Contemporary Issues in the Open Management of Subcondylar Fractures of the Mandible

Jeffrey Cranford, MD[1] Sameep Kadakia, MD[1] Raja Sawhney, MD, MFA, FACS[2] Yadranko Ducic, MD, FRCS(C), FACS[3]

[1] Department of Facial Plastic Surgery, New York Eye and Ear Infirmary of Mount Sinai, New York, New York
[2] Department of Facial Plastic and Reconstructive Surgery, University of Florida Health Science Center, Gainesville, Florida
[3] Otolaryngology and Facial Plastic Surgery Associates, Fort Worth, Texas

Address for correspondence Sameep Kadakia, MD, Department of Facial Plastic Surgery, New York Eye and Ear Infirmary of Mount Sinai, 310 East 14th St., New York, NY 10003-4201 (e-mail: skadakia@nyee.edu).

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Abstract

Subcondylar fractures encompass a large portion of mandible fractures. Owing to their proximity to the temporomandibular joint and difficulty achieving surgical exposure, treatment of these fractures has been challenging and highly debated throughout the literature. While no one modality is the accepted gold standard, there are multiple options for addressing these fractures that can yield satisfying results for both patient and surgeon alike. A thorough literature review was conducted using PubMed, analyzing articles in the past 15 years for relevance to the subject matter. Various search terms were used to glean information regarding closed treatment, open treatment, and the risks and benefits of the different surgical approaches involved. The articles were reviewed by all of the authors for applicability and quality of data provided. A total of 50 articles were selected for inclusion in the current study. The open management of subcondylar fractures encompasses a vast array of techniques. While some surgeons advocate closed treatment in some circumstances, open treatment affords numerous advantages with the advent of multiple access modalities. There is no single superior method, and as such, the craniofacial surgeon should have a comprehensive understanding of options so as to select the appropriate option that is individualized to the patient. A clear understanding of fracture biomechanics balanced with patient expectations and operative safety allows for the surgeon to make a sound decision for treatment.

Keywords
- trauma
- condylar fracture
- management

Fractures of the subcondylar region make up 20 to 62% of all mandible fractures.[1,2] The vulnerability of the nearby temporomandibular joint (TMJ), difficult surgical access, and limited bone stock for osteosynthesis has made fractures of this region controversial and challenging to treat. A growing appreciation of the benefits of open reduction and internal fixation (ORIF) has led to the continued evolution of surgical approaches and the innovation of new technologies. In this article, the advancements in management, surgical approaches, and osteosynthesis will be reviewed to provide the surgeon with a detailed understanding of the issues that surround this challenging subject.

Treatment Goals

Although surgical instincts may presuppose the need for anatomic reduction of fracture segments and restoration of anatomy, closed management techniques rarely adhere to this principle and instead, emphasize the achievement of acceptable functional results. Closed management,

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commonly referred to by the misnomer, "closed reduction," is based on restoration of premorbid occlusion rather than direct visual reduction of the fracture. Bony or connective tissue healing in malposition is considered acceptable so long as masticatory function is preserved.

Closed treatment avoids the morbidity of scarring and facial nerve dysfunction associated with ORIF and, thus, should be employed when the same outcome can be obtained by conservative means. Decades of comparative studies have produced clear indications for ORIF as well as clear indications for closed treatment; however, controversy remains as to the optimal management of those remaining fractures that do not meet clear-cut indications for either ORIF or closed treatment.

General criteria which have been suggested as goals for treatment include pain-free mouth opening (with interincisal opening greater than 40 mm), good excursion of the jaw in all directions, restoration of preinjury occlusion, stable TMJ function, and good facial symmetry.[3]

Closed Treatment

Closed treatment comprises two differing treatment strategies: (1) a period of rigid maxillomandibular fixation (MMF) followed by functional therapy; (2) functional therapy without a period of MMF. Varying periods of MMF have been recommended, ranging from not at all to a full, 6-week course, as is used with non-subcondylar mandibular fractures. As the mechanism of repair has been increasingly recognized to be due to neuromuscular adaptation to the neoarticulation rather than osseous healing of fragments in the correct anatomic position, a shift toward shorter and shorter periods of immobilization has occurred.[4] Many experts recommend management with mobilization and functional rehabilitation using training elastics at the outset.[5,6] This permits the early initiation of physiotherapy exercises and helps patients achieve their premorbid range of motion sooner than if MMF were used. This practice is not undisputed, however, and some authors continue to champion the use of MMF for 4 to 6 weeks, pointing out that subcondylar fractures are below the joint capsule and pose minimal risk of TMJ ankylosis.[7]

