Journal of Cranio-Maxillo-Facial Surgery 44 (2016) 1641–1645

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Use of a modified high submandibular approach to treat condylar base fractures: Experience with 44 consecutive cases treated in a single institution

Mauro Pau*, Kawe Navisany, Knut Ernst Reinbacher, Tomislav Zrnc, Jürgen Wallner, Katja Schwenzer-Zimmerer

Department of Oral and Maxillofacial Surgery (Head: Prof. Katja Schwenzer-Zimmerer), Medical University of Graz, Austria

ARTICLE INFO

Article history:
Paper received 1 February 2016
Accepted 13 July 2016
Available online 2 August 2016

Keywords:
Condylar fractures
High submandibular approach
Mandibular fractures

ABSTRACT

Purpose: The aim of this article is to present our experience treating fractures of the condylar base with a modification of the high submandibular approach (HSA).
Materials and methods: Between June 2012 and April 2015, 44 fractures of the condylar base were treated in the Department of Oral and Maxillofacial Surgery of the Medical Hospital of Graz using the modified HSA.
Results: We did not observe any damage (even transient) to the facial nerve or any complication related to violation of the parotid capsule (such as a salivary fistula, Frey syndrome, or a sialocele).
Conclusions: This approach provides good access to the condylar base, ensuring easier internal fixation, excellent protection of the facial nerve and parotid gland, and good cosmetic results.

1. Introduction

Fractures of the condylar process are common maxillofacial injuries accounting for 25–52% of all mandibular fractures (Ellis et al., 1985; Silvennoinen et al., 1992). A principal concern with open reduction and internal fixation (ORIF) is that many complications can develop after the open treatment of fractures of the condylar process. These can occur intraoperatively (e.g., hemorrhage) or postoperatively (infection, facial nerve palsy, Frey syndrome, salivary fistula, and/or unsightly scarring) (Ellis et al., 2000).

Moreover, treatment of condylar fractures is challenging, because the fractures are difficult to access, the bone fragments are small and difficult to align anatomically, and hardware placement is challenging (Bouchard and Perreaulty, 2014; Pau et al., 2012).

Although the treatment remains controversial, the ORIF of extracapsular fractures is considered the gold standard of care by an increasing number of investigators (Ellis and Throckmorton, 2000; Throckmorton and Ellis, 2000).

* Corresponding author. Department of Oral and Maxillofacial Surgery, Medical University of Graz, Auenbruggerplatz 7, A-8036 Graz, Austria. Fax: +43 316 385 3511.
E-mail address: pauromau@tiscali.it (M. Pau).

1.1. Surgical technique

A 3-cm-long curved skin incision line is drawn immediately postero-inferior to the palpable mandibular angle, and a vasoconstrictor is subcutaneously injected (Fig. 1). After incision of the skin and subcutis, dissection proceeds on the plane of the platysma muscle. Wide undermining in all four directions allows mobilization of the incision upward to the level of the ear lobule and forward to the anteroparotid region (Fig. 2). At this level, the platysma is transected horizontally and the masseteric fascia exposed. The buccal branches of the facial nerve are carefully identified using a nerve stimulator (Fig. 3).

Dissection is usually extended cranially to the lower buccal branch of the nerve to gain a perpendicular view of the region of the condylar base and to protect the nerve. The masseter is then spread along the direction of its fibers and the fracture fragments exposed (Fig. 4). We use the method of Gahir et al. (2013) to distract the mandible downward, ensuring protection of the skin and the mandibular branch of the facial nerve. First, the skin inferior to the mandibular angle is pierced with a 14-gauge venous cannula. The needle is then removed and a distraction wire inserted through a plastic catheter. The wire is then anchored to a 2.0-mm-diameter screw placed on the mandibular angle (Gahir et al., 2013) (Fig. 4).

http://dx.doi.org/10.1016/j.jcms.2016.07.009
1010-5182/

Fig. 1. An intraoperative photograph showing the 3-cm-long skin incision along the mandibular angle (dotted line).

