

**Surgical treatment of low mandibular condyle fracture – Do surgeons select the optimal technique? A review of the literature and an international questionnaire survey**

Frida Stråhlman<sup>a\*</sup>

Marko Oksa<sup>a</sup>

Aleksi Haapanen<sup>b</sup>

Johanna Snäll<sup>b</sup>

*<sup>a</sup>Department of Oral and Maxillofacial Diseases, University of Helsinki, Helsinki, Finland*

*<sup>b</sup>Department of Oral and Maxillofacial Diseases, University of Helsinki and Helsinki University Hospital, Helsinki, Finland*

Corresponding author:

\*Frida Stråhlman, Department of Oral and Maxillofacial Diseases, University of Helsinki, Haartmaninkatu 4 E, 00029 Helsinki University Hospital, Helsinki, Finland

E-mail: [frida.strahlman@helsinki.fi](mailto:frida.strahlman@helsinki.fi)

+358-09-4711

## Abstract

Surgical treatment of condylar fractures is a much-discussed topic and a number of different techniques are used. We sent out a survey to maxillofacial trauma surgeons in the Nordic countries to gather information about regional differences in surgical praxis and post-operative treatment. A review of the literature was also conducted regarding the success-rate of different fixation plates. The survey yielded significant differences in the primary choice of fixation plate for the case of a subcondylar fracture presented, the most popular choices being two straight four-hole miniplates (27.8 %), a seven-hole lambda plate (25.0 %) as well as one straight four-hole miniplate (22.1 %). There was also division between respondents regarding choice of mono- versus bicortical screws (52.8 % versus 47.2 %) and post-operative dietary recommendations (soft diet ranging from two to eight weeks). The literature shows ample evidence favouring the use of two straight four-hole titanium miniplates for internal fixation over the use of a single straight four-hole miniplate, however newer three-dimensional plate designs are constantly being developed and have thus far shown promising results. We conclude that for optimal prognosis the single straight plate should not be used, only evidence-based treatment methods should be implemented. While there is some evidence to support the use of different three-dimensional plate designs, further research should be conducted before these can be seen as a viable choice for the standard double plating system.

**Keywords:** mandibular fracture; condylar fracture; fixation plates; open reposition; internal fixation

## Introduction

Condylar process fractures are among the most common types of fractures in the face.

The optimal treatment method depends of several factors, in particular the patient's medical history, occlusion, the type of condyle fracture, and the relationship of the condylar head to the temporomandibular fossa (1). Differences between surgical versus non-surgical treatment strategies have been studied extensively. It has been suggested that acceptable results are achieved with both methods, but surgical treatment may lead to superior long-term results in certain fracture types (2). Surgical treatment is advised especially in fractures with a severe dislocation of the condylar fragment, leading to malocclusion or an evident loss of ramus height (2,3).

Despite decades of research, there remains an ongoing debate regarding the optimal design for internal fixation plates. One of the most pressing factors that make the internal fixation of condylar fractures particularly challenging is the limited space for fracture reduction and plate fixation (4). Differences in condylar as well as fracture anatomy often combined with difficult surgical access contribute to the complexity of the issue (1). Suboptimal fracture reduction or fixation can lead to fracture instability and further complications. These include loosening or fracture of screws and bending or breaking of the fixation plate (2,5). If the rigidity of the fixation is compromised, it can lead to secondary displacement and malocclusion (6).

To date, there still has not been enough evidence to back the use of any specific plating system, particularly regarding newer three-dimensional miniplates. The lack of

consensus regarding the choice of fixation plate has led to a wide range of different plates being in current use.

The aim of this study was to clarify surgical fixation preferences of mandibular condyle fractures among maxillofacial trauma surgeons in the Nordic countries. In addition, we compared this data to the evidence available in the literature. Our hypothesis was that there will be vast differences in plate preferences among surgeons and hence the field could benefit from more specific guidelines.