The proven functional results and surgical simplicity of closed treatment and have historically made it the mainstay of treatment for most subcondylar fractures. If good occlusion, pain-free function, and good facial symmetry can be obtained by closed treatment, then the patient need not be exposed to the intraoperative and postoperative risks associated with ORIF, rare as they may be. The question then becomes, which patients are adequately served by closed management and which ones warrant the undertaking of the increased surgical risk with ORIF?

Closed management is best used to treat patients with nondislocated, nondisplaced fractures who have difficulty coming into occlusion on their own. Patients who are able to achieve normal premorbid occlusion reproducibly on their own may be managed with a soft diet only. Patients whose occlusion cannot be reduced except under general anesthesia with muscle relaxation, may be considered for closed treatment if the surgeon or patient prefers[5]; however, certain fracture characteristics in the cohort may yield indications for ORIF, as will be discussed below.

The management of patients with moderate fracture displacement (i.e., 10–45 degrees in the frontal or sagittal plane), is the most controversial; and it may well be that this group of fractures can be adequately managed by either treatment approach. Many times, the selection of treatment in this cohort is determined by factors particular to an individual case, according to what Assael refers to as "an evidence-based art." This author notes the multitude of patient variables that influence treatment outcomes, confounding studies and rendering attempts at an uncontestable global treatment scheme impossible.[8]

In the face of conflicting data and controversy, it is clear that the treatment selection must be patient centered. Patient-reported scores can deviate substantially from objectively measured outcome variables. For instance, in one study, the mean maximum interincisal opening was 34 mm—well below what is typically reported with either technique and likely to be deemed unacceptable by most surgeons—however, only 13% of the patients reported any reduced jaw movement.[9] While restoration of premorbid function is a laudable goal, it is important to recognize that patient satisfaction is not directly correlated to objective measures.

Ellis reported the ability to manage virtually all unilateral subcondylar fractures with closed treatment provided the patient is compliant and has a good complement of posterior dentition regardless of the degree of displacement, albeit at the expense of altered TMJ function.[5] In cases where closed treatment is used to manage displaced condylar fractures, translation of the neoarticulation is likely to be impaired. This manifests as a jaw deviation toward the side of the fracture on mouth opening and jaw protrusion as well as reduced jaw excursion away from the side of the fracture. These abnormalities have no functional significance and, may not be important to some patients.

In an attempt to select for patients who will do well with closed treatment and do not warrant ORIF, Ellis retrospectively reviewed 332 patients in whom a simple, intraoperative clinical assessment was performed.[6] He found that if the operator applies a posteriorly directed force to the chin when closing the mouth and does not observe deviation toward the side of the fracture, or if deviation is observed, but returns to the midline with the release of the pressure, closed treatment will be almost universally successful. Only 16 of the 105 patients treated with closed management demonstrated jaw deviation on mouth opening, which was generally minor, and only 1 had malocclusion. Although the patients who demonstrated "drop back" had significantly higher degrees of fracture displacement on imaging, this study shows that some displaced fractures provide sufficient support to maintain proper occlusion and do not need be corrected with ORIF.

Various outcome variables, including occlusion, mastication, mandibular range of motion, posterior mandibular height, and pain, have been compared among closed and open approaches with generally conflicting results.[10] The notable exception is the restoration of posterior mandibular

height, which is consistently better in cases treated with ORIF. A distinction, however, must be made between the anatomically shortened ramus, as detected on perioperative imaging, and the functionally shortened ramus, as evidenced by malocclusion or facial asymmetry. Patients with ramus shortening who do not have occlusive disturbances may be managed with closed treatment. Asymmetries that result may be effectively masked by overlying soft tissue or may not be discernible to the untrained eye of the patient.