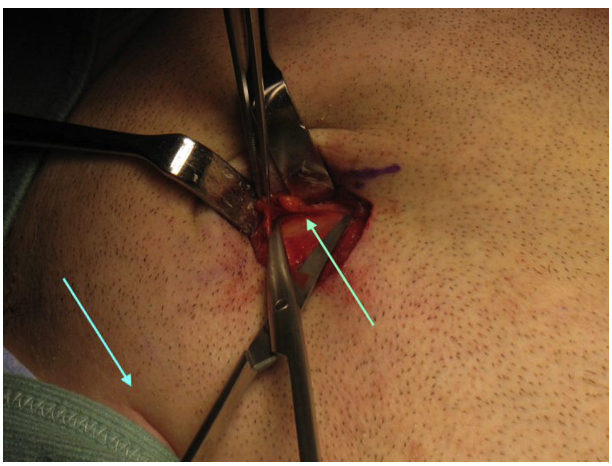


Fig. 2. After mobilization of the incision site to the level of the ear lobule (blue arrow), the platysma (green arrow) was carefully incised down to the masseteric fascia.

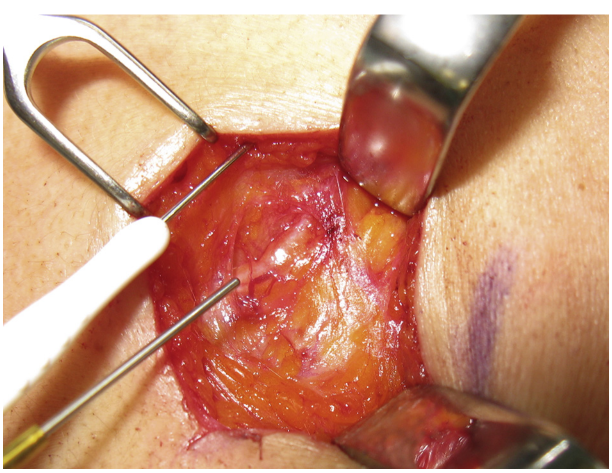


Fig. 3. Identification of a buccal branch of the facial nerve.

After the repositioning of the fracture, internal fixation, and removal of the screw, wire, and catheter, the wound is irrigated with antibacterial solution and closed in a layered manner. No drain is placed.

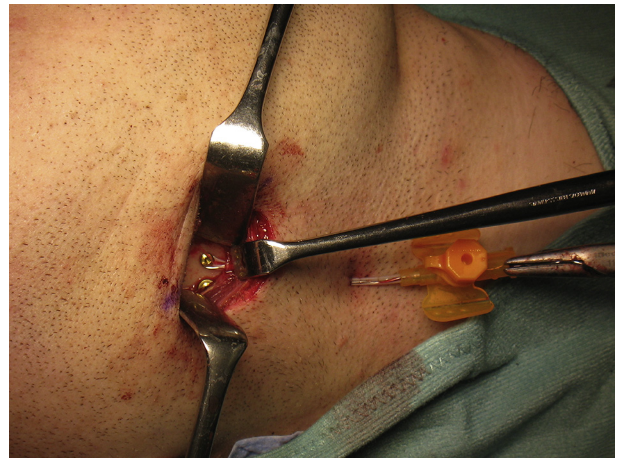


Fig. 4. After spreading of the masseter and exposure of the bone, a distraction wire was passed through the cheek with the support of a 14-gauge cannula. The wire was fixed to a 2.0-mm-diameter screw placed on the mandibular angle.