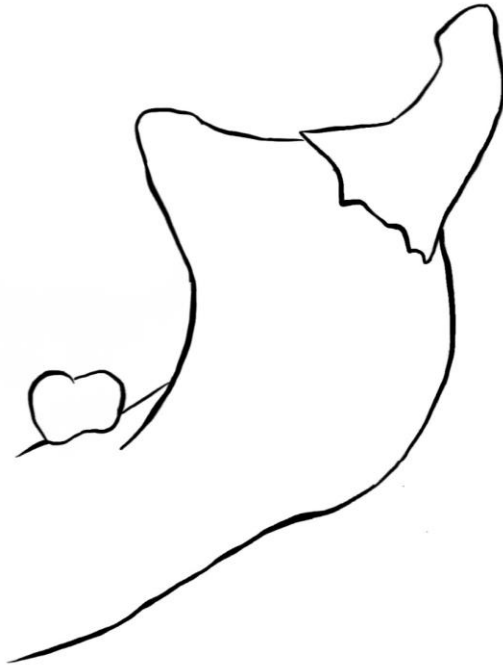
## Materials and methods

The present study consisted of a survey and a literature review.

### Survey

An anonymous online survey was conducted for maxillofacial trauma surgeons currently working in the Nordic countries. The survey was sent out via e-mail to Estonian, Swedish, Danish and Norwegian associations for oral and maxillofacial surgery for further distribution to their members. In addition, the survey was sent directly to Finnish and Icelandic surgeons. The survey was aimed at specialised practitioners treating mandibular fracture patients in their daily work. Those with ongoing specialisation were excluded. Data was collected over a period of six weeks in January and February of 2020.

The Survey consisted of general questions regarding demographic information and a patient case (Table 1).



*The condylar fracture case showed the image above, a dislocated fracture of the mandibular subcondylar region. The case patient was described as healthy, non-smoking, non-drinking, compliant and with moderate pain.*

The aim was to clarify preferences regarding the following factors: choice of treatment strategy (surgical versus non-surgical), preferred internal fixation plate, choice of screws (monocortical versus bicortical) and use of intermaxillary fixation (IMF). Responses were collected using Google forms.

## Literature review

A literature review was conducted regarding the most common currently studied plating systems for internal fixation of mandibular condylar fractures. The aim was to compare the findings to the data collected in the survey. The literature search was performed in May 2020 using the PubMed database, with the terms mandible, condyle, fracture fixation and plates (full search terms in Appendix). The search yielded 824 articles. The inclusion criteria for the search were articles written in English, published between January 2010 and May 2020. Articles regarding condylar fractures in children or adolescents were excluded, as well as articles solely focusing specific fixation plates that were not covered by the survey.

## Results

### Survey

The survey yielded a total of 45 responses from surgeons currently treating mandibular fractures in their daily work. Three of these were excluded because of ongoing specialisation of the respondent. The remaining 42 responses were submitted by maxillofacial surgeons from Estonia, Finland, Iceland, Norway and Sweden. General information of the respondents is presented in Table 1.

For to a typical subcondylar fracture as presented in the case, a clear majority (85.7 %, n=36) chose open reduction and internal fixation (ORIF) as treatment strategy. The three most popular surgical plates were two straight four-hole plates (27.8 %, n=10), a

seven-hole lambda plate (25.0 %, n=9) and a single straight four-hole plate (22.1 %, n=8). However, there was reported use of all plating options presented in the survey. Both mono- and bicortical screws were widely used, the occasional use locking screws was also common. Four respondents (11.1%) reported routinely use of IMF in conjunction with ORIF, with the duration ranging from two to six weeks. Soft diet recommendations ranged from two to eight weeks. Respondents' surgical practices are presented in Table 2.

## Review of the literature

A total of 29 articles met the inclusion (Table 3 and 4) (4,7–34). Five studies focused solely on one specific type of fixation plate (7,9,11,25,34), while all others compared different plating options with one another. Five articles did not use the option of two straight four-hole titanium miniplates as a comparison to other plating options (7,9,11,19,27). In all other articles but one (24), this plating option was deemed as either optimal or equally as good as the best option for fixation of condylar fractures. In addition, the systematic review determined two four-hole straight fixation plates as the gold standard for internal fixation of condylar fractures (35). On the other hand, the use of a single straight four-hole miniplate was studied in 14 papers (11,13,14,20–24,26,27,30,32–34) of which 10 (14,20–24,26,30,32,34) concluded that a single plate does not provide sufficient stability to the fixation and may thus lead to complications. There was no evidence that any specific placement of the single straight miniplate

would have any significant impact on the outcome. The newer three-dimensional fixation plates were included in fewer studies; four-hole box plate (n=11) (8,12,13,16,17,19,21,22,24,29,33), five-hole strut plate (n=7)(8,9,12,16,17,19,21) and seven-hole lambda plate (n=8)(7,8,12,16,17,19,21,29). All these studies found the three-dimensional plates provided adequate stability, with the exception of one study (22) that recorded a fracture risk for the box plate in some specific scenarios, when used in combined mandibular fractures.

