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A Case of Complex Bilateral Comminuted Mandibular Fractures in a Young Man Following a High-Velocity Motorcycle Collision

ABSTRACT

Objective: To describe the clinical presentation, surgical management and postoperative outcomes of a patient with complex bilateral comminuted mandibular fractures, which resulted from high-velocity motorcycle trauma, and to highlight the role of preoperative planning using three-dimensional modeling in fracture management.

Methods:

Design:	Case Report
Setting:	Tertiary Academic Medical Center
Patient:	One

Results: A 26-year-old man sustained severe mandibular trauma following a high-velocity motorcycle collision with a bus. Clinical evaluation, craniofacial computed tomography imaging, and intraoral examination revealed bilateral comminuted mandibular fractures involving the left body, angle, and ramus as well as the right symphysis, parasymphysis and body. Preoperative planning included review of computed tomography imaging and simulation using a three-dimensional printed mandibular model to facilitate pre-bending of fixation plates. Surgical management consisted of maxillomandibular fixation followed by open reduction and internal fixation using titanium reconstruction plates and miniplates through combined submandibular and transoral approach. Successful reduction and fixation of the fracture segments were achieved with restoration of pre-injury occlusion and mandibular continuity. Postoperative recovery was uneventful, with no evidence of facial asymmetry, neurological deficits, or hardware complications. Follow-up examinations demonstrated satisfactory functional and cosmetic outcomes with progressive improvement in occlusion and mandibular mobility.

Conclusion: Complex bilateral mandibular fractures resulting from high-energy trauma require careful preoperative evaluation and stable surgical fixation to restore mandibular anatomy and function. The use of three-dimensional printed models may serve as a valuable adjunct in surgical planning and plate adaptation in complex mandibular fracture management.

Keywords: *mandibular fractures; jaw fractures; open fracture reduction; internal fixators; maxillomandibular fixation; three-dimensional printing*

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Mandibular fractures are among the most common injuries encountered in maxillofacial trauma, frequently resulting from high-velocity motor vehicle collisions, and often occurring at multiple sites because of the mandible's ring-like anatomy.[1-4] Complex comminuted mandibular fractures involving multiple segments may disrupt mandibular continuity and lead to significant impairment in occlusion, mastication, speech, and facial symmetry, making precise anatomical reduction and stable fixation essential for functional recovery.[4] Advances in imaging and surgical planning, particularly the use of three-dimensional (3D) reconstruction and additive manufacturing, have facilitated improved preoperative assessment and operative planning in complex craniofacial trauma.[5] This report presents a case of complex bilateral comminuted mandibular fractures following a high-velocity motorcycle collision, and highlights the surgical management and potential role of patient-specific 3D-printed mandibular model in preoperative planning.

CASE REPORT

A 26-year-old man presented with facial trauma following a motorcycle collision with a bus at an intersection in Calamba, Laguna. The accident occurred at approximately 4 am on January 20, 2025. The patient was traveling at an estimated speed of 100 km/h while wearing a half-face helmet when the left side of his lower jaw struck the bus during impact.

The patient reported loss of consciousness for approximately 10 minutes following the collision. He denied blurring of vision, epistaxis, rhinorrhea, vomiting or persistent neurological symptoms. However, malocclusion and gingival bleeding were noted immediately after the injury. Initial evaluation at a nearby local hospital included a craniofacial computed tomography (CT) scan, which demonstrated comminuted fractures of the mandible.

The patient was initially treated with oral antibiotics and analgesics, advised ENT consult and discharged. He then consulted a private otorhinolaryngologist at a nearby clinic and was advised surgery. Due to financial constraints, definitive surgical treatment was delayed for a month. During this period, the malocclusion persisted, and the patient experienced significant difficulty in mastication. He reported that oral intake was limited to liquids consumed through a straw because of the inability to achieve stable occlusion. Two weeks prior to consultation at our institution, the patient decided to travel to Manila and was evaluated by another private otorhinolaryngologist who also advised surgery. The patient was subsequently referred to the University of Santo Tomas Hospital Clinical Division – Ambulatory Care Services for continuation of management. The patient had no known comorbidities. He was a non-smoker, did not consume alcoholic beverages, and denied illicit drug use.

