylar fractures, allowing the use of only one plate, fulfilling the principles of functionally stable osteosynthesis[34].

Application of miniplates has become, nowadays, the most common technique of open fixation. Nevertheless, anatomical and biomechanical limitations make it challenging when a considerable complication arises. Individual human mandible anatomy, bone density, position, and orientation of the masticatory muscles are some of the factors that play an important role in biomechanical behavior. The loosening of screws, bending instability of miniplates and plate fractures have been observed as a consequence of transferred loads and stress distribution in the bone and osteosynthesis system, due to the static and fatigue limits in miniplates.

Within the complex of biomechanical behavior of the mandible, bite forces associated to the reaction forces applied to masticatory muscles, such as masseter, temporalis, medial pterygoid, and lateral pterygoid, being the temporalis with a force of 329.2 N, the masseter with 272.0 N and the medial pterygoid with 174.8 N, the muscles with the greater proportion of acting force.

Force load configurations relay on biting with occlusal contact on the contralateral side of the fractured condylar process and biting with occlusal contact on the ipsilateral side of the fracture. After surgical treatment, the clinician should tell the patient to avoid loading of the mandible, yet patients do crunching and clenching with the teeth when sleeping and lifting substantial objects, contributing to loading risks and inadequate compliance of the patient.

Another element to discuss is the existence of full dentition or absence of it with or without an adequate occlusal relationship. This is critical to the stresses that might be excreted inside the condylar neck osteosynthesis devices; where full dentate patients will distribute evenly the bite forces. Although a patient with full dentition might exert higher masticatory forces, therefore, more load to the fracture and plates. It is important to know the fatigue limit for bending of titanium, which is approximately 450-500 MPa, to avoid exceeding the configurations, the equivalent stresses up to 2700 MPa definitely exceed the static yield limit of titanium. Due to the previous statements, it is recommended to use two fixation plates at the site[35].

Within the results after a closed or open reduction, four important criteria must be met: (1) ranges of relatively normal movements, without pain, with an interincisal distance of 40 mm, (2) good occlusion, (3) stable TMJ, and (4) facial and mandibular symmetry[12,36].

However, not all condylar fractures are managed by means of open reduction with internal fixation. Some authors considerate open reduction as a contraindication in head fractures, comminuted or not, due to the incidence of the high risk of avascular necrosis associated with loss of condylar function, resulting in the development of fibrous or osseous ankylosis[37,38].

Nevertheless, some others decide to do surgical treatment based on their expertise and access to high technology. Minimally invasive techniques using endoscopes have been introduced to treat condylar mandible fractures and soft tissue surgery to offer advantages for selected cases such as preventing salivary fistulae, minimize blood loss and reduce the risk of facial nerve palsy or other neurologic complications[15,39,40].

It is of great relevance to know the complications associated with the treatment of condylar fractures. In the transoperative period, hemorrhage may occur at the treated site, as well as an encounter of anatomical structures of relevance such as the VII cranial nerve or damage to one of its branches. Post-operative complications may include a greater number of complications associated with the approach and manipulation of the area such as infection, paraesthesia, salivary fistula or facial nerve paresis, auriculotemporal nerve dysfunction, Frey's syndrome, and scar resulting from the extraoral approach[15,22,41,42].

Discussion

The management of condylar fractures remains controversial among some surgeons. However, as time goes by and as comparative and analytical studies are carried out within the issue, parameters and criteria are established to facilitate the decisions taken regarding the management and treatment of condylar fractures.

Studies have suggested better results with respect to buccal openness, protrusion, lateral excursions, pain, and malocclusion through open reduction as opposed to closed reduction management[17,24]. Zide established indications for condylar fracture management by means of open reduction, according to the techniques, materials, miniplates, and scientific reports of the moment; however, today there are advances in which is reported and the existing paradigm has changed with respect to the management of condylar fractures. New materials and techniques have been generated, so open reduction has become more popular and used to obtain optimal results[14,38].

Access to the fracture line is one of the main issues to be defined for adequate exposure, segment alignment, and stable internal fixation. Choosing the right approach for fracture placement is elemental to avoid complications such as facial nerve damage, associated infection, salivary fistulas, and related cosmetic conditions[43,44].