## Discussion

The aim of this study was to record surgical fixation preferences of mandibular condyle fractures among surgeons and compare the data to the available evidence found in the literature. Our hypothesis was that there would be vast differences in plate preferences and hence the field would benefit from more specific guidelines. Our hypothesis was confirmed, there was a wide array of different treatment strategies, and some of these were not in line with recommendations found in the literature.

ORIF is supported by the literature as the treatment strategy of choice for dislocated subcondylar fractures (1,2,6), which is in line with the findings of the survey: 87.5 % chose a surgical over a non-surgical treatment strategy. While it is widely accepted that ORIF is the primary treatment choice for condylar fractures (36), the choice of fixation system remains controversial. This is greatly reflected in the survey as a wide array of primary choices regarding fixation plate. According to the literature, a double straight



four-hole plating system remains the best option currently available (35). While this was indeed the most popular choice according to the survey, only 27.8% of respondents reported it as their primary choice of plating system for a typical subcondylar fracture. Despite the overwhelming evidence found in the literature suggesting that a single straight four-hole miniplate provides insufficient fracture stabilisation (35), this was still the primary choice for 22.1% of the respondents. This highlights the fact that the field needs clearer guidelines regarding the choice of fixation plate for condylar fractures.

While there is constantly new research being published suggesting that some three-dimensional miniplates could be comparable to two straight miniplates, the results vary depending on the published paper. In particular, the box, strut and lambda plates could provide a feasible alternative for the standard double plate in cases where the distal fragment of the condyle is small and thus the lack of space rules out the double plating method (19,21,24,29). More research needs to be conducted in order to single out an optimal three-dimensional plate design as the current findings differ greatly from each other.

Very little research has been conducted regarding the optimal type of fixation screw. There is some evidence supporting the use of bicortical or long screws in conjunction with miniplates, as these provide increased stabilisation (36). This could be crucial especially when the distal fragment is small and does not provide enough space for several screws. Injury of the Maxillary artery during drilling or mounting bicortical screws has been considered, but there is a lack of evidence regarding the subject. The risk for

vein injury can be reduced by drill-stoppers. The missing consensus regarding the optimal screw type was also evident in the results of the survey: half of the respondents reported bicortical screw use while the other half rely on monocortical fixation. Most of the publications regarding ORIF of condylar fractures do not specify which type of screws were used, which makes reviewing the literature difficult. The data available regarding the use of locking screws is also sparse. Half of the survey respondents reported the occasional use of locking screws. More attention should be paid to screw types in further studies.

There is little consensus regarding which surgical approach should be used for condylar fractures, although one study suggested that specifically for a subcondylar fracture an intraoral route is superior (37). A variety of strategies have been presented in the literature, our survey grouped these as either intraoral or extraoral. 86.1 % preferred an extraoral approach while 13.9 % used an intraoral approach. The advantage of an extraoral approach is better visibility and ease of access resulting in a shorter operation time. However, there is a risk of nerve damage, visible scarring or formation of salivary fistula (38,39). While the intraoral approach effectively avoids these problems, there is a lack of space and visibility, which makes fixation more demanding, resulting in longer operating times (37). Endoscopic assistance is becoming increasingly popular and there is mounting evidence of fewer complications (36), however the method is technically challenging and requires vast training as well as investment in equipment.

As internal fixation has proven to provide sufficient stabilisation, IMF is rarely used in conjunction with ORIF unless the achieved fixation is suboptimal. This was also evident in the survey, as only 11.1 % reported using MMF routinely as part of treatment. There is also a general consensus that following a soft diet post-operatively is of utmost importance for the success of the treatment. The progressive loading post-operatively not only protects from fixation fracture or torsion, but also improves mobility (6,40). All respondents reported recommending a soft diet post-operatively, however a range of two to eight weeks was recorded. Thus, there is considerable variation in postoperative instructions between surgeons.

In conclusion, the current research evidence supports the use of two straight four-hole miniplates, but further research should be conducted regarding newer three-dimensional plating systems. The use of one single four-hole miniplate cannot be advised according to the literature. There is not enough evidence regarding the use of mono- versus bicortical screws to make any conclusion to which system is superior. In a similar manner, consistent evidence for the sufficient length of a soft diet post-operatively is required. Several factors remain unclear even in seemingly straight forward mandibular condylar fracture cases as well as in postoperative care. Further research and international treatment recommendations would benefit the field.