Some studies suggest closed treatment is associated with a higher incidence of TMJ pain; however, conflicting reports exist.[10] This question is a difficult one to answer empirically given the generally high incidence of TMJ problems in the general population[8] and the fact that a delayed sequelae may not be apparent during a study's measured time interval, sometimes appearing 10 to 20 years after the initial trauma.[11]

Indications for Open Reduction with Internal Fixation

The question of which patients are best served by ORIF has undergone continual revision as the functional consequences of closed treatment have been more fully realized and open techniques have been rendered safer through the use of facial nerve monitoring and endoscopic techniques. Such advancements have shifted the risk–benefit ratio of ORIF, allowing for wider use of ORIF well beyond the absolute indications originally proposed by Zide and Kent: (1) displacement of the condyle into the middle cranial fossa; (2) difficulty in obtaining adequate occlusion by closed reduction; (3) lateral capsular displacement of the condyle; or (4) invasion of the condylar neck by a foreign body, such as in a gunshot wound.[12]

For a long time, the debate between open and closed treatment was fueled by retrospective and nonrandomized prospective studies, with some showing both techniques, achieving roughly equivalent functional results[13–15] and others associating closed treatment a wide range of unfavorable outcomes, including malocclusion, mandibular asymmetry, impaired mastication, impaired healing of fragments, and pain.[16–18] The first prospective, randomized controlled trial was published by Eckelt et al, comprising 88 patients across seven institutions, and found that functional results, as well as the patient's subjective feelings, were significantly improved after ORIF. This study demonstrated that patients with fracture displacements of $>$ 10 degrees or ramus height shortening $>$ 2 mm benefit from ORIF with respect to such functional parameters as mouth opening, lateral excursion, protrusion, and malocclusion.[19] One notable limitation to this oft-cited study is the lack of detail regarding the method of closed treatment used, which is known to vary widely and is likely to influence outcomes. More recent prospective studies have corroborated the results of Eckelt et al,[20,21] though conflicting data exist for fractures with displacement of $<$ 45 degrees.[22] Dislocation of the condylar head from the temporomandibular fossa, another commonly cited indication for ORIF, results in significant reduction in ramus height and, thus, warrants open treatment as well.[23]

Another condition which is often considered an indication for ORIF is the presence of midfacial fractures with associated condylar fractures. In the case of panfacial fractures, reestablishing mandibular height creates a stable base from which to reset maxillary dentition, reestablish occlusion and then rebuild the midface as a whole.[5] By recreating appropriate occlusion, proper maxillary projection and width can be reestablished. Bilateral condylar fractures are an area where treatment is more controversial. The presence of bilateral subcondylar fractures does not, in itself, mandate operative repair, and many authors advocate using the same decision-making principles used in unilateral fracture management.[5]

Approaches to Open Repair

Unlike mandibular fractures of the symphysis, body or angle, which can be easily approached transorally, the approach to the subcondylar region is complicated by the oblique orientation afforded by the transoral approach and the overlying facial nerve that is placed at risk by other open approaches. The sheer variety of surgical approaches reported in the literature is testament to the fact that no one approach is superior. The most important factor to consider when selecting an approach is the fracture location. In cases where the fracture line is far from the skin incision, forceful soft-tissue retraction is often required to allow access for reduction and plating, which may result in traction injury to the facial nerve. Surgeons are encouraged to be facile with at least two techniques, one for high condylar neck fractures and one for condylar base fractures. Few studies have been performed comparing surgical approaches, making it difficult to draw definitive conclusions. In a prospective randomized controlled trial, 105 patients with displaced condylar neck fractures were randomized to ORIF via an extraoral approach (submandibular, preauricular, retromandibular) or an endoscopic-assisted transoral approach, and comparable functional results were achieved irrespective of the technique used.[24] Each surgeon is likely to be best served by choosing the approach with which he or she is most comfortable.

The Preauricular Approach

The preauricular approach, known for its unparalleled access to the TMJ, provides the most direct approach to high subcondylar and neck fractures. It is especially useful in cases of medial condylar displacements where medial exploration is required.[23] In the case of low subcondylar fractures, however, access to the distal ramus segment may be too limited to allow for placement of a miniplate and screws inferior to the fracture line without overaggressive retraction on the facial nerve.