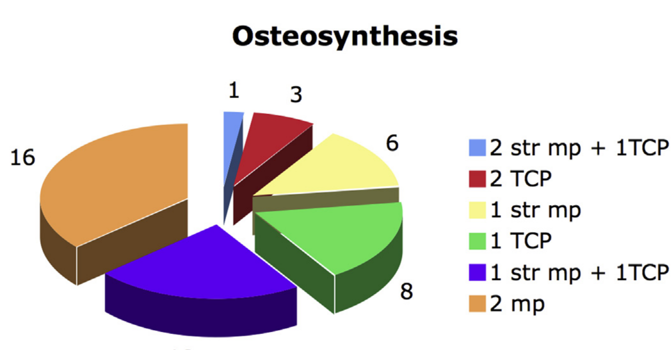
2. Materials and methods

Between June 2012 and April 2015, a total of 42 patients were admitted to our inpatient department for operative treatment of fractures of the condylar base. Their ages ranged from 11 to 83 years; 32 patients were male and 10 were female. In two cases, both condyles were fractured. In 21 patients, the condylar fracture was associated with other facial fractures; and, in five cases, the condylar base was broken into more than two fragments. All patients scheduled for open reduction complained of post-traumatic malocclusion and exhibited radiological dislocation of the fractures.

After nasal intubation, arch bars or intermaxillary fixation (IMF) screws were placed in every patient. The hardware for internal fixation was selected according to the location of the fracture and the dimensions of the fractured fragments (Table 1).

Intermaxillary fixation with elastics was applied intraoperatively. Active functional rehabilitation, occlusal guidance with elastics, and soft feeding were continued for 6 weeks postoperatively. The arch bars and the IMF screws were removed under local anesthesia. Each patient was recalled 5 months postoperatively to clinically and radiologically evaluate the outcome and to explore any need for removal of the plates or for secondary procedures. The operation and follow-up were performed by different surgeons.

Table 1
The pattern of internal fixation.



mp, miniplate; str mp, straight miniplate; TCP, trapezoid plate (Medartis, Basel, Switzerland).

3. Results

No impairment (even transient) of the facial nerve or any complication related to violation of the parotid capsule (e.g., salivary fistula, Frey syndrome, or sialocele) was observed.

In all cases, scar quality was judged to be satisfactory by both clinicians and patients (Fig. 5). At 5 months postoperatively, no postoperative malocclusion or reduction of the mouth opening was reported.

We observed four complications: three failures of fixation hardware in two patients (bilaterally in one case), and one instance of fracture misalignment. All patients underwent repeat surgery for anatomical repositioning and stable internal fixation.

The facial nerve was encountered in almost 80% of dissections.

The mean operating time on isolated fractures, including the placement of arch bars, was 128 min.

4. Discussion

The main concerns in managing condylar fractures are adequate exposure, correct alignment of bone segments, and stable internal fixation. Further goals when approaching the condylar base are minimizing the risk of facial nerve damage; avoiding complications, such as salivary fistula, sialocele, and/or infection; and ensuring good cosmetic results. The search for an incision affording these features has led to the development of many approaches that can be roughly divided into intraoral and transfacial.

The intraoral approaches have two principal advantages: they do not leave visible scars and they do not jeopardize the facial nerve (Mueller et al., 2006). Despite these advantages, surgical management of condylar fractures via an intraoral approach can be extremely difficult, especially for fractures featuring fragment comminution and those with a medial displacement of the proximal stump (Kellman and Cienfuegos, 2009; Arcuri et al., 2012). Moreover, this approach requires the use of dedicated instruments and is associated with a steep learning curve (Silverman, 1925; Jacobovicz et al., 1998; Schmelzeisen et al., 2009; Colletti et al., 2014). Accordingly, even experienced surgeons have progressively abandoned this route (Colletti et al., 2014).

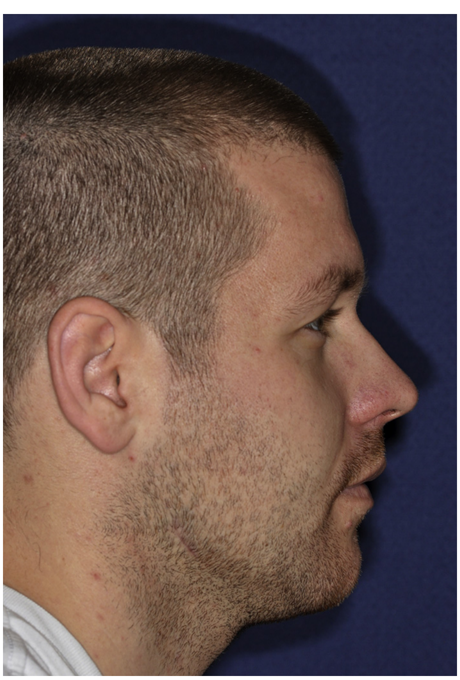


Fig. 5. A postoperative photograph of the same patient described in Figs. 1–4 showing the esthetic results obtained 8 months after surgery. The scar is barely visible. It lies immediately postero-inferior to the mandibular angle and is hidden in a natural shadow.