### Conflicts of interest

The authors declare no conflict of interest.

## Funding

This research did not receive any specific grant from funding agencies. Author J.S. was funded by the Paulo Foundation, and J.S. and A.H. were funded by the Helsinki University Hospital Fund.

## References

1. 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. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2006 Jul;34(5):306–14. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518206000564>
2. Alyahya A, bin Ahmed A, Nusair Y, Ababtain R, Alhussain A, Alshafei A. Mandibular condylar fracture: a systematic review of systematic reviews and a proposed algorithm for management. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2020 Mar; Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0266435620300991>
3. Sanati-Mehrziy P, Massenburg BB, Sherif RD, Ingargiola MJ, Motakef S, Taub PJ. Review of Endoscopic Repair of Mandible Fractures. *Journal of Craniofacial Surgery* [Internet]. 2019;30(2):489–92. Available from: <http://Insights.ovid.com/crossref?an=00001665-201903000-00048>
4. ben Achour A, Meißner H, Teicher U, Haim D, Range U, Brosius A, et al. Biomechanical Evaluation of Mandibular Condyle Fracture Osteosynthesis Using the Rhombic Three-Dimensional Condylar Fracture Plate. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2019 Sep;77(9):1868.e1-1868.e15. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239119304513>
5. Vesnaver A, Ahčan U, Rozman J. Evaluation of surgical treatment in mandibular condyle fractures. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2012 Dec;40(8):647–53. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518211002587>
6. Derfoufi L, Delaval C, Goudot P, Yachouh J. Complications of Condylar Fracture Osteosynthesis. *Journal of Craniofacial Surgery* [Internet]. 2011 Jul;22(4):1448–51. Available from: <http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00001665-201107000-00064>
7. Smolka W, Liokatis P, Cornelius C-P. Open Reduction and Internal Fixation of Unilateral Mandibular Condylar Base and Neck Fractures Using a Lambda Plate: Selection Criteria for Application. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2020 Feb; Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239120301117>
8. Sukegawa S, Kanno T, Masui M, Sukegawa-Takahashi Y, Kishimoto T, Sato A, et al. Which fixation methods are better between three-dimensional anatomical plate and two

- miniplates for the mandibular subcondylar fracture open treatment? *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2019 May;47(5):771–7. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518218305432>
9. Lechler C, Probst F, Cornelius C-P, Smolka W. Open Reduction and Internal Fixation of Mandibular Condylar Base and Neck Fractures Using Strut Plates. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2018 Jul;76(7):1494–503. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239118300867>
  10. 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. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2018 Jun;76(6):1255–66. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239117315434>
  11. Ghezta NK, Bhardwaj Y, Rani P, Ram R. Efficacy of Retromandibular Transparotid Approach for the Management of Extracapsular Subcondylar Mandibular Fractures Using 2-mm Titanium Miniplates: A Prospective Clinical Study. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2016 Aug;74(8):1613–21. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239116300350>
  12. Cortelazzi R, Altacera M, Turco M, Antonicelli V, de Benedittis M. Development and Clinical Evaluation of MatrixMANDIBLE Subcondylar Plates System (Synthes). *Craniomaxillofacial Trauma & Reconstruction* [Internet]. 2015 Jun 10;8(2):94–9. Available from: <http://journals.sagepub.com/doi/10.1055/s-0034-1395382>
  13. Spinzia A, Patrone R, Belli E, Dell’Aversana Orabona G, Ungari C, Filiaci F, et al. Open reduction and internal fixation of extracapsular mandibular condyle fractures: a long-term clinical and radiological follow-up of 25 patients. *BMC Surgery* [Internet]. 2014 Dec 7;14(1):68. Available from: <http://bmcsurg.biomedcentral.com/articles/10.1186/1471-2482-14-68>
  14. Rai A. Comparison of single vs double noncompression miniplates in the management of subcondylar fracture of the mandible. *Annals of Maxillofacial Surgery* [Internet]. 2012;2(2):141. Available from: <http://www.amsjournal.com/text.asp?2012/2/2/141/101339>
  15. Zieliński R, Kozakiewicz M, Konieczny B, Krasowski M, Okulski J. Mechanical Evaluation of Titanium Plates for Osteosynthesis High Neck Condylar Fracture of Mandible. *Materials* [Internet]. 2020 Jan 27;13(3):592. Available from: <https://www.mdpi.com/1996-1944/13/3/592>
  16. Kozakiewicz M, Zieliński R, Konieczny B, Krasowski M, Okulski J. Open Rigid Internal Fixation of Low-Neck Condylar Fractures of the Mandible: Mechanical Comparison of 16 Plate Designs. *Materials* [Internet]. 2020 Apr 22;13(8):1953. Available from: <https://www.mdpi.com/1996-1944/13/8/1953>
  17. Kozakiewicz M, Zieliński R, Krasowski M, Okulski J. Forces Causing One-Millimeter Displacement of Bone Fragments of Condylar Base Fractures of the Mandible after Fixation by All Available Plate Designs. *Materials* [Internet]. 2019 Sep 25;12(19):3122. Available from: <https://www.mdpi.com/1996-1944/12/19/3122>
  18. de Souza GM, Rodrigues DC, Celegatti Filho TS, Moreira RWF, Falci SGM. In-vitro comparison of mechanical resistance between two straight plates and a Y-plate for