Overall, it is safe to declare that endoscopic surgery is certainly a good replacement for approaches through the skin, for condylar fractures; avoiding the complications related to the traditional open technique and those related to the close technique such as the lengthened MMF, non-anatomical reduction, and difficulties associated with mandibular movements, making endoscopic technique very attractive for surgeons with enhanced experience[16,45].

We agree with some authors that an intraoral approach endoscopically assisted is an excellent option in cases of neck and subcondylar fractures, due to the detailed management of the segments and lower incidence of facial nerve damage, salivary fistulas, and visible scars. However, it is a resource that is limited for some hospitals or centers, due to the high technology surgical equipment, surgeons with experience, and human resource in training, which may imply a steep learning curve[45].

Based on other studies such as a 16-year retrospective study made in Nigeria in 2015, in which they aimed to analyze cases of mandibular condylar fractures complicated by TMJ ankylosis after treatment, stating evidence that trauma to condyles may result in an intra-articular hematoma, leading to fibrosis, excessive bone formation, hypomobility of TMJ, and ultimately to ankylosis of the joint. We also corroborate that the pattern of intracapsular condylar fractures with the concomitant widening of the mandible leads to a lateral pole of the condyle or the condyle stump becoming displaced laterally or superolaterally in relation to the zygomatic arch, where it fuses resulting in ankylosis[46]. In our experience, we prefer an open reduction in fracture cases that involve the condylar head, only if it fits or corresponds to an extracapsular localization. We see as necessary the extraction of the segments that are comminuted, because we have patients that have returned to our department with more than 5 years evolution ankylosis.

Regarding the follow-up to an open reduction, we suggest a 5-year observation; this being absolutely important in patients that present bilateral condylar fracture, to avoid chances of existing ankylosis. Furthermore, we recommend a more exhaustive control in cases of pediatric patients, taking into consideration

the ongoing growth and development of the associated structures. In pediatric patients, we suggest a follow-up time lapse based on the stage of development in which he/she may be at the time, giving time for the development to conclude.

Conclusion

Condylar fractures should be managed according to the clinical and case presentation. Treatment and management by means of open or closed reduction should be the one with the greatest functional and esthetic benefit for the patient and with less expectation of complications associated with transoperative, immediate, and long-term post-operative time.

It is essential for hospital centers in which trauma is handled, to make multicenter studies that collaborate in research networks at the national and international level to have acceptable data that would contribute in the management and treatment of condylar fractures and the complications that they may involve.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