On presentation, the patient was alert and hemodynamically stable. Facial examination revealed no Battle's sign, periorbital ecchymosis or facial asymmetry. There were no step deformities over the zygomaticomaxillary complex nor malar depression. Neurological examination showed no sensorimotor deficits. *(Figure 1)* Extraoral examination and palpation revealed step deformities over the left mandibular angle and right parasymphysis. There were no loose teeth, trismus, or deviation of the mandible on mouth opening. No sensory deficits involving the lower lip or chin were identified. Intraoral examination demonstrated malocclusion with a severe left lateral open bite. A mucosal break was noted along the alveolar process between the central and lateral incisors. *(Figure 2)*

Review of the craniofacial CT scan demonstrated a comminuted displaced fracture involving the body, angle, and ramus of the left mandible; and a comminuted displaced fracture involving the symphysis–parasymphysis and body of the right mandible. There were no fractures involving the condylar or coronoid processes. A 3D CT reconstruction confirmed the extent of mandibular fragmentation and displacement. *(Figure 3)*

To facilitate preoperative planning, a patient-specific 3D model of the mandible was generated from the patient's craniofacial CT dataset. Digital Imaging and Communications in Medicine (DICOM) files were imported into 3D Slicer Version 4.11 (Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA) where segmentation of the mandibular structures was performed using threshold-based and manual refinement techniques. The segmented mandible was then converted into a stereolithography (STL) file and exported to Meshmixer (Autodesk Inc., San Rafael, CA, USA) for final mesh editing and surface refinement. The finalized STL file was subsequently used to produce a physical 3D printed mandibular model using an Ultimaker 2+ Connect 3D printer (Ultimaker B.V., Utrecht, Netherlands) using polylactic acid (PLA) filament. The model allowed simulation of fracture reduction and pre-bending of fixation plates prior to surgery, which helped reduce intraoperative operative time and improved plate adaptation. *(Figure 4)* Our surgical objectives included anatomical reduction of fracture fragments, restoration of pre-injury occlusion, and reestablishment of mandibular continuity and structural stability.

The patient underwent maxillomandibular fixation using Erich arch bars and wires followed by open reduction and internal fixation (ORIF) of mandibular fractures using titanium plates and screws.

Figure 1. Preoperative clinical appearance of the patient. Preoperative facial photographs demonstrating frontal, submental and oblique views of the patient one month following trauma. No significant facial asymmetry is noted, although mandibular instability and occlusal disturbance were present on intraoral examination. Photos published with permission.

Figure 2. Intraoral findings demonstrating malocclusion. Preoperative intraoral photograph demonstrating severe left lateral open bite and malocclusion. No loose teeth or trismus observed.