The incision is made in the preauricular crease extending from the superior pole of the helix to the inferior edge of the tragus and is carried through the skin and subcutaneous tissues. Superior to the zygomatic arch, the temporoparietal fascia is incised to reach the superficial layer of the deep temporal fascia, taking care to avoid damaging the superficial temporal vessels and auriculotemporal nerve. Blunt dissection proceeds anteriorly for 1.5 to 2 cm and inferiorly immediately anterior to the cartilaginous external auditory

canal at the same depth. The superficial layer of the deep temporal fascia is incised from the root of the zygoma anterosuperiorly in an oblique orientation, parallel (and posterior) to the expected course of the temporal branch of the facial nerve. The temporal branch crosses the zygomatic arch anywhere from 8 to 35 mm anterior to the external auditory canal. A periosteal elevator can be inserted under the superficial layer of the deep temporal fascia, which is contiguous with the periosteum of the lateral zygomatic arch, and this layer can be elevated, creating a tunnel extending inferior to the zygomatic arch. The intervening tissue can then be sharply divided posteriorly, along the original axis of the vertical skin incision. This subperiosteal flap can be reflected anteriorly from the root of the zygomatic arch, thereby protecting the temporal branch of the facial nerve. Dissection proceeds anteriorly until the articular eminence and the entire TMJ capsule is revealed. Dissection and retraction can proceed inferiorly to reveal the subcondylar region.[25,26]

To minimize the need for soft-tissue retraction inferiorly and, therefore, risk of traction injury to the facial nerve, some authors have proposed centering dissection over the fracture line itself, sometimes referred to as the preauricular transparotid approach.[7,27] This allows for more direct, perpendicular access that facilitates fracture reduction and fixation, but means traversing the parotid and navigating the complex anatomy of the facial nerve. Nonetheless, these authors have reported rates of facial nerve palsy that are nearly equivalent to standard approaches.[27]

The Submandibular Approach

The submandibular approach provides excellent access to fractures of the ramus and low subcondylar areas, but offers limited access to high subcondylar and neck fractures given the significant distance from the incision site. While this approach avoids sectioning the parotid, as is generally required by the retromandibular approach, gaining access to high subcondylar fractures can require significant retraction and, thus, risks traction injury to the facial nerve. Reported rates of facial nerve injury range from 5.3 to 48.1%, but it is commonly felt that risk can be minimized by use of a transcutaneous trocar.[28]

A 4- to 5-cm incision positioned in a natural skin crease approximately 2 cm below the angle of the mandible is made and carried down through the platysma. Dissection is then continued superiorly toward the inferior border of the mandible, taking care to identify and preserve the marginal mandibular branch of the facial nerve immediately beneath the platysma muscle. Alternatively, the capsule of the submandibular gland can be identified and the overlying facial vein and artery may be ligated and turned upward, thereby protecting the facial nerve. Once the masseter is encountered, it is sharply divided along the inferior border to expose the mandible and subperiosteal dissection is performed superiorly to expose the fracture.

The Eckelt and Wilk modifications of the submandibular approach were described to assist with exposure and identification of the facial nerve.[23] Although they provide a better view of the condylar neck than the traditional submandibular incision, the distance between the incision and fracture site is still substantial, and the risk of facial nerve injury is therefore comparable.[27]

The Retromandibular Approach

The advantage of this approach is that it provides direct, straight-line access to the entire posterior ramus and condylar neck, making it an excellent choice for low subcondylar fractures. Although there is minimal distance from the skin incision to the area of interest, it entails dissection through the parotid gland, with the attendant risks of salivary fistula (2.3%) and facial nerve injury (17.2%).[29] Another disadvantage of this approach stems from its limited access to medially displaced condylar segments, which can make fracture reduction difficult. In severe anteromedial fracture dislocations, a vertical ramus osteotomy or even a concurrent preauricular approach may be required to allow for retrieval of the condylar segment, with fixation performed through access afforded by the retromandibular approach.[23]

A skin incision is made immediately posterior to the ramus extending from a point approximately 0.5 cm inferior to the lobule to the angle of the mandible and carried down through the subcutaneous tissue and scanty platysma. The parotid capsule is incised and blunt dissection in the anteromedial direction commences toward the posterior border of the mandible, with all spreads made parallel to the course of the nerve and utilizing the facial nerve monitor. The masseter and periosteum are typically incised between the marginal mandibular and buccal branches of the facial nerve. Soft tissue is retracted superiorly and subperiosteal dissection is performed to the sigmoid notch. Of special note, the incised parotid fascia should be carefully reapproximated during closure to minimize the chance of parotid fistula or sialocele.