- fixation of mandibular condyle fractures. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2018 Jan;46(1):168–72. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518217303797>
19. Albogha MH, Mori Y, Takahashi I. Three-dimensional titanium miniplates for fixation of subcondylar mandibular fractures: Comparison of five designs using patient-specific finite element analysis. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2018 Mar;46(3):391–7. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518217304523>
  20. Cavalieri-Pereira L, Spagnol G, Sverzut CE, de Moraes M, Trivellato AE. Resistance of four fixation techniques used to treat subcondylar fractures. *Oral and Maxillofacial Surgery* [Internet]. 2018 Mar 17;22(1):91–6. Available from: <http://link.springer.com/10.1007/s10006-018-0675-0>
  21. Murakami K, Yamamoto K, Sugiura T, Horita S, Matsusue Y, Kirita T. Computed Tomography–Based 3-Dimensional Finite Element Analyses of Various Types of Plates Placed for a Virtually Reduced Unilateral Condylar Fracture of the Mandible of a Patient. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2017 Jun;75(6):1239.e1-1239.e11. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239117302239>
  22. Vieira e Oliveira TR, Kemmoku DT, da Silva JVL, Noritomi PY, Passeri LA. Finite Element Evaluation of Stable Fixation in Combined Mandibular Fractures. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2017 Nov;75(11):2399–410. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239117307206>
  23. Çimen E, Önder ME, Cambazoğlu M, Birant E. Comparison of Different Fixation Types Used in Unilateral Mandibular Condylar Fractures. *Journal of Craniofacial Surgery* [Internet]. 2016 Jul;27(5):1277–81. Available from: <http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00001665-201607000-00037>
  24. Darwich MA, Albogha MH, Abdelmajeed A, Darwich K. Assessment of the Biomechanical Performance of 5 Plating Techniques in Fixation of Mandibular Subcondylar Fracture Using Finite Element Analysis. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2016 Apr;74(4):794.e1-794.e8. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S027823911501558X>
  25. Hijazi L, Hejazi W, Darwich MA, Darwich K. Finite element analysis of stress distribution on the mandible and condylar fracture osteosynthesis during various clenching tasks. *Oral and Maxillofacial Surgery* [Internet]. 2016 Dec 23;20(4):359–67. Available from: <http://link.springer.com/10.1007/s10006-016-0573-2>
  26. Conci RA, Tomazi FHS, Noritomi PY, da Silva JVL, Fritscher GG, Heitz C. Comparison of Neck Screw and Conventional Fixation Techniques in Mandibular Condyle Fractures Using 3-Dimensional Finite Element Analysis. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2015 Jul;73(7):1321–7. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239115001093>
  27. Aquilina P, Parr WCH, Chamoli U, Wroe S, Clausen P. A Biomechanical Comparison of Three 1.5-mm Plate and Screw Configurations and a Single 2.0-mm Plate for Internal Fixation of a Mandibular Condylar Fracture. *Craniofacial Trauma & Reconstruction* [Internet]. 2014 Sep 10;7(3):218–23. Available from: <http://journals.sagepub.com/doi/10.1055/s-0034-1375172>