References

1. Sawazaki R, Júnior SM, Asprino L, Moreira RW, de Moraes M. Incidence and patterns of mandibular condyle fractures. J Oral Maxillofac Surg. 2010;68:1252-9.
2. Zachariades N, Mezitis M, Mourouzis C, Papadakis D, Spanou A. Fractures of the mandibular condyle: a review of 466 cases. Literature review, reflections on treatment and proposals. J Craniomaxillofac Surg. 2006;34:421-32.
3. Loukota RA, Eckelt U, De Bont L, Rasse M. Subclassification of fractures of the condylar process of the mandible. Br J Oral Maxillofac Surg. 2005;43:72-3.
4. Loukota RA, Neff A, Rasse M. Nomenclature/classification of fractures of the mandibular condylar head. Br J Oral Maxillofac Surg. 2010;48:477-8.
5. Abdel-Galil K, Loukota R. Fractures of the mandibular condyle: evidence base and current concepts of management. Br J Oral Maxillofac Surg. 2010;48:520-6.
6. Ellis E 3rd, Palmieri C, Throckmorton G. Further displacement of condylar process fractures after closed treatment. J Oral Maxillofac Surg. 1999;57:1307-16.
7. Ellis E, Throckmorton GS. Treatment of mandibular condylar process fractures: biological considerations. J Oral Maxillofac Surg. 2005; 63:115-34.
8. Zide MF, Kent JN. Indications for open reduction of mandibular condyle fractures. J Oral Maxillofac Surg. 1983;41:89-98.
9. Lukota AR, McCann PJ. Condylar neck fractures. In: Booth PW, Eppley BL, Schmelzeisen R. Maxillofacial Trauma and Esthetic Facial Reconstruction. 2nd ed. St. Louis, Missouri: Elsevier; 2012. p. 270-87.
10. Chang S, Yang Y, Liu Y, Wang J, Zhang W, Ma Q, et al. How does the remodeling capacity of children affect the morphologic changes of fractured mandibular condylar processes after conservative treatment? J Oral Maxillofac Surg. 2018;76:1279.
11. Silvennoinen U, Iizuka T, Oikarinen K, Lindqvist C. Analysis of possible factors leading to problems after nonsurgical treatment of condylar fractures. J Oral Maxillofac Surg. 1994;52:793-9.
12. Walker RV. Condylar fractures: nonsurgical management. J Oral Maxillofac Surg 1994;52:1185-8.
13. Ellis E 3rd. Method to determine when open treatment of condylar process fractures is not necessary. J Oral Maxillofac Surg. 2009;67:1685-90.
14. Zide MF. Discussion an accurate method for open reduction and internal fixation of high and low condylar process fractures. J Oral Maxillofac Surg. 1994;52:812.
15. Schmelzeisen R, Cienfuegos-Monroy R, Schön R, Chen CT, Cunningham L Jr., Goldhahn S, et al. Patient benefit from endoscopically assisted fixation of condylar neck fractures a randomized controlled trial. J Oral Maxillofac Surg. 2009;67:147-58.
16. Bayat M, Parvin M, Meybodi AA. Mandibular subcondylar fractures: a review on treatment strategies. Electron Physician. 2016;8:3144-9.
17. Eckelt U, Schneider M, Erasmus F, Gerlach KL, Kuhlisch E, Loukota R, et al. Open versus closed treatment of fractures of the mandibular condylar process-a prospective randomized multi-centre study. J Craniomaxillofac Surg. 2006;34:306-14.
18. Hlawitschka M, Eckelt U. Assessment of patients treated for intracapsular fractures of the mandibular condyle by closed techniques. J Oral Maxillofac Surg. 2002;60:784-91.
19. Vesnaver A. Open reduction and internal fixation of intra-articular fractures of the mandibular condyle: our first experiences. J Oral Maxillofac Surg. 2008;66:2123-9.
20. He D, Yang C, Chen M, Bin J, Zhang X, Qiu Y, et al. Modified preauricular approach and rigid internal fixation for intracapsular condyle fracture of the mandible. J Oral Maxillofac Surg. 2010;68:1578-84.
21. Alexander R, Su JY, Stark MM. An accurate method for open reduction and internal fixation of high and low condylar process fractures. J Oral Maxillofac Surg. 1994;52:808-12.
22. Ellis 3rd E, Zide MF. Transfacial aproaches to the mandible. In: Surgical Approaches to the Facial Skeleton. 2nd ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2006. p. 151-89.
23. Kudva A, Kamath AT, Rajan J, D'Souza C. A modified peri-angular approach for exposure of condylar fractures. J Oral Maxillofac Surg. 2018;76:1504-8.
24. Jeter TS, Van Sickels JE, Nishioka GJ. Intraoral open reduction with rigid internal fixation of mandibular subcondylar fractures. J Oral Maxillofac Surg. 1988;46:1113-6.
25. Vajgel A, Santos Tde S, Camargo IB, de Oliveira DM, Filho JR, Vasconcellos RJ, et al. Treatment of condylar fractures with an intraoral approach using an angulated screwdriver: results of a multicentre study. J Craniomaxillofac Surg. 2015;43:34-42.
26. Colletti G, Battista VM, Allevi F, Giovanditto F, Rabbiosi D, Biglioli F, et al. Extraoral approach to mandibular condylar fractures: our experience with 100 cases. J Craniomaxillofac Surg. 2014;42:e186-94.
27. Satish KP, Anuradha V, Lalitha T, Kashi N. A comparative evaluation of the outcome of treating condylar fractures with the mini retromandibular and the pre auricular approaches. J Oral Maxillofac Surg. 2013;25:305-9.
28. Kanno T, Sukegawa S, Tatsumi H, Nariai Y, Ishibashi H, Furuki Y, et al. The retromandibular transparotid approach for reduction and rigid internal fixation using two locking miniplates in mandibular condylar neck fractures. Int J Oral Maxillofac Surg. 2014;43:177-84.
29. Hakim SG, Wolf M, Wendlandt R, Kimmerle H, Sieg P, Jacobsen HC, et al. Comparative biomechanical study on three miniplates osteosynthesis systems for stabilisation of low condylar fractures of the mandible. Br J Oral Maxillofac Surg. 2014;52:317-22.
30. Ahuja SA, Galinde J, Asnani U, Mistry YA. Comparative evaluation of clinical outcomes using delta plates and conventional miniplates for internal fixation of mandibular condylar fractures in adults. J Oral Maxillofac Surg. 2018;76:1255-66.
31. Lechler C, Probst F, Cornelius CP, Smolka W. Open reduction and internal fixation of mandibular condylar base and neck fractures using strut plates. J Oral Maxillofac Surg. 2018;76:1494-503.
32. Ellis E 3rd. Open reduction and internal fixation of combined angle and body/symphysis fractures of the mandible: how much fixation is enough? J Oral Maxillofac Surg. 2013;71:726-33.
33. Kolk A, Neff A. Long-term results of ORIF of condylar head fractures of the mandible: a prospective 5-year follow-up study of small-fragment positional-screw osteosynthesis (SFPSO). J Craniomaxillofac Surg. 2015; 43:452-61.
34. Meyer C, Martin E, Kahn JL, Zink S. Development and biomechanical testing of a new osteosynthesis plate (TCP) designed to stabilize mandibular condyle fractures. J Craniomaxillofac Surg. 2007;35:84-90.

