Clinical Note

Unexpected Plate Fracture in a Three-Dimensional Subcondylar Locking Plate System

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Abstract: Fractures of the mandibular condyle still account for a significant proportion of all mandibular fractures, and open reduction and internal rigid fixation of subcondylar fractures has become the standard treatment for this condition. The preference for this approach rests on the considerable technical progress made in this domain, especially in hardware development (e.g., three-dimensional anatomically specifically shaped and biomechanically stable locking subcondylar plate systems), as well as on an improved understanding of the osteobiology and osteophysiology of fracture healing. However, in the present case, the postoperative complication of unexpected fatigue plate fracture in a 68-year-old male patient after open treatment of a subcondylar fracture of the mandible could not be averted despite application of a mechanically stiff enough locking plate and anatomically accurate fracture reduction. This unusual case highlights the need for further osteophysiological research and for possible modification of the hardware system in view of the biomechanically complex nature of mandibular subcondylar fracture surgical treatment.

Key words: Mandibular condyle fracture, Open reduction and internal fixation, Plate fracture, Subcondylar locking plate, Fracture healing

Introduction

The mandibular condylar process is one of the most frequent sites of mandibular fracture1. Although absolute and relative indications for open reduction and internal fixation (ORIF) have been proposed, treatment choices in such patients tend to be based on the surgeon’s experience and preferences. However, a recent systematic review and a meta-analysis2 showed that ORIF provides superior functional clinical outcomes for the management of adult mandibular condyle fractures, with quicker rehabilitation of oromandibular function and quicker reintegration into social activities, when subjectively and objectively compared with conservative treatment. These clinical benefits have made ORIF the standard treatment for subcondylar fractures, supported by technical progress in less invasive surgical approaches, the accumulation of clinical evidence, hardware developments (e.g., three-dimensional (3D) anatomically specifically shaped and biomechanically stable locking plate systems for subcondylar fracture open treatment), the introduction of computer-assisted surgical techniques and devices, and a better understanding of the osteobiology of maxillofacial fracture healing1-3).

The mechanism of the plate systems used in ORIF is based on the biomechanical and biophysical principles of functionally stable osteosynthesis during biting and the occlusal 3D forcing mechanism, and knowledge of these principles has, in turn, revealed the importance of 3D shape design with locking fixation and sufficient neutralization of the tension and compression forces to promote stable fracture healing4).

However, despite the application of a mechanically stiff locking plate and anatomically accurate fracture reduction, an unexpected postoperative plate fracture occurred in a 68-year-old male patient who had undergone open treatment of a mandibular fracture. This complication may suggest the need for modification of the hardware for subcondylar fracture ORIF, in view of the biomechanical complexity of such trauma surgeries.

Material and Method

Patient

A 68-year-old man presented to the emergency room of Masuda Red Cross Hospital, Japan, after a fall from the roof of a two-story house. He was conscious with a full Glasgow coma scale score of 15 but had high-energy traumatic injuries including intra-abdominal organ injury, pelvic fracture, tibia and ankle fractures, wrist fracture, and multiple rib fractures. He also had the maxillofacial injuries of facial laceration and mandibular fractures, with a displaced right symphysis and shattered alveolus and dislocated left lower condylar neck fractures (Fig. 1). Emergency surgeries were performed to achieve hemostasis in the abdomen and external skeletal fixation, followed by facial
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On post-trauma day 11, surgery was performed in a conventional manner according to the AO-CMF techniques via an intraoral approach for symphysis fracture: ORIF using two 2.0-mm locking miniplates (AO; MatrixMANDIBLE 2.0; DePuy Synthes, Paoli, PA) for bimaxillary stable occlusal restoration, followed by repair of the subcondylar fracture via a retromandibular transparotid approach, as described in our previous reports. Briefly, after attempting an anatomically perfect reduction of the fractured condylar segment with no bony defect, condylar neck fracture fixation was performed using a single 3D subcondylar strut-form locking miniplate (MatrixMANDIBLE subcondylar plate system, DePuy Synthes). The plate did not need to be bent for adjustment, and anatomically it fitted well to the bony surface of the mandibular lower condylar neck, providing double-buttress rigid fixation for stabilization. Stable occlusion was then confirmed before wound closure after the release of intraoperative intermaxillary fixation. No postoperative maxillomandibular fixation or training elastic was used. An oral liquid diet was initiated on postoperative day 1, followed by instructions to maintain a soft diet for the next 4 weeks.