Of the transfacial approaches, the preauricular remains one of the preferred options. The incision is suitable for the treatment of diacapitular and condylar neck fractures (Biglioli and Colletti, 2009; Pau et al., 2012) but is distinctly unsuitable for treatment of subcondylar fractures. Fixation is cumbersome, because screws cannot be perpendicularly oriented to the plate (Narayanan et al., 2012). Moreover, the reported incidence of facial nerve damage after preauricular incision has ranged from 3.2% to 42.9% (Hammer et al., 1997; Tang et al., 2009).

Three principal transfacial routes have been described to treat fractures of the condylar base: these are the submandibular, transparotideal, and anteroparotid transmasseteric routes.

The submandibular (Ridson) approach is one of the most preferred when fractures of the mandibular body and mandibular angle are treated. However, if the fractures are located in the ramus or middle or high condyle, the incision affords only restricted exposure, rendering the operation difficult; this, in turn, qualitatively affects the quality of internal fixation (Ebenezer and Ramalingam, 2011). Moreover, the reported incidence of facial nerve injury after submandibular incision is 5.3–48.1% (Widmark et al., 1996). For these reasons, we consider the Ridson approach obsolete.

The transparotideal route is generally commenced via a retromandibular incision between the ear lobe and the mandibular angle. This approach has the following advantages: the incision is close to the condylar process; it causes no obvious scars; and it affords wide exposure of the fractured end and the posterior edge of the ramus (Ebenezer and Ramalingam, 2011). Nevertheless, use of this route can trigger several serious complications, including Frey syndrome, seroma, infection, salivary fistula, sialocele, temporary facial nerve impairment, and/or permanent damage to the facial nerve (Ellis et al., 2000; Biglioli and Colletti, 2009; Lutz et al., 2010; Bouchard and Perreaulty, 2014; Bhutia et al., 2015; Dalla Torre et al., 2015). In our opinion, the risks of these complications are associated with the two principal drawbacks of the approach: opening the parotid capsule and dissection through the gland.

The anteroparotid transmasseteric route avoids the two latter steps by featuring dissection along the SMAS to the anterior border of the parotid gland and then exposure of the bone by dividing the fibers of the masseter muscle.

Dissection through the masseter muscle instead of the parotid gland reduces the risk of Frey syndrome, sialocele, and salivary fistula (Narayanan et al., 2012). The masseter is spread at the level of an anatomical “nerve-free” window between the buccal and marginal mandibular branches of the facial nerve, thus avoiding damage to the nerve (Narayanan et al., 2012; Lutz et al., 2010). Furthermore, the incidence of cross-anastomosis between the zygomatic and buccal branches of the nerve is 87%–100%, and many rami always communicate between the buccal branches. Thus, even if the buccal branch is slightly injured, any loss of function is noticeable (May and Schaitkin, 2000; Bernstein and Nelson, 1984; Narayanan et al., 2012; Lutz et al., 2010). For these reasons, the anteroparotid transmasseteric route is probably the safest way by which to approach the condylar area.

To the best of our knowledge, three principal anteroparotid transmasseteric approaches have been described: these are the retromandibular (Tang et al., 2009), transmasseteric anteroparotid (TMAP) (Wilson et al., 2005), and high submandibular (HSA) (Eckelt and Gerber, 1991) approaches.