35. Wagner A, Krach W, Schicho K, Undt G, Ploder O, Ewers R, et al. A 3-dimensional finite-element analysis investigating the biomechanical behavior of the mandible and plate osteosynthesis in cases of fractures of the condylar process. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;94:678-86.
36. Walker RV. Discussion: open reduction of condylar fractures of the mandible in conjuction with repair of discal injury: a preliminary report. J Oral Maxillofac Surg. 1988;46:262.
37. Ellis E 3rd, Simon P, Throckmorton GS. Occlusal results after open or closed treatment of fractures of the mandibular condylar process. J Oral Maxillofac Surg. 2000;58:260-8.
38. Haug RH, Assael LA. Outcomes of open versus closed treatment of mandibular subcondylar fractures. J Oral Maxillofac Surg. 2001;59:370-5.
39. Schön R, Gutwald R, Schramm A, Gellrich NC, Schmelzeisen R. Endoscopy-assisted open treatment of condylar fractures of the mandible: extraoral vs intraoral approach. Int J Oral Maxillofac Surg. 2002; 31:237-43.
40. Lauer G, Schmelzeisen R. Endoscope-assisted fixation of mandibular condylar process fractures. J Oral Maxillofac Surg. 1999;57:36-9.
41. Ellis E 3rd, McFadden D, Simon P, Throckmorton G. Surgical complications with open treatment of mandibular condylar process fractures. J Oral Maxillofac Surg. 2000;58:950-8.
42. Bruneau S, Courvoisier DS, Scolozzi P. Facial nerve injury and other complications following retromandibular subparotid approach for the management of condylar fractures. J Oral Maxillofac Surg. 2018;76:812-8.
43. Pau M, Navisany K, Reinbacher KE, Zrnc T, Wallner J, Schwenzer-Zimmerer K, et al. Use of a modified high submandibular approach to treat condylar base fractures: experience with 44 consecutive cases treated in a single institution. J Craniomaxillofac Surg. 2016;44:1641-5.
44. Hou J, Chen L, Wang T, Jing W, Tang W, Long J, et al. A new surgical approach to treat medial or low condylar fractures: the minor parotid anterior approach. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014;117:283-8.
45. Akdag O, Yildiran G, Abaci M, Tosun Z. Endoscopic-assisted treatment combined with transoral and transbuccal approach to mandibular subcondylar fractures. J Oral Maxillofac Surg. 2018;76:831.
46. Anyanechi CE. Temporomandibular joint ankylosis caused by condylar fractures: a retrospective analysis of cases at an urban teaching hospital in Nigeria. Int J Oral Maxillofac Surg. 2015;44:1027-33.