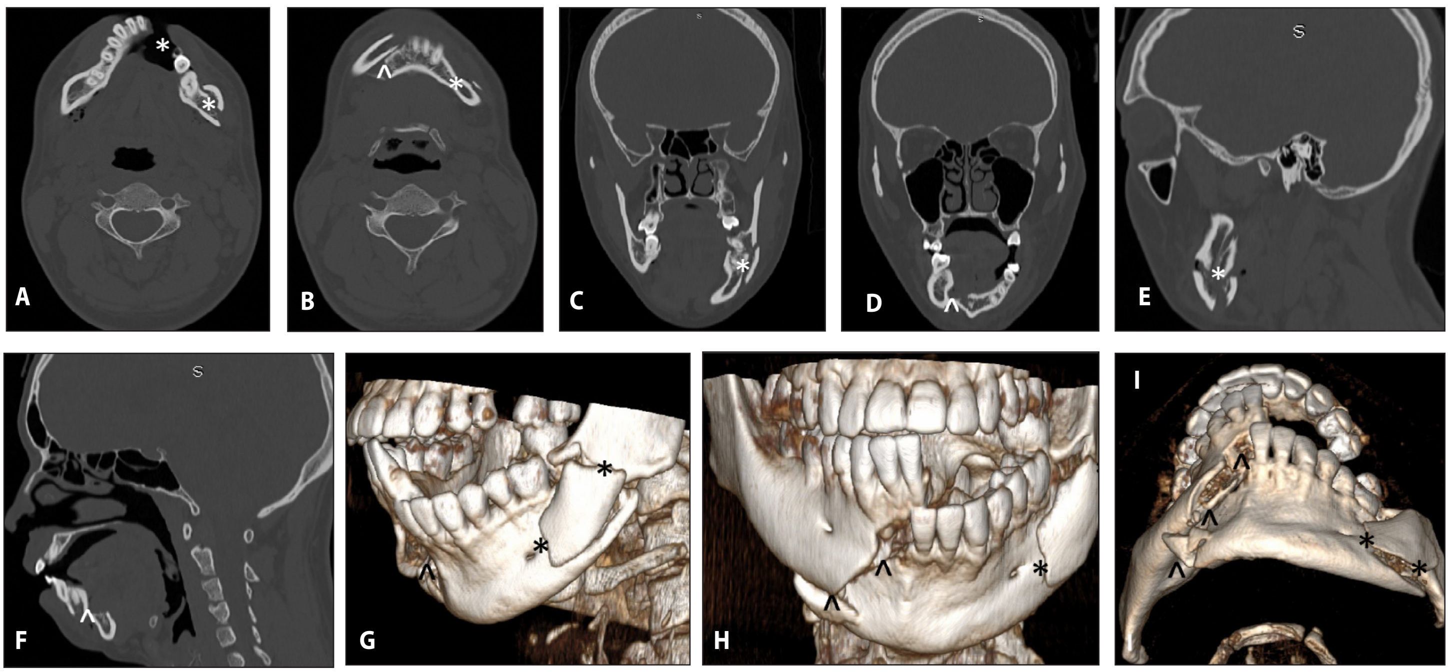


Figure 3. Preoperative craniofacial CT imaging. Representative **A., B.** axial, **C., D.** coronal, **E., F.** sagittal and **G.,H.,I.** three-dimensional reconstructed CT images demonstrating bilateral comminuted mandibular fractures involving the left body, angle, and ramus (asterisks, *); as well as the right symphysis-parasymphysis and body (arrowheads, ^)

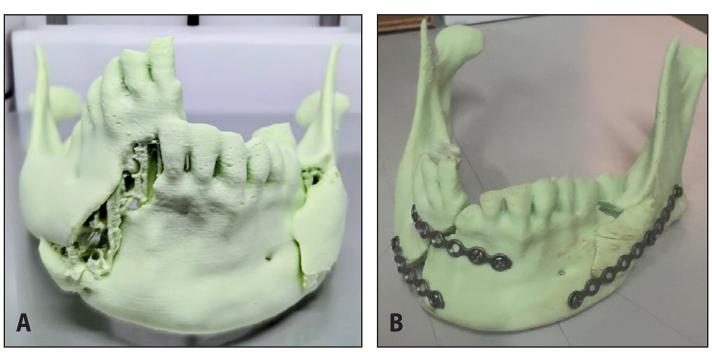
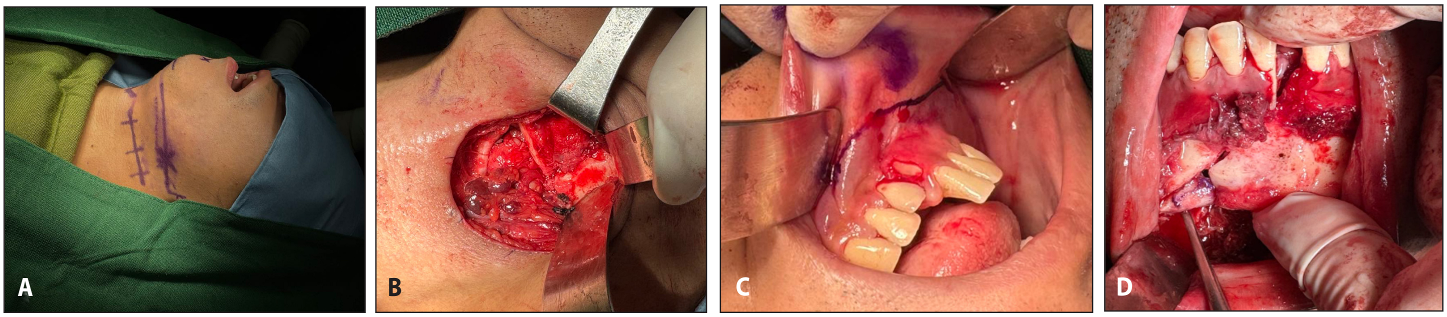