In the retromandibular anteroparotid transmasseteric approach, the incision is placed between the ear lobe and the mandibular angle (Tang et al., 2009). Dissection then runs above the SMAS to the anterior border of the parotid gland and through the masseter to the bone (Tang et al., 2009). This approach exposes the entire condylar area and the skin incision can be reduced to 2 cm in length, ensuring an optimal esthetic outcome (Biglioli and Colletti, 2009; Colletti et al., 2014). Unfortunately, remaining anterior to the parotid gland can be difficult or impossible if the anterior process of the gland is highly developed (Biglioli and Colletti, 2009; Colletti et al., 2014). Therefore, accidental violation of the parotid is possible, and complications, including temporary facial nerve palsy, infections, and a sialocele, have been reported (Tang et al., 2009; Biglioli and Colletti, 2009; Colletti et al., 2014).

The incision of the transmasseteric anteroparotid approach (TMAP) has a preauricular portion followed (downward) by a perilobular and then a cervical extension (Wilson et al., 2005). The cervical course of the incision can develop in three possible manners: retromandibular, lazy "S" cervicomastoidal, and via rhytidectomy (Wilson et al., 2005). As with the retromandibular anteroparotid transmasseteric approach, the dissection runs above the SMAS to the anterior border of the parotid gland and then through the masseter to the bone (Wilson et al., 2005). This approach seems not to be associated with a risk of opening the parotid capsule. In a review of 129 cases, Narayanan et al. (2012) did not mention this complication at all. Another principal advantage of the TMAP is exposure of the entire condyle. At any rate, dissection is wide, and the incision used is thus necessarily longer than those of other approaches (Wilson et al., 2005).

The high submandibular approach (HSA) was first described in the early 1990s by Eckelt and Gerber (1991). Although several modifications have been proposed, the main points of this approach remain the following: a 4–5-cm-long skin incision is made below the border of the mandible, antero-inferiorly to the parotid gland and cranially to the classic submandibular approach. To save the marginal branch of the facial nerve, the dissection proceeds antero-superiorly on the platysma. Platysma and masseter muscles are incised cranially to the marginal branch of the facial nerve or at the level of the space between the upper and lower buccal branches (Eckelt and Gerber, 1991; Rasse et al., 1993; Eckelt, 1999a,b; Eckelt et al., 2006; Trost et al., 2008, 2009; Wilk, 2009; Lutz et al., 2010).

As is true of the TPMAP, the HSA does not expose patients to complications associated with violation of the parotid. Additionally, transection of the masseter tendon enables visualization of the entire condylar process (Trost et al., 2008; Wilk, 2009). In comparison with the TMAP, the HSA has the principal advantage of a shorter incision, thus reducing the need for dissection and minimizing consequent complications (Trost et al., 2008).

Nevertheless, in our experience, the HSA has two principal drawbacks. First, because the scar is visible, the cosmetic outcome is poor, especially in comparison with that of the mini-retromandibular approach. Second, in some cases, transection of the masseter causes muscular scarring with temporary impairment of the mouth opening.

To improve the esthetic outcomes, we have, since April 2012, adopted the perimandibular modification of the HSA described by Wilk (2009). In this approach, the incision runs immediately postero-inferiorly to the palpable mandibular angle, and the scar is well-hidden in a natural shadow (Fig. 5). In comparison with the method of Wilk (2009), we have reduced the skin incision to 3 cm and gently spread the masseter muscle along the direction of the fibers; we do not transect the muscle.

Shortening of the incision and minimizing muscle dissection optimizes the cosmetic results and reduces muscle scarring, but it can limit exposure of the highest portion of the condylar process, rendering this version of the HSA unsuitable for treating fractures of the condylar neck. Accordingly, careful patient selection is mandatory to avoid the need for second incisions or extension of the skin incision with transection of the masseter muscle. We find the classification of Loukota et al. (2005) particularly useful for distinguishing between condylar neck and base fractures: the former run upward to the line tangential to the sigmoid notch and perpendicular to the axis of the posterior border of the mandibular ramus, whereas the latter run downward to that line (Fig. 6; Loukota et al., 2005). In our experience, this version of the HSA enables easy and stable fixation of condylar base fractures but is not recommended for fractures running upward to the tangent to the sigmoid notch (Fig. 7).