Although the retromandibular scar is generally cosmetically acceptable, a rhytidectomy modification may be used for patients with high aesthetic concerns.[30] One prospective clinical series compared the rhytidectomy modification with the traditional retromandibular approach and found it offered less conspicuous scarring and wider exposure, but was associated with increased operative times, largely due to the more involved closure.[31]

Numerous additional modifications of this approach have been described in an attempt to minimize facial nerve injury. Chossegros et al proposed lifting the tail of the parotid gland to access the mandibular ramus, obviating the need for identification of the marginal mandibular nerve, reporting 11% incidence of transient palsy.[32] After reporting a 20% incidence of temporary facial nerve injury, Choi et al suggested that facial nerve palsy could be reduced through knowledge of the precise branching pattern and performed a facial nerve dissection via a standard parotidectomy incision before repairing the fracture.[33]

Certain authors have proposed dissecting beyond the anterior margin of the parotid to access the mandible via blunt dissection through a "nerve-free window" between the buccal and marginal mandibular nerve branches.[34,35] This provides the basis for what has become known as the anteroparotid transmasseteric approach (APTM). Some surgeons elect to divide the masseter in the vicinity of the buccal

branch, considering the muscles, it innervates often receive dual innervation from contralateral nerve fibers and, thus, assume less surgical hazard. The disadvantage of APTM is a longer incision, typically performed by extending the traditional retromandibular incision upward to the pretragal level; however, proponents point out that the preauricular component is not cosmetically significant. With increasing experience the length of the incision may be decreased, with one group reporting the use of the APTM approach through a 2 cm incision positioned 1 cm posterior to the angle of the mandible.[36]

Oral Approach/Endoscopic Reduction and Internal Fixation

The transoral approach provides access to the subcondylar region while avoiding the problem of cutaneous scarring and minimizing risk to the facial nerve. Before the advent of endoscopic techniques, special instrumentation and surgical techniques had been advanced to combat the poor visualization of the dorsal ramus and subcondylar region provided by the intraoral approach. These techniques have largely been replaced by the use of the 30-degree angled endoscope, which affords superior visualization of the subcondylar region. Hardware can be applied through a transbuccal stab incision made directly over the fracture line or by using angulated drills and screwdrivers via pure intraoral access.

Endoscopic-assisted reduction and internal fixation (ERIF) provides the benefits of ORIF by achieving anatomic reduction while, at the same time, reducing the risk of facial nerve injury, limiting the problem of external scarring, and eliminating the need for MMF.[3,37,38] In a prospective randomized, multicenter trial, Schmelzeisen et al compared ERIF with ORIF in 74 patients with displaced condylar neck fractures and found comparable functional results.[39] Mueller et al reviewed their experience in treating 150 subcondylar fractures with ERIF and found, after excluding a subgroup of 14 high condylar neck fractures that pose a surgical challenge regardless of approach, ERIF yielded an anatomic reduction in 94% cases.[37]

Certain limitations to ERIF exist and understanding which fracture characteristics present operative challenges allow the surgeon to prepare appropriately. Fractures with medial displacement of the proximal segment, termed medial override fractures, present less commonly, but can prove difficult to reduce endoscopically since the ascending ramus obscures visualization and obstructs manipulation of the proximal segment. Reduction can be achieved by first converting the fracture to a lateral override fracture, but this, in itself, may prove challenging and some consider medial override fractures a contraindication to ERIF. Moderate or high degrees of fracture comminution makes accurate fracture reduction difficult to achieve endoscopically since the surgeon cannot rely on alignment of the anterior and posterior borders of the ramus as a sign of proper reduction. Thus, an extraoral approach is advised for subcondylar fractures with significant comminution.[37] Fractures with true dislocation of the condylar head can likewise be difficult to reduce endoscopically and are considered a contraindication to ERIF by many.[7]

Two main endoscopic approaches to the subcondylar region have been set forth. The method originally described by Jacobovicz in 1998 and the one favored by the senior authors (Y.D., R.S.) involves use of an endoscope via an intraoral incision with or without the use of a transcutaneous stab incision and trocar for screw placement. This approach has been well-described in the literature, including the experience of the senior author.[26,40,41] Troulis and Kaban later described an endoscopic-assisted extraoral approach to subcondylar fractures via a mini-Risdon approach through a 1.5-cm submandibular incision. They reported a more comfortable orientation with visualization of the operative field "en face." Some authors have suggested this technique is less technically challenging,[42,43] but most authors who have focused on ERIF advocate for the isolated intraoral approach, at least for laterally displaced subcondylar fractures.[37,44] The value of the endoscopic-assisted extraoral approach may lie in its ability to treat more difficult-to-reduce fractures. In a prospective, nonrandomized clinical trial, Schon et al examined the management of 17 patients with condylar fractures according to either intraoral or extraoral endoscopic-assisted approaches and sought to define indications for each. They concluded that the intraoral endoscopic approach was reliable for condylar fractures when lateral override was present and that the extraoral endoscopic approach was indicated for severely dislocated fractures such as medial override fractures. Recently, a means of minimizing the submandibular incision to only a few millimeters was described by retrograde dissecting toward the planned submandibular incision through an intraoral incision and then performing the external stab incision to permit passage of an endoscope.[45]