28. Hakim SG, Wolf M, Wendlandt R, Kimmerle H, Sieg P, Jacobsen H-C. Comparative biomechanical study on three miniplates osteosynthesis systems for stabilisation of low condylar fractures of the mandible. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2014 Apr;52(4):317–22. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S026643561400059X>
29. de Jesus GP, Vaz LG, Gabrielli MFR, Passeri LA, v. Oliveira T, Noritomi PY, et al. Finite element evaluation of three methods of stable fixation of condyle base fractures. *International Journal of Oral and Maxillofacial Surgery* [Internet]. 2014 Oct;43(10):1251–6. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0901502714002616>
30. Aquilina P, Chamoli U, Parr WCH, Clausen PD, Wroe S. Finite element analysis of three patterns of internal fixation of fractures of the mandibular condyle. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2013 Jun;51(4):326–31. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0266435612005177>
31. Haim D, Müller A, Leonhardt H, Nowak A, Richter G, Lauer G. Biomechanical Study of the Delta Plate and the TriLock Delta Condyle Trauma Plate. *Journal of Oral and Maxillofacial Surgery* [Internet]. 2011 Oct;69(10):2619–25. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239111000565>
32. Christopoulos P, Stathopoulos P, Alexandridis C, Shetty V, Caputo A. Comparative biomechanical evaluation of mono-cortical osteosynthesis systems for condylar fractures using photoelastic stress analysis. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2012 Oct;50(7):636–41. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S026643561100684X>
33. Pilling E, Eckelt U, Loukota R, Schneider K, Stadlinger B. Comparative evaluation of ten different condylar base fracture osteosynthesis techniques. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2010 Oct;48(7):527–31. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0266435609005506>
34. Parascandolo S, Spinzia A, Parascandolo S, Piombino P, Califano L. Two load sharing plates fixation in mandibular condylar fractures: Biomechanical basis. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2010 Jul;38(5):385–90. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518209001905>
35. Marwan H, Sawatari Y. What Is the Most Stable Fixation Technique for Mandibular Condyle Fracture? *Journal of Oral and Maxillofacial Surgery* [Internet]. 2019 Dec;77(12):2522.e1-2522.e12. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239119308973>
36. Abdel-Galil K, Loukota R. Fractures of the mandibular condyle: evidence base and current concepts of management. *British Journal of Oral and Maxillofacial Surgery* [Internet]. 2010 Oct;48(7):520–6. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0266435609005695>
37. Nam SM, Kim YB, Lee SJ, Park ES, Lee JH. A comparative study of intraoral versus retromandibular approach in the management of subcondylar fracture. *BMC Surgery* [Internet]. 2019 Dec 5;19(1):28. Available from: <https://bmcsurg.biomedcentral.com/articles/10.1186/s12893-019-0487-7>
38. Al-Moraissi EA, Louvrier A, Colletti G, Wolford LM, Biglioli F, Ragaey M, et al. Does the surgical approach for treating mandibular condylar fractures affect the rate of seventh

cranial nerve injuries? A systematic review and meta-analysis based on a new classification for surgical approaches. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2018 Mar;46(3):398–412. Available from:

<https://linkinghub.elsevier.com/retrieve/pii/S1010518217303748>

39. Shi D, Patil PM, Gupta R. Facial nerve injuries associated with the retromandibular transparotid approach for reduction and fixation of mandibular condyle fractures. *Journal of Cranio-Maxillofacial Surgery* [Internet]. 2015 Apr;43(3):402–7. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1010518214003655>
40. Khiabani K, Zinhighayegh B, Amirzade-Iranaq MH. Does dynamic intermaxillary fixation with elastics improve outcomes following unilateral condylar fracture? *Journal of Oral and Maxillofacial Surgery* [Internet]. 2020 Sep; Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0278239120311095>



## Appendix

*("mandible"[MeSH Terms] OR "mandible"[All Fields] OR "mandibular"[All Fields]) AND (condylar[All Fields] OR condyle[All Fields] OR neck[All Fields] OR subcondylar[All fields]) AND ("fracture fixation, internal"[MeSH Terms] OR ("fracture"[All Fields] AND "fixation"[All Fields] AND "internal"[All Fields]) OR "internal fracture fixation"[All Fields] OR ("fracture"[All Fields] AND "internal"[All Fields] AND "fixation"[All Fields]) OR "fracture internal fixation"[All Fields] OR "osteosynthesis"[All Fields]) AND ("miniplate"[All fields] OR "bone plates"[MeSH Terms] OR ("bone"[All Fields] AND "plates"[All Fields]) OR "bone plates"[All Fields] OR "plate"[All Fields] OR "hardware"[MeSH Terms]).*