We observed four complications in three patients. In two patients, the internal fixation hardware failed (in one case, it failed bilaterally). We had used single four-hole, straight, 2.0-mm-long miniplates to fix all three fractures. Such plates had been used to fix six fractures in all, meaning that over 50% of plates failed. This confirmed that this fixation pattern should be abandoned in favor of more stable solutions, such as two double-four-hole, straight, 2.0-mm-long miniplates placed in a triangular manner (Dalla Torre et al., 2015) or a single trapezoidal plate (TCP; Medartis, Basel,

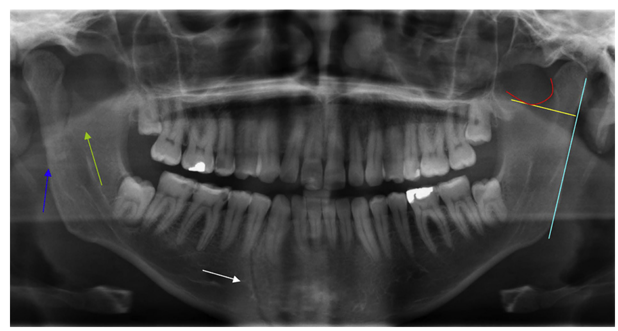


Fig. 6. A preoperative X-ray of the same patient shown in Figs. 1–5. (Right) Running fractures of the condylar base (green and blue arrows) and the ipsilateral mandibular body (white arrow) are evident. The condylar base shows two fracture lines; one runs postero-inferiorly from the transition between the condylar neck and sigmoid notch to the posterior border of the ramus (blue arrow). The second runs postero-inferiorly from the transition between the muscular process and the sigmoid notch to the posterior border of the ramus (green arrow). This fracture pattern creates three fragments: the condylar process, the sigmoid notch, and the mandibular ramus. (Left) The classification of Loukota et al. is shown: sigmoid notch (red curved line), vertical axis of the mandibular ramus (azure line), and the tangent to the sigmoid notch oriented perpendicular to the axis of the ramus (yellow line). Fractures of the condylar base run downward to the yellow line.

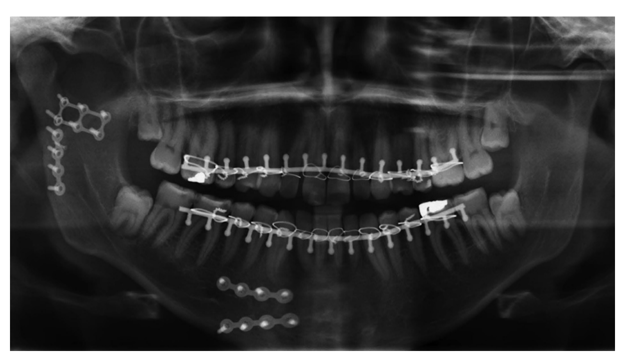


Fig. 7. A postoperative X-ray showing repositioning and internal fixation of the same fractures shown in Fig. 6. The condylar process was first fixed to the ramus using a bicortical 1.2-mm-long micro-screw and then stabilized using a straight four-hole 2-mm-long miniplate placed along the posterior border of the ramus. Finally, the sigmoid was secured to a six-hole miniplate, and the same plate was used to connect the muscular process anteriorly and the condylar process posteriorly.

Switzerland; Trost et al., 2009; Wilk, 2009). In the remaining 38 cases, a TCP plate or several miniplates were successfully placed (Table 1 and Fig. 7).

In one case, postoperative orthopantomography revealed inappropriate repositioning of the fracture. The patient was scheduled for repeat surgery; the fracture was correctly re-aligned and fixed using the same approach.

The mean operative time was 128 min. This time included placing the arch bars and passing the distraction wire, as described above. These maneuvers take (respectively) about 45 and 15 min, thus reducing the operative time to about 65 min. The modified HSA takes distinctly longer than the TMAP (46 min; Narayanan et al., 2012) and the mini-retromandibular approach (33 min; Biglioli and Colletti, 2009). In our opinion, this is explained by the need to dissect the facial nerve; this was encountered in about 80% of all dissections. This confirms that the probability of encountering the nerve during HSA (Lutz et al., 2010) is considerably higher than those associated with other approaches, such as the mini-retromandibular approach (50%) (Colletti et al., 2014) and the TMAP (7%) (Narayanan et al., 2012).