Disadvantages of ERIF that have been cited include the significant learning curve, longer operative times, the need for an experienced assistant surgeon, and the need for dedicated instrumentation, such as specialized plate holders and trocars.[37,39] Studies have shown, however, that operative times can be markedly reduced by increasing experience, with average operative times as low as 32 minutes reported.[3,26] As endoscopic skills and equipment become an increasingly important part of the craniofacial surgeon's armamentarium, it is expected that ERIF techniques will become increasingly accessible.

Improved instrumentation, particularly the small head-angulated screwdriver system, has led to renewed interest in the transoral approach to subcondylar fractures without endoscopic assistance. Several authors have recently reported satisfactory outcomes after ORIF performed through a nonendoscopic transoral approach using angulated screwdrivers.[46–48] Visualization of fractures located above the sigmoid notch is significantly limited, however, and this technique may be most applicable to low subcondylar fractures.[48]

Achievement of Stable Osteosynthesis

Although ORIF techniques yield favorable outcomes overall, the high mechanical demands of the condylar region coupled with limited bone stock available for screw fixation make it a region prone to complications such as screw loosening or

plate bending, resulting inadequate stability in up to 35% of the cases.[49] Although a single 2.0-mm miniplate oriented along the condylar axis can be effective if the fragments are properly aligned, functional forces exceed the rigidity of a single miniplate, and micromovements at the fracture site can occur, predisposing the patient to nonunion, fibrous union, or TMJ disorders. Sturdier types of osteosynthesis, including 2.4 mm plates, 2.0 mm mini-dynamic compression plates, and bicortical screws are prone to failure as well and often are too bulky to apply to the narrow condylar segment. The use of two four-hole miniplates with monocortical screws has proven to be the most reliable means of fixation and is generally considered the gold standard.[50,51] An anterior plate is positioned along the rim of the sigmoid notch, which resists tensile strains, while a posterior plate is positioned along the posterior ramus, which resists compressive strains.[52]

The use of two miniplates in the narrow condylar neck region is not always feasible, however, and various novel plate designs have been proposed to overcome the anatomic constraints of this region. Three-dimensional (3D) miniplates, the most popular of which is the trapezoidal condylar plate (TCP), are geometrically closed quadrangular plates that get their name, not from a 3D shape, but rather their ability to create stability in three dimensions. The TCP is positioned with its anterior arm along the sigmoid notch and its posterior arm along the posterior border of the ramus, essentially acting as two single plates, but requiring only two screws in the proximal condylar segment compared with the four required by the double miniplate technique. The mechanical connection between the two plate's arms provides greater internal stability and leverage in resisting shearing, bending, and torsional forces.

A prospective cohort study using TCPs in the management of 75 subcondylar fractures demonstrated good anatomic restoration without any mechanical failures.[53] Recently, an in vitro study demonstrated TCPs induced the least amount of strain on cortical bone and were best at resisting displacement.[54] A variety of 3D plates, shapes have been designed, with narrower plates purposed for use in the condylar neck and larger, wider plates used for condylar base or comminuted fractures where additional holes for screw placement are needed. A recent position article drafted by an international consortium of surgeons reported that a more stable condylar neck fracture repair can be achieved using either 3D miniplates or two straight miniplates compared with a single miniplate.[55]

Conclusion

The management of subcondylar fractures has historically been fraught with controversy. Decades of research have yielded a greater understanding of TMJ biomechanics and the benefits of ORIF in cases of displaced and foreshortened subcondylar fractures. Challenges associated with open management have spawned the innovation of new surgical techniques and the adaptation of new technologies, which have broadened the options available to the craniofacial surgeon in the treatment of subcondylar fractures.

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