Australian Dental Journal
The official journal of the Australian Dental Association
AUSTRALIAN DENTAL ASSOCIATION INC.
*Australian Dental Journal* 2016; 61:(1 Suppl): 74–81
doi: 10.1111/adj.12399

# Bone fractures: assessment and management

L Lim,* P Sirichai†

*Consultant Oral and Maxillofacial Surgeon, Westmead Hospital, Westmead, New South Wales, Australia.
†Registrar, Department of Oral and Maxillofacial Surgery, Westmead Hospital, Westmead, New South Wales, Australia.

## ABSTRACT

Severe dental traumatic injuries often involve the supporting bone and soft tissues. This article outlines the current concepts in the management of dentoalveolar fractures for the general dental practitioner with case reports to illustrate management principles and techniques.

*Keywords:* Alveolar fracture, dental trauma, dentoalveolar fractures, dentoalveolar injury, dentoalveolar trauma.

## INTRODUCTION

Dentoalveolar fractures are dental injuries that also involve a fracture of the supporting alveolar bone. They are the most severe in the spectrum of dental traumatic injuries. These bone fractures often present with a combination of other dental injuries such as luxation, avulsion and tooth root fractures.[1] They are often complicated by associated injuries to the soft tissues that may range from injuries to the periodontal ligament, lacerations of gingival tissues, lips, tongue and floor of mouth.[1]

### Classification of bone fractures

Andreasen[2] has classified bone fractures into the following types:

(1) Comminution of the alveolar socket: crushing of the bone, usually associated with intrusive or lateral luxation.
(2) Fracture of the socket wall: a fracture confined to the facial or lingual socket wall – often associated with luxation and avulsion injuries.
(3) Fracture of the alveolar process: alveolar process fracture which may or may not involve the alveolar sockets.
(4) Fracture of the mandible or maxilla: may or may not involve the alveolar sockets.

### Patient assessment

Patient assessment with dentoalveolar fractures can be challenging due to the severity of the injury which may include displacement of teeth and bone with bleeding, and soft tissue lacerations. In addition, the patient may often be quite distressed such that pain and anxiety management is required prior to the patient being examined.[3]

### History

Some important aspects of history taking include:

(1) Exclude possible head injury – determine if there has been any loss of consciousness, nausea, vomiting, amnesia or confusion. If there is suspicion of possible head injury, the patient should be referred for appropriate medical management.
(2) Tetanus prophylaxis – determine if tetanus immunization is up to date. Patients with heavily contaminated wounds, especially those contaminated with soil or with extensively devitalized tissue should receive tetanus prophylaxis regardless of their immunization status.[4–6]
(3) Details of the accident including the time of injury will assist in decision making regarding potential for replantation of traumatized teeth.[7]
(4) Account for all missing teeth and tooth fragments – there is a possibility of teeth fragments being inhaled, swallowed or embedded.[8–10] It is not uncommon for tooth fragments to be embedded in the lip (Fig. 1a–c).[9,10] An index of suspicion in patients with lip lacerations and fractured incisor tooth fragments that have not been located or accounted for should alert the clinician to possible embedded tooth fragments. A simple radiograph of the lip can reveal a radiopacity and is helpful to include or exclude this possibility.