However, we observed no damage (even transient) to the facial nerve.

5. Conclusions

The modified HSA is an adequate approach for treatment of condylar base fractures. The technique has three main advantages: excellent protection of the facial nerve, excellent protection of the parotid gland, and good cosmetic outcome. However, the operative time is longer than those of other similar approaches; the probability of encountering the facial nerve is high; and the technique is not suited to treatment of fractures of the condylar neck.

Conflict of interest

None declared.

References

Arcuri F, Brucoli M, Baragiotta N, Benech R, Ferrero S, Benech A: Analysis of complications following endoscopically assisted treatment of mandibular condylar fractures. J Craniofac Surg 23(3): e196–e208, 2012

Bernstein L, Nelson RH: Surgical anatomy of the extraparotid distribution of the facial nerve. Arch Otolaryngol 110: 177–183, 1984

Biglioli F, Colletti G: Transmasseter approach to condylar fractures by mini-retromandibular access. J Oral Maxillofac Surg 67: 2418–2424, 2009

Bouchard C, Perreaulty MH: Postoperative complications associated with the retromandibular approach: a retrospective analysis of 118 subcondylar fractures. J Oral Maxillofac Surg 72: 370–375, 2014

Bhutia O, Kumar L, Jose A, Roychoudhury A, Trikha A: Evaluation of facial nerve following open reduction and internal fixation of subcondylar fracture through retromandibular transparotid approach. J Craniomaxillofac Surg 43(6): 944–949, 2015

Colletti G, Battista VM, Allevi F, Giovanditto F, Rabbiosi D, Biglioli F: Extraoral approach to mandibular condylar fractures: our experience with 100 cases. J Craniomaxillofac Surg 42(5): e186–e194, 2014

Dalla Torre D, Burtscher D, Widmann G, Pichler A, Rasse M, Puelacher W: Surgical treatment of mandibular condyle fractures using the retromandibular anterior transparotid approach and a triangular-positioned double miniplate osteosynthesis technique: a clinical and radiological evaluation of 124 fractures. J Craniomaxillofac Surg 43(6): 944–949, 2015

Ebenezer V, Ramalingam B: Comparison approaches rigid fixation sub-condylar fractures. J Maxillofac Oral Surg 10(1): 38–44, 2011

Eckelt U, Gerber S: Zugschraubenosteosynthese bei Unterkiefergelefortsatzfrakturen. Dtsch Z Mund Kiefer Gesichtschir 15: 51–57, 1991

Eckelt U: Problem areas—condylar neck. In: Booth W, Schendel A, Hausamen JE (eds), Maxillofacial surgery, vol. 1. London: Churchill Livingston, 207–220, 1999a

Eckelt U: Condylar neck fractures: lag screws. In: Härle F, Champy M, Terry BC (eds), Atlas of craniomaxillofacial osteosynthesis. Stuttgart: Thieme, 58, 1999b

Eckelt U, Schneider M, Erasmus F, Gerlach KL, Kuhlisch E, Loukota R, et al: Open versus closed treatment fractures mandibular condylar proccess—a prospective randomized multi-centre study. J Craniomaxillofac Surg 34: 306–314, 2006

Ellis III E, Moos KF, el-Attar A: Ten years of mandibular fractures: an analysis of 2137 cases. Oral Surg Oral Med Oral Pathol 59(2): 120–129, 1985

Ellis III E, McFadden D, Simon P, Throckmorton G: Surgical complications with open treatment of mandibular condylar process fractures. J Oral Maxillofac Surg 58: 950–958, 2000

Ellis III E, Throckmorton GS: Facial symmetry after closed and open treatment of fractures of the mandibular condylar process. J Oral Maxillofac Surg 58(7): 719–728, 2000

Gahir D, Khandavilli S, Burnham R: A simple technique to aid open reduction and internal fixation of condylar fractures approached via retromandibular incision. Br J Oral Maxillofac Surg 51(5): 457–458, 2013