Figure 4. Three-dimensional printed mandibular model for preoperative planning. **A.** Patient-specific three-dimensional printed mandibular model generated from CT imaging data demonstrating the fracture pattern involving the left mandibular body, angle and ramus, as well as the right symphysis-parasymphysis region; and **B**. Simulation of fracture reduction on the printed model after deliberate separation of fracture segments, followed by preoperative plate adaptation and fixation to achieve anatomical reduction prior to surgery

A transcutaneous submandibular approach was used to expose the fractures involving the left mandibular body, angle, and ramus. A transoral vestibular approach was used to access the fractures involving the right symphysis–parasymphysis and body. Following exposure of the fracture sites, manual reduction of the fractured segments was performed to restore occlusion. Maxillomandibular fixation was temporarily established using arch bars and wires. *(Figure 5)* Rigid fixation was achieved using a 2.4 mm locking reconstruction plate applied to the left mandibular body, angle, and ramus. With one of the fracture loads already stabilized by the reconstruction plate, we decided to fix the remaining fracture using 2.0 mandibular miniplate applied at the symphysis-parasymphyseal area. One plate was applied



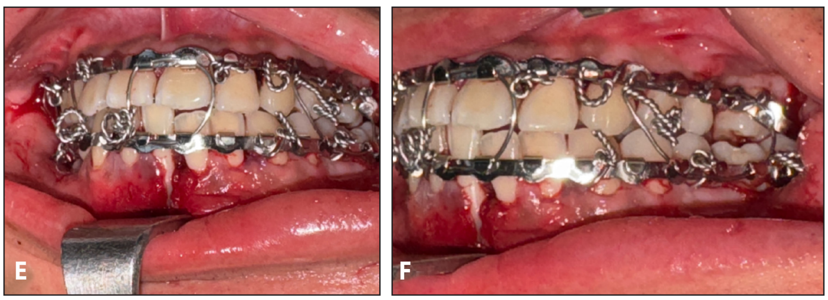


Figure 5. Intraoperative exposure of mandibular fracture sites and maxillomandibular fixation. Intraoperative photographs demonstrating **A., B.** submandibular or transcervical approach (Risdon incision) typically placed 2 cm below the inferior border of the mandible, for exposure of fractures involving the left mandibular body, angle and ramus; **C.** gingivobuccal incision for exposure of the symphysis-parasymphysis fracture site; **D.** manual reduction of fractures at the symphysis-parasymphyseal area; and **E., F.** temporary maxillomandibular fixation using Erich arch bars and wires

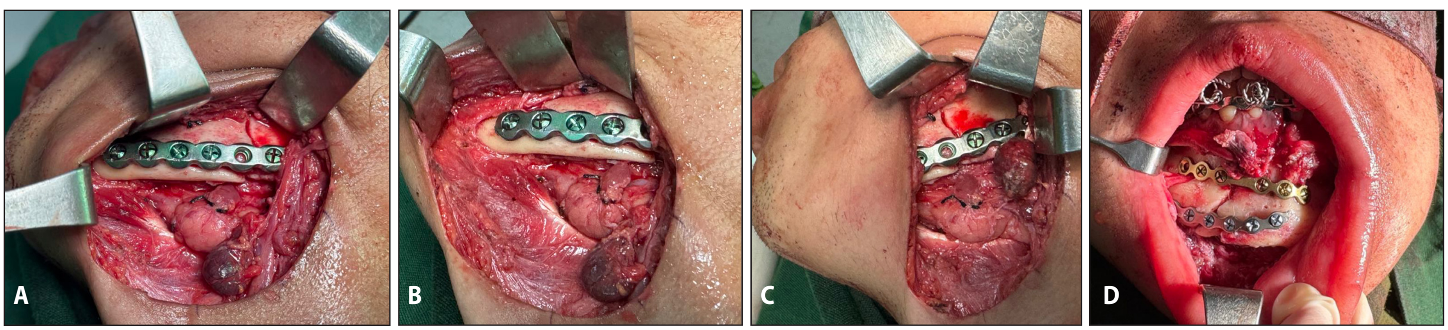


Figure 6. Plate fixation of mandibular fractures. Intraoperative photographs demonstrating **A., B., C.** definitive fixation of fracture segments using a 2.4 mm locking reconstruction plate applied along the left mandibular body, angle and ramus; and **D.** 2.0 mm miniplates applied along ideal lines of osteosynthesis for the right symphysis-parasymphysis region