Postoperative course

His postoperative clinical course was uneventful, and radiographic evaluation confirmed the accurate anatomical reduction of the displaced condylar segment with internal rigid fixation (Fig. 1B). About 1 month postoperatively, active physical therapy and functional mouth opener activator treatment were provided. He returned to a normal diet. With active functional training, the range of temporomandibular joint (TMJ) movement improved gradually at 2 months postoperatively, with an interincisal distance exceeding 40 mm, without deviation and with stable individual centric occlusion.

Results

However, the patient heard a metallic fracture sound suddenly in the left ear on biting, not long after the 2-month follow-up. We took a panoramic X-ray and found a posterior fracture of the strut plate (Fig. 2A).

The patient did not have any problematic symptoms at the surgical site such as pain, demonstrating the same satisfactory stable occlusion and range of TMJ motion without deviation. Stable individual centric occlusion was also maintained. Thus, no...
additional surgical intervention such as plate replacement was required. The patient underwent close follow-up in the outpatient clinic. There was no clicking of the TMJ and no pain, and no clinically problematic symptoms with TMJ movement were observed. After a 3-month stay in the hospital for orthopedic trauma treatment and rehabilitation, the patient was discharged from the hospital.

Although postoperative follow-up showed that there was no deviation in TMJ function with continued stable individual centric occlusion, the plates on his mandibles were removed 6 months postoperatively, and complete union with bony healing on the left condyle was confirmed (Fig. 2B). Intraoperatively, the fracture site had healed completely with bone union and none of the screws had loosened, although the posterior plate fracture was evident (Fig. 3A).

Detailed microscopic examination of the plate showed a continuous fatigue fracture of the plate (AO-CMF; DePuy Synthes; Fig. 3B).

Discussion

Because the use of heavy plates is usually not always applicable to the subcondylar and condylar segments, the two miniplates technique with monocortical screws has been shown to be the most reliable and functionally stable osteosynthesis procedure for subcondylar fractures, and it is currently considered standard practice. Wagner et al.5 demonstrated its biomechanical superiority experimentally in 2002. Additionally, in terms of immediate function without maxillomandibular fixation, this double miniplate fixation exceeded the functional force exerted on the condyle, enabling immediate functional loading, as reported in both a biomechanical model study and clinical trials1,3,5,6.

Following these basic bony biological and biomechanical studies, specially anatomically designed 3D plates for subcondylar fracture ORIF were proposed and are now available for clinical use.4,6 Of these, 3D plates of various shapes, such as squares and rectangles, have been introduced for subcondylar fracture treatment and are regarded as the best mechanical components to ensure primary stabilization of condylar fractures by stabilizing the double buttresses of the anterior and posterior parts. Unlike in the two miniplates technique, these specially designed plates are even smaller and show greater osteosynthetic stability through the mechanical connection between the two plate arms4,7. Moreover, their smaller size helps to avoid excessive soft tissue stripping during surgery and improves handling in minimally invasive surgical approaches. Actual clinical results have suggested that use of these 3D plates is superior to the previous two miniplates technique4,7. Furthermore, visual analyses of the macroscopic fracture line displacement and photoelastimetric analysis of the pre- and postsurgical strain patterns have been reported4,6,7.

According to Champy et al.8, as a rule, internal rigid fixation has to be sufficiently stable in mandibular fracture ORIF to fulfill the principles of functionally stable osteosynthesis and thus induce sound bone healing. The osteosynthesis device has to be rigid enough to withstand physiological masticatory forces applied to the condylar region, and the plate design has to fit the strain pattern occurring in the condylar region during oromandibular function. Tensile strain lines along the rim of the sigmoid notch and compressive strain lines along the posterior border of the ramus, parallel to the condylar axis, were recently confirmed in detail by Meyer et al.7 using a mechanical loading model similar to that used in other biomechanical investigations of fractured condyle models3,4.