Hammer B, Schier P, Prein J: Osteosynthesis of condylar neck fractures: a review of 30 patients. Br J Oral Maxillofac Surg 35: 288–291, 1997

Jacobovicz J, Lee C, Trabulsy PP: Endoscopic repair of mandibular subcondylar fractures. Plast Reconstr Surg 101(2): 437–441, 1998

Kellman RM, Cienfuegos R: Endoscopic approaches to subcondylar fractures of the mandible. Facial Plast Surg 25(1): 23–28, 2009

Loukota RA, Eckelt U, Rasse M: Subclassification of fractures of the condylar process of the mandible. Br J Oral Maxillofac Surg 43: 72–73, 2005

Lutz JC, Clavert P, Wolfram-Gabel R, Wilk A, Kahn JL: Is the high submandibular transmasseteric approach to the mandibular condyle safe for the inferior buccal branch? Surg Radiol Anat 32: 963–969, 2010

May M, Schaitkin BM: The facial nerve, 2nd edn. New York: Thieme Medical Publishers, 491–503, 2000

Mueller RV, Czerwinski M, Lee C, Kellman RM: Condylar fracture repair: use of the endoscope to advance traditional treatment philosophy. Facial Plast Surg Clin North Am 14(1): 1–9, 2006

Narayanan V, Ramadorai A, Ravi P, Nirvikalpa N: Transmasseteric anterior parotid approach for condylar fractures: experience of 129 cases. Br J Oral Maxillofac Surg 50: 420–424, 2012

Pau M, Feichtinger M, Reinbacher KE, Ivancic P, Kärcher H: Trans-tragal incision for improved exposure of diacapitular and condylar neck fractures. Int J Oral Maxillofac Surg 41(1): 61–65, 2012

Rasse M, Fialka V, Paternostro T: Modifikationen des Zuganges zum Kiefergelenk und Ramus mandibulae. Acta Chir Austriaca 25: 49–54, 1993

Schmelzeisen R, Cienfuegos-Monroy R, Schön R, Chen CT, Cunningham Jr L, Goldhahn S: Patient benefit from endoscopically assisted fixation of condylar neck fractures—a randomized controlled trial. J Oral Maxillofac Surg 67(1): 147–158, 2009

Silvennoinen U, Iizuka T, Lindqvist C, Oikarinen: Different patterns of condylar fractures: an analysis of 382 patients in a 3-year period. J Oral Maxillofac Surg 50(10): 1032–1037, 1992

Silverman SL: A new operation for displaced fractures at the neck of the mandibular condyle. Dent Cosm 67: 876, 1925

Tang W, Gao C, Long J, Lin Y, Wang H, Liu L, et al: Application of modified retromandibular approach indirectly from the anterior edge of the parotid gland in the surgical treatment of condylar fractures. J Oral Maxillofac Surg 67: 552–558, 2009

Trost O, El-Naaj IA, Trouilloud P, Danino A, Malka G: High cervical transmasseteric anteroparotid approach for open reduction and internal fixation of condylar fracture. J Oral Maxillofac Surg 66: 201–204, 2008

Trost O, Trouilloud P, Malka G: Open reduction and internal fixation of low subcondylar fractures of mandible through high cervical transmasseteric anteroparotid approach. J Oral Maxillofac Surg 67: 2446–2451, 2009

Throckmorton GS, Ellis III E: Recovery of mandibular motion after closed and open treatment of unilateral mandibular condylar process fractures. Int J Oral Maxillofac Surg 29(6): 421–427, 2000

Widmark G, Bagenholm T, Kahnberg KE, Lindahl L: Open reduction of subcondylar fractures: a study of functional rehabilitation. Int J Oral Maxillofac Surg 25(2): 107–111, 1996

Wilk A: High perimandibular approach/modified Ridson–Strasbourg approach. In: Fractures of the mandibular condyle—basic considerations and treatment. New Malden: Quintessence Publishing, 143–153, 2009

Wilson AW, Ethunandan M, Brennan PA: Transmasseteric anteroparotid approach for open reduction and internal fixation of condylar fractures. Br J Oral Maxillofac Surg 43: 57–60, 2005