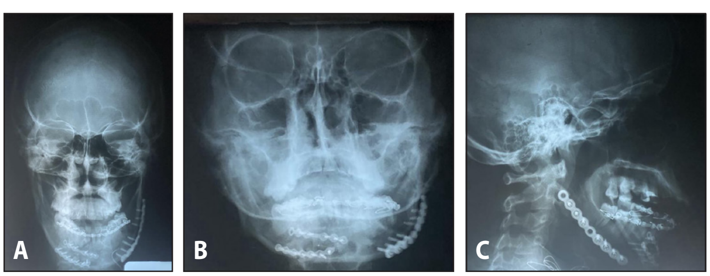


Figure 7. Postoperative radiographic evaluation. Postoperative craniofacial radiographs demonstrating stable fixation of mandibular fractures: **A.** Anterioposterior skull radiograph showing restoration of mandibular alignment with fixation plates and screws; **B.** Occipitomental view demonstrating reconstruction plate and miniplates placement along fracture lines; and **C.** Lateral skull radiograph showing reconstruction plate fixation and mandibular arch bars in situ with no evidence of hardware displacement or loosening

just below the apices of the tooth roots, and another plate applied on the inferior border of the mandible. *(Figure 6)* After completion of osteosynthesis, the maxillary arch bars were removed while the mandibular arch bars were maintained temporarily for four weeks to provide additional stability in load-sharing areas.

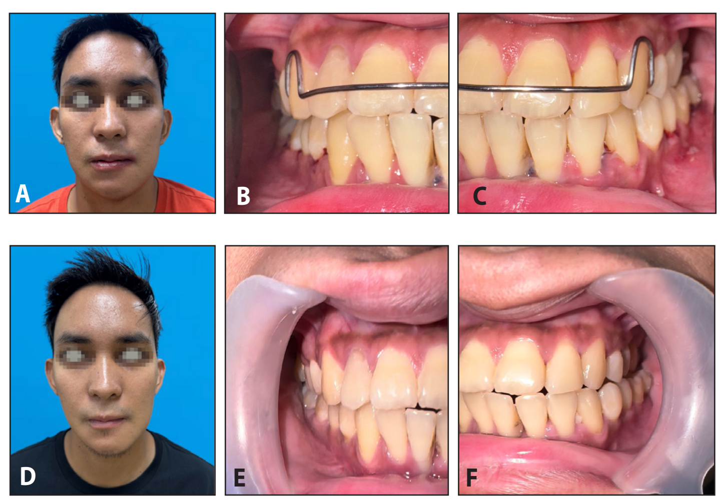


Figure 8. Postoperative outcome. Clinical facial and intraoral photographs at four **(A, B, C)** and five **(D, E, F)** weeks postoperatively demonstrating restoration of occlusion and satisfactory facial symmetry following mandibular fracture fixation. Erich arch bars and wires were removed at four weeks post-op. Photos published with permission.

Postoperatively, the patient demonstrated restoration of pre-injury occlusion with no facial asymmetry or sensorimotor deficits involving the lower lip and chin. The patient was prescribed broad-spectrum antibiotics for seven days. Dietary management initially consisted of liquid intake via straw followed by gradual progression to a soft diet as tolerated. Daily oral hygiene and wound care were maintained. The patient was also referred to rehabilitation medicine for jaw opening and closing exercises to facilitate functional recovery. Postoperative panoramic radiography demonstrated proper placement of fixation plates and screws with no evidence of hardware loosening or compromise. *(Figure 7)* Serial follow-up examinations at one, two, four, and five weeks postoperatively demonstrated progressive improvement in occlusion and mandibular function with satisfactory cosmetic and functional outcomes. *(Figure 8)*