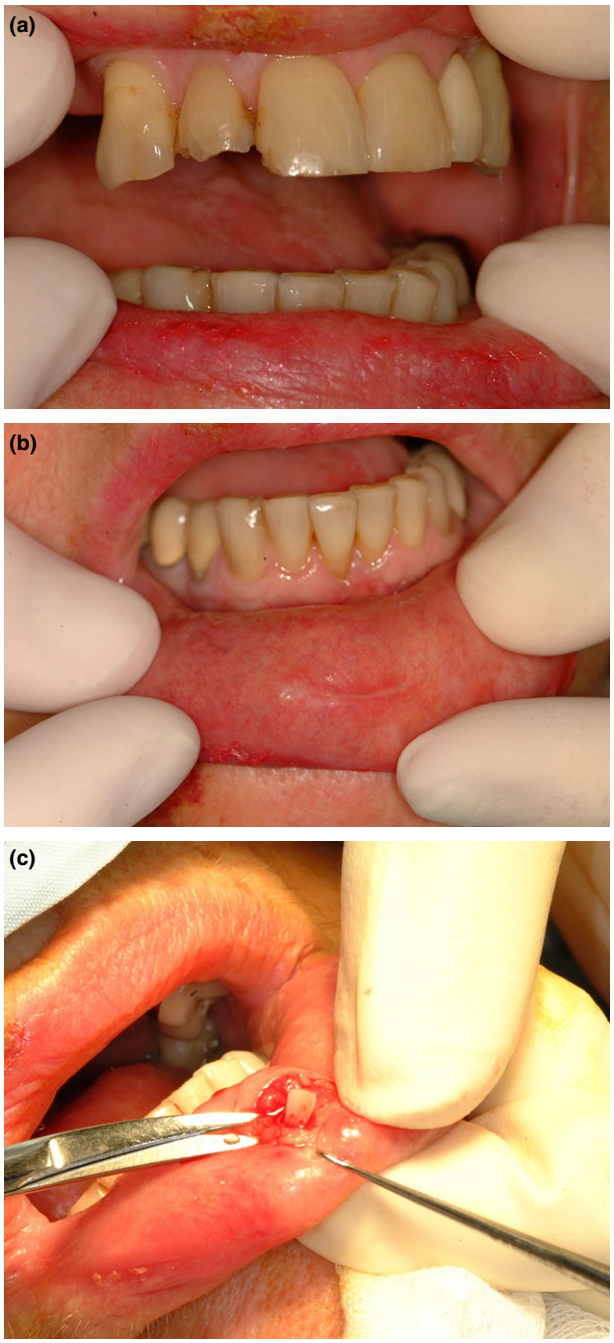


**Fig. 1** Embedded tooth fragment in lower lip. (a) Fractured 12 tooth with missing tooth fragment. (b) Embedded fragment in lower lip. (c) Removal of tooth fragment from lower lip.

## Examination

Systematic assessment in an organized manner is required. A simple principle to remember is to 'assess outside in' and to 'treat inside out'. Start by assessing extraorally, taking note of jaw integrity, lip lacerations, gingival lacerations, displacement of the alveolus and teeth, and the occlusion. It may be difficult to assess occlusion if the teeth and supporting alveolar bone are displaced. Remember to also assess the floor of the mouth and tongue for lacerations and swelling. Use a moist sponge to clean blood clots and debride blood from the skin, lips and gingiva. Gentle suction with a large bore blunted end suction device on low suction is often helpful to remove blood clots intraorally and pooling of saliva to allow adequate visualization. If there is active bleeding, placing pressure with saline soaked gauze can help to achieve haemostasis, or in some cases use of local anaesthetic with a vasoconstrictor can help both pain management and reduce bleeding. Manually assess the degree of mobility and displacement of the fractured segments. Gentle manual pressure on the segment and assessing the nature of the movement of the fractured segment will reveal if it is localized to a tooth or if alveolar bone is also involved. Should the entire alveolus be mobile and move together with the tooth or teeth, then a bone fracture should be diagnosed. Often, there may be a combination of both tooth fractures and bone fractures in more severe trauma cases involving multiple teeth.

## Radiographic assessment

A panoramic radiograph is a useful screening tool to give a general overview of the dentition, as well as possibly any underlying jaw fractures. Occasionally a bone fracture of the alveolus may extend down to involve the parasymphysis of the mandible. The common site for this is between the canine and lateral incisor. Periapical radiographs are useful to determine any associated tooth fractures. However, often they may not be very diagnostic for alveolar bone fractures because, unless extremely displaced, it can be difficult to visualize the line of fracture within the socket or at the alveolar level.[11] Hence, clinical assessment becomes paramount. In addition, with severe injuries intraoral radiographs may be difficult to obtain if there is significant bleeding, laceration, displaced teeth and patient discomfort. Cone beam CT scans are useful and can give detailed information for selected cases.[11] However, in an acute setting this may not be practical and should not delay the reduction and fixation of the fractures.

## Management

Management of these fractures involves:

(1) **Reduction:** the alveolar bone fracture must be reduced back into its original anatomic position. This usually requires manual pressure to disengage and reposition displaced bone segments and teeth (Fig. 2b–c). Occasionally, there will be comminution and exposure of underlying bone and these may need to be either removed or reduced via an open approach (Figs. 3c–d, 4a–b).