<b>Table 1: background information</b>		
<b>Degree</b>	<b>n</b>	<b>%</b>
MD	1	2.4
DDS/DMD	28	68.3
Both MD and DDS/DMD	12	29.3
<b>Country</b>	<b>n</b>	<b>%</b>
Estonia	4	9.8
Finland	20	48.8
Iceland	6	14.6
Norway	5	12.2
Sweden	6	14.6
<b>Age</b>	<b>Range</b>	<b>Mean</b>
	31-62	48.2
<b>Sex</b>	<b>n</b>	<b>%</b>
Women	10	24.4
Men	31	75.6

**Table 2: Survey results**

<b>Surgical treatment of subcondylar fractures</b>	Yes n (%)	No (%)
	36 (85.7)	6 (14.3)

<b>Primary choice of surgical route</b>	Intraoral n (%)	Extraoral n (%)	Endoscopic n (%)
	5 (13.9)	31 (86.1)	0 (0)

<b>Primary choice of surgical plate:</b>	n (%)
<b>One straight 4-hole plate</b>	8 (22.1)
<b>Two straight 4-hole plates</b>	10 (27.8)
<b>4-hole box plate</b>	2 (5.6)
<b>5-hole strut plate</b>	5 (13.9)
<b>7-hole lambda plate</b>	9 (25.0)
<b>Other</b>	2 (5.6)

<b>Primary choice of screws</b>	Monocortical n (%)	Bicortical n (%)
	19 (52.8)	17 (47.2)

<b>Use of locking screws</b>	Yes n (%)	No (%)
	18 (50.0)	18 (50.0)

<b>Maxillomandibular fixation (MMF) used routinely</b>	Yes n (%)	No (%)	
	4 (11.1)	32 (88.9)	
<b>Weeks used maxillomandibular fixation (MMF)</b>	Range	Mean	Median
	from 2-6	3.5	3
<b>Soft food diet recommended (weeks)</b>	from 2-8	4.9	4

<b>Table 3: prospective / retrospective studies investigating condylar fracture plating</b>							
	Title (Year)	Research type	Number of assessed cases	Investigated plate type	Optimal plate	Suboptimal plate	Fracture type
1	Open Reduction and Internal Fixation of Unilateral Mandibular Condylar Base and Neck Fractures Using a Lambda Plate: Selection Criteria for Application (2020)	Clinical study	11	5	5	N/A	B, C, D
2	Which fixation methods are better between three-dimensional anatomical plate and two miniplates for the mandibular subcondylar fracture open treatment? (2019)	retrospective clinical study	30	2, 3, 4, 5	2, 3, 4, 5	N/A	D
3	Open Reduction and Internal Fixation of Mandibular Condylar Base and Neck Fractures Using Strut Plates (2018)	Clinical study	30	4	4	N/A	B, C, D
4	Comparative Evaluation of Clinical Outcomes Using Delta Plates and Conventional Miniplates for Internal Fixation of Mandibular Condylar Fractures in Adults (2018)	Randomised prospective study	20	2, 6	2, 6	N/A	D
5	Efficacy of Retromandibular Transparotid Approach for the Management of Extracapsular Subcondylar Mandibular Fractures Using 2-mm Titanium Miniplates: A Prospective Clinical Study (2016)	Prospective cohort study	39	1	1	N/A	A, D
6	Development and Clinical Evaluation of MatrixMANDIBLE Subcondylar Plates System (Synthes) (2015)	Retrospective study	62	2, 3, 4, 5	2, 3, 4, 5	N/A	B, C, D
7	Open reduction and internal fixation of extracapsular mandibular condyle fractures: a long-term clinical and radiological follow-up of 25 patients (2014)	Retrospective study	25	1, 2, 3	(1), 2, 3	N/A	B, C, D
8	Comparison of single vs double noncompression miniplates in the management of subcondylar fracture of the mandible. (2012)	Randomized prospective clinical study	30	1, 2	2	1	D

*Plates: 1. 1x 4-hole straight plate, 2. 2x 4-hole straight plates, 3. box plate, 4. strut plate, 5. lambda plate, 6. other*  
*Fracture line: A. head B. high neck, C. low neck, D. subcondylar*