DISCUSSION

Comminuted mandibular fractures typically result from high-energy trauma that delivers concentrated forces to the oromandibular complex.[1] Epidemiologic studies consistently demonstrate that young adult males represent the majority of patients sustaining mandibular trauma, with road traffic accidents remaining the most common etiology worldwide.[6] High-velocity motorcycle collisions are particularly associated with complex fracture patterns because of the magnitude and direction of forces transmitted to the facial skeleton.[7,8]

In our present case, the patient sustained a high-speed collision that produced bilateral comminuted fractures involving multiple mandibular segments.

The fundamental objectives in the management of mandibular fractures include anatomical reduction, stable immobilization, prevention of infection, and restoration of functional occlusion.[1] Various treatment modalities have been described, ranging from closed reduction with maxillomandibular fixation (MMF) to open reduction with internal fixation (ORIF). Advances in plate-and-screw fixation systems have significantly improved outcomes by allowing rigid stabilization of fracture fragments while enabling early functional rehabilitation.[9,10]

Bilateral mandibular fractures present additional biomechanical challenges. The presence of an intermediate segment between fracture lines creates increased torsional forces during mastication, predisposing the segment to rotational instability.[11] This mechanical behavior underscores the importance of achieving rigid fixation, particularly in load-bearing regions of the mandible. In our present case, a reconstruction plate was used along the left mandibular body, angle, and ramus to provide load-bearing stability, while miniplates were applied to the symphysis–parasymphysis region where load-sharing fixation was sufficient.

Several studies have examined the comparative effectiveness of reconstruction plates and miniplates in mandibular fracture fixation. Sukegawa and colleagues demonstrated that reconstruction plates may provide superior outcomes in comminuted fractures and fractures lacking adequate dentition because they function as load-bearing devices capable of maintaining mandibular continuity.[12] Conversely, finite element analysis studies have suggested that miniplate fixation may produce smaller interfragmentary gaps in certain fracture configurations, particularly in parasymphyseal fractures.[13] Consequently, the selection of fixation method must be individualized based on fracture pattern, comminution, and biomechanical considerations.

In our present case, a combined surgical approach consisting of a transcutaneous submandibular incision and a transoral vestibular approach allowed adequate exposure of the different fracture sites while minimizing unnecessary soft tissue dissection. This approach facilitated accurate reduction and stable fixation of the fracture segments while preserving acceptable aesthetic outcomes.

An important feature of our case was the use of a 3D-printed mandibular model for preoperative planning. Advances in digital imaging and additive manufacturing have enabled surgeons to produce patient-specific anatomical models directly from CT imaging data. These models allow simulation of fracture reduction and pre-contouring of fixation plates prior to surgery. In our patient, pre-bending of the titanium reconstruction plate and miniplates on the printed model minimized intraoperative plate adjustments and contributed to improved plate adaptation. This strategy has been reported to reduce operative time and enhance surgical accuracy in complex craniofacial trauma cases.[5, 15]

Another notable aspect of our case was the delay in definitive surgical management due to financial constraints, which resulted in persistent malocclusion and difficulty with oral intake for approximately one month following injury. Delayed treatment of mandibular fractures may increase the risk of malunion, infection, and prolonged functional impairment. Despite this delay, satisfactory outcomes were achieved after surgical reduction and fixation.

Postoperative outcomes following ORIF of mandibular fractures are generally favorable when stable fixation and proper occlusion are achieved. However, complications have been reported in up to 15% of cases.[1] These complications may include infection, hardware exposure or failure, osteomyelitis, malunion, non-union, and wound dehiscence.[16, 17] In the present case, the patient experienced uneventful postoperative recovery with restoration of pre-injury occlusion and mandibular continuity, and follow-up imaging confirmed stable hardware placement without complications.

In conclusion, our case highlights the importance of comprehensive preoperative evaluation, appropriate surgical exposure, and rigid fixation in the management of complex mandibular fractures. Furthermore, the integration of 3D modeling into surgical planning may enhance operative efficiency and accuracy, particularly in cases involving multiple fracture sites and comminuted mandibular segments.

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