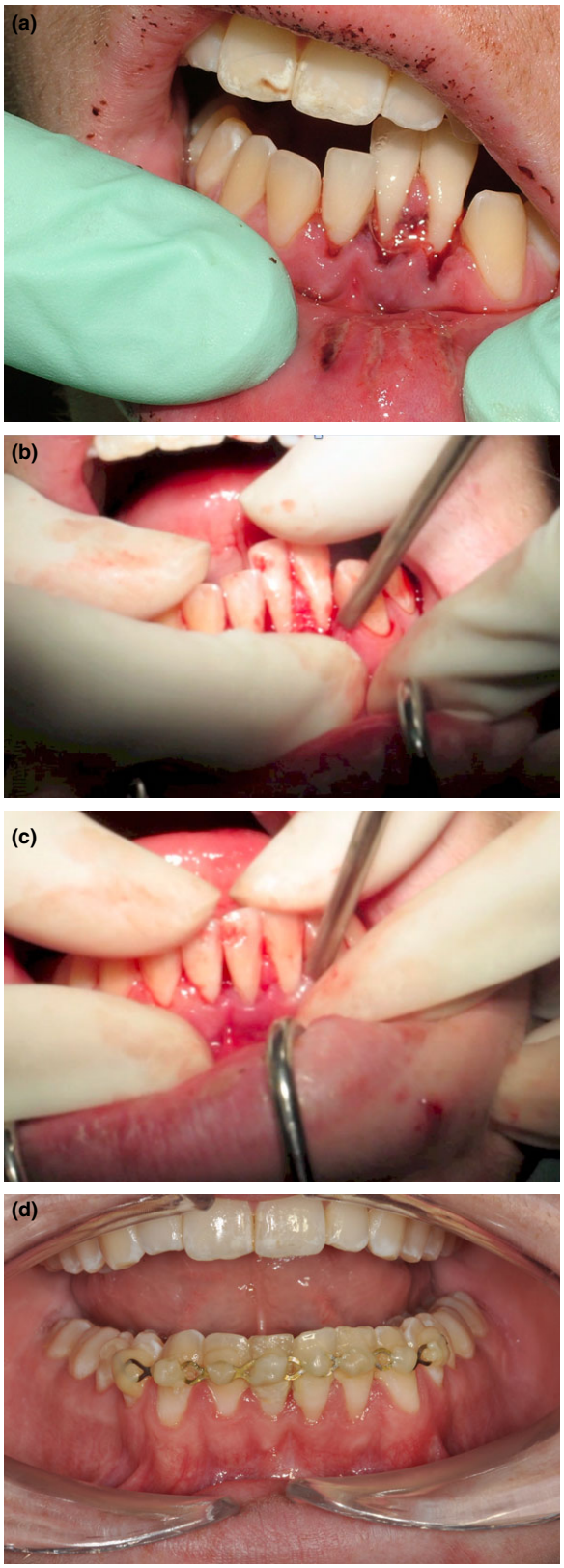


**Fig. 2** Closed reduction and splinting of dentoalveolar fracture. (a) Displaced dentoalveolar fracture involving teeth 32, 31, 41. (b) Bi-manual technique shown with digital pressure on labial plate with index finger and simultaneous vertical pressure to reduce fracture and reposition teeth. (c) Fracture reduced and teeth repositioned. (d) TTS composite resin splint.

(2) **Fixation:** once adequate reduction has been accomplished, the bone, attached teeth and soft tissues must be stabilized with rigid fixation. Unlike pure dental injuries, once there is a bone fracture, the stabilization needs to follow orthopaedic principles of bone healing. Hence, more rigid fixation is required with increased time of fixation (6 weeks) for complete bone union.[12] Composite resin and rigid or semi-rigid wire splint (depending on the extent of the bone injury) is preferred (Figs. 2d, 3e, 4c).

(3) **Suturing:** due to the increase in forces and severity of impact, dentoalveolar fractures are often associated with soft tissue lacerations including the gingivae and lips. Closure of lacerations is usually done after splinting and fixation is completed. The exception would be in cases of a large lip laceration with associated bleeding, where some preliminary sutures to manage haemostasis can be placed as an initial step and then final suturing can be completed after reduction and fixation of the fractures.

## Treatment planning

Treatment planning and decision making involves deciding on two broad principles:

(1) Can this injury be treated by closed reduction or is open reduction required? It is preferable to reduce the fracture without raising a flap to maintain better vascular supply to the fracture and to reduce the risk of compromising blood supply to the teeth and bone, and to reduce risk of soft tissue recession. This approach will also minimize patient discomfort and help recovery. However, it may not be possible if there are open comminuted fractures or if the fractures are extensively displaced. In these cases, an open approach would be required.[13]

(2) Can the patient be treated under local anaesthetic in the dental setting or does the patient require a general anaesthestic in a hospital setting?