**Table 4: experimental biomechanical evaluations investigating condylar fracture plating**

	Title (Year)	Loading test type	Investigated plate type	Optimal plate	Suboptimal plate	Fracture classification
1	Mechanical Evaluation of Titanium Plates for Osteosynthesis High Neck Condylar Fracture of Mandible (2020)	Polyurethane mandibles, FEM analysis	2, 6	(2)	6	B
2	Open Rigid Internal Fixation of Low-Neck Condylar Fractures of the Mandible: Mechanical Comparison of 16 Plate Designs (2020)	Polyurethane mandibles	2, 3, 4, 5, 6	2, 6	5, 6	C
3	Forces Causing One-Millimeter Displacement of Bone Fragments of Condylar Base Fractures of the Mandible after Fixation by All Available Plate Designs (2019)	Polyurethane mandibles	2, 3, 4, 5, 6	2, 6	6	D
4	Biomechanical Evaluation of Mandibular Condyle Fracture Osteosynthesis Using the Rhombic Three-Dimensional Condylar Fracture Plate (2019)	200 porcine mandibles	2, 6	2, 6	N/A	B
5	In-vitro comparison of mechanical resistance between two straight plates and a Y-plate for fixation of mandibular condyle fractures (2018)	40 polyurethane hemi-mandibles	2, 6	2, (6)	N/A	D
6	Three-dimensional titanium miniplates for fixation of subcondylar mandibular fractures: Comparison of five designs using patient-specific finite element analysis (2018)	FEM analysis	3, 4, 5, 6	3	N/A	D
7	Resistance of four fixation techniques used to treat subcondylar fractures.(2018)	84 polyurethane mandibles	1, 2	2	1	D

8	Computed Tomography-Based 3-Dimensional Finite Element Analyses of Various Types of Plates Placed for a Virtually Reduced Unilateral Condylar Fracture of the Mandible of a Patient (2017)	FEM analysis	1, 2, 3, 4, 5, 6	2, 3, 4, 5	1, 6	D
9	Finite Element Evaluation of Stable Fixation in Combined Mandibular Fractures (2017)	FEM analysis	1, 2, 3	2	1	A, B, C, D
10	Comparison of Different Fixation Types Used in Unilateral Mandibular Condylar Fractures: An In Vivo Study With New Biomechanical Model (2016)	30 polyurethane mandibles	1, 2, 6	2	1, 6	D
11	Assessment of the Biomechanical Performance of 5 Plating Techniques in Fixation of Mandibular Subcondylar Fracture Using Finite Element Analysis (2016)	FEM analysis	1, 2, 3, 6	3	1	D
12	Finite element analysis of stress distribution on the mandible and condylar fracture osteosynthesis during various clenching tasks (2016)	FEM analysis	2	2	N/A	D
13	Comparison of Neck Screw and Conventional Fixation Techniques in Mandibular Condyle Fractures Using 3-Dimensional Finite Element Analysis (2015)	FEM analysis	1, 2	2	1	D
14	A Biomechanical Comparison of Three 1.5-mm Plate and Screw Configurations and a Single 2.0-mm Plate for Internal Fixation of a Mandibular Condylar Fracture (2014)	FEM analysis	1, 6	N/A	6	D
15	Comparative biomechanical study on three miniplates osteosynthesis systems for stabilisation of low condylar fractures of the mandible (2014)	40 synthetic bony mandibles	2, 6	2, (6)	N/A	D
16	Finite element evaluation of three methods of stable fixation of condyle base fractures (2014)	FEM analysis	2, 3, 5	2, 3, 5	N/A	D

17	Finite element analysis of three patterns of internal fixation of fractures of the mandibular condyle (2013)	FEM analysis	1, 2	2	1	D
18	Biomechanical study of the Delta plate and the TriLock Delta condyle trauma plate (2011)	120 porcine mandibles	2, 6	2, 6	N/A	B, C
19	Comparative biomechanical evaluation of mono-cortical osteosynthesis systems for condylar fractures using photoelastic stress analysis (2011)	10 photoelastic resin mandibles	1, 2	2	1	D
20	Comparative evaluation of ten different condylar base fracture osteosynthesis techniques. (2010)	164 fresh minipig mandibles	1, 2, 3, 6	2	6	D
21	Two load sharing plates fixation in mandibular condylar fractures: Biomechanical basis (2010)	FEM analysis	2	2	1	D

*Plates: 1. 1x 4-hole straight plate, 2. 2x 4-hole straight plates, 3. box plate, 4. strut plate, 5. lambda plate, 6. other*

*Fracture line: A. head B. high neck, C. low neck, D. subcondylar*