In efforts to further enhance the results, a locking system for subcondylar fractures was developed and is now commercially available. Its greater primary stability across the fracture gap has reduced micromovement and screw loosening4,8. The locking plate system used in the present case was first introduced in 2010 (MatrixMANDIBLE subcondylar plate system) and has been gradually improved4. It consists of implants specifically designed to suit the different fracture patterns of the subcondylar and condylar neck regions. The 3D shape of the strut plate with its connection arms provides greater internal stability and more optimal leverage. It combines the concept of double buttress
osteoosynthesis compared with non-locking miniplates. Bite force, when locking miniplates are used in mandibular fracture al.

overloading of the plate before sound bony union. Agarwal et

activator were provided postoperatively without revision surgery, would not have occurred before stable fixation was complete. Mechnical weakness of the plate resulting from early metal fatigue without the need for intraoperative bending adjustment, provided by the anterior part of the plate. As this specific well healed in about 2 months owing to the mechanical support the locking system on this 3D plate, the fractured segment was ramus, parallel to the condylar axis be focused according to the line along the posterior border of the relatively large compressive strain with torsion stress load could be loaded on the plate, causing higher continuous fatigue than was earlier healing occurred, followed by greater mechanical stress

Functional loading in our case is that even greater occlusal force explanation of the plate failure due to continuous oromandibular four cases in our previous 3 years of use, as we reported recently1), although complications with similar previous 3D subcondylar plate systems, such as screw loosening in non-locking systems and plate fracture in a locking system, have been reported6- 6. However, Seemann et al.6 reported that the complications related to hardware failure in fixation with specially designed plates or miniplates would occur only when a non-anatomical reduction of the condylar segment was achieved. Failures may be more likely in cases with osteosynthesis failure, because the plates have to exert a reconstructive role due to non-anatomical reduction. In cases of fractures with bony substance loss or insufficient contact of fragments, even mechanically stiff plates may show failure, because they were not designed for reconstructive purposes6-9). On the basis of previous reports, non-anatomical reductions, especially with a transoral approach, should be avoided1-6).

The present case demonstrates that a good anatomical reduction can be achieved through an extraoral approach, such as a retromandibular transparotid direct open approach. A possible explanation of the plate failure due to continuous oromandibular functional loading in our case is that even greater occlusal force with earlier healing occurred, followed by greater mechanical stress loaded on the plate, causing higher continuous fatigue than was anticipated. At the posterior border of the subcondylar region, relatively large compressive strain with torsion stress load could be focused according to the line along the posterior border of the ramus, parallel to the condylar axis3-7), and this could have affected the fracture of the posterior part in this case. However, thanks to the locking system on this 3D plate, the fractured segment was well healed in about 2 months owing to the mechanical support provided by the anterior part of the plate. As this specific subcondylar plate fitted anatomically to the patient’s fracture site without the need for intraoperative bending adjustment, mechanical weakness of the plate resulting from early metal fatigue would not have occurred before stable fixation was complete. Active physical therapy and use of a functional mouth opening activator were provided postoperatively without revision surgery, and the clinical course was satisfactory. This might have caused overloading of the plate before sound bony union. Agarwal et al.10 suggested that significant and early functional occlusal force exertion was more likely to occur, accompanied by a much greater bite force, when locking miniplates are used in mandibular fracture osteosynthesis compared with non-locking miniplates.

There is a need for further research on the osteobiology and stabilization with a precontoured curved profile to fit the fracture area anatomically, and this can be further improved by bending.

In the present case, however, at around 2 months postoperatively, we experienced a plate fracture during the course of an otherwise uneventful follow-up with functional improvement. Plate fracture in this 3D locking miniplate system has not been reported before, and we also have not encountered any other cases in our previous 3 years of use, as we reported recently1), although complications with similar previous 3D subcondylar plate systems, such as screw loosening in non-locking miniplates in a locking system, have been reported6- 6. However, Seemann et al.6 reported that the complications related to hardware failure in fixation with specially designed plates or miniplates would occur only when a non-anatomical reduction of the condylar segment was achieved. Failures may be more likely in cases with osteosynthesis failure, because the plates have to exert a reconstructive role due to non-anatomical reduction. In cases of fractures with bony substance loss or insufficient contact of fragments, even mechanically stiff plates may show failure, because they were not designed for reconstructive purposes6-9). On the basis of previous reports, non-anatomical reductions, especially with a transoral approach, should be avoided1-6).

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There is a need for further research on the osteobiology and osteophysiology in fracture healing during postoperative rehabilitation and on the potential for modifications of hardware (e.g., the applicability of patient-specific titanium plate or osteoconductive bioactive plates), with consideration of the current trends in maxillofacial osteosynthesis11). The present case demonstrates the biomechanically complex nature of mandibular subcondylar fractures and their surgical treatment and care.

Conflict of Interest

The authors have declared that no COI exists.

References