## Treatment principles

When there are multiple severely injured or displaced teeth, the principles of repositioning and retaining as many teeth as possible despite the appearance that their long-term prognosis may be poor should be kept in mind.[14] In these combined tooth and bone fractures, the aim of treatment is not only to preserve the involved teeth where possible but also, and in many cases more importantly, for long-term success of prosthetic replacement, to try and maintain as much bone and soft tissue support as possible. This may involve repositioning or replanting teeth to allow splinting

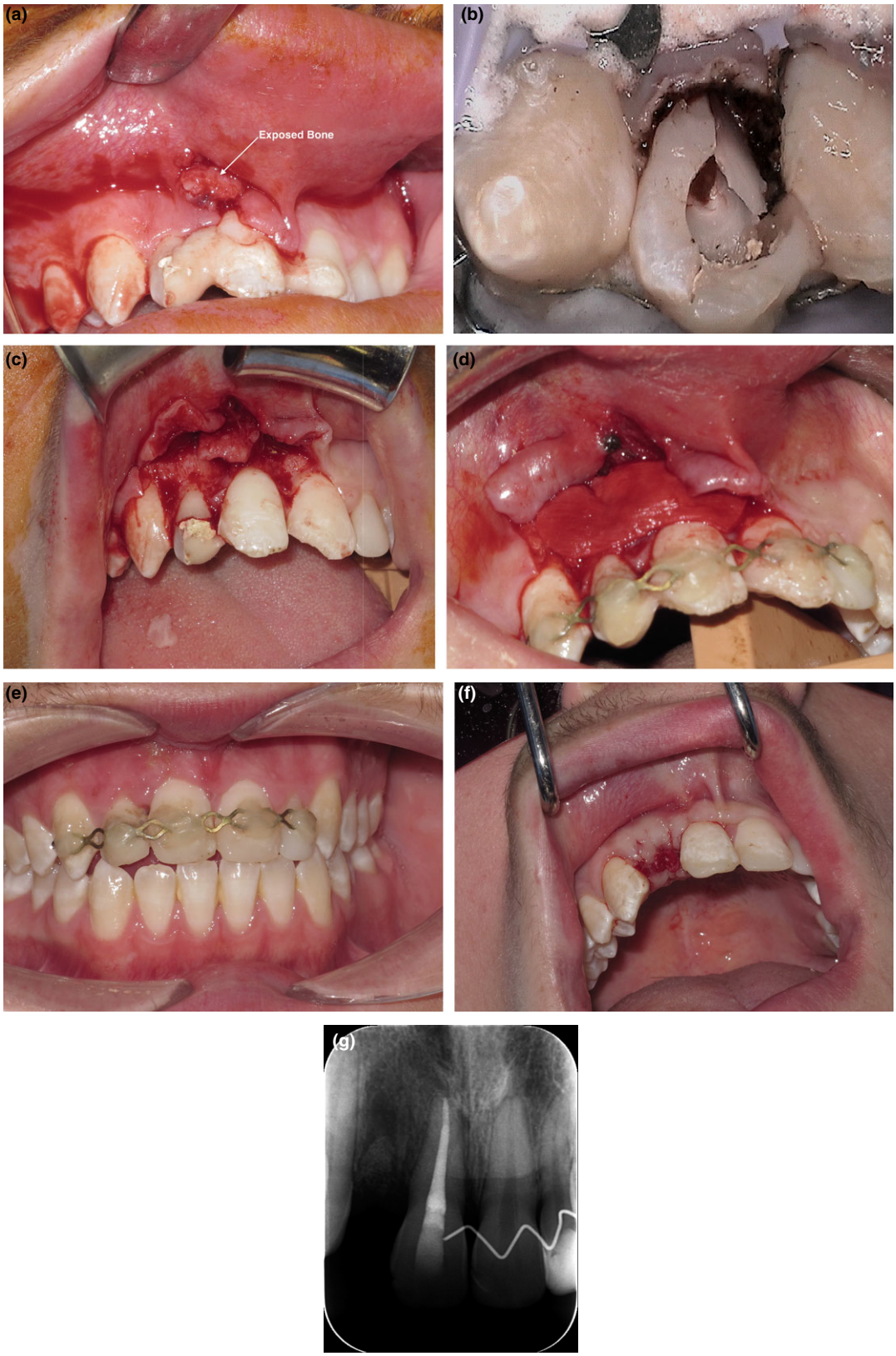


**Fig. 3** Open reduction, bone repositioning, splinting with delayed tooth extraction. (a) Dentoalveolar fracture showing displaced and exposed labial bone and soft tissue injury. (b) Fractured 12. (c) Surgical exposure showing displaced bone plate. (d) Reduction of bone, repositioning of teeth and collagen membrane over labial bone. The 12 tooth was left *in situ* to protect the bone fracture. (e) Postoperative view showing TTS splinting of teeth and healing of bone fracture and soft tissue laceration. (f) Delayed extraction of the fractured 12 tooth following bone healing with socket augmentation. (g) Endodontic treatment of the 11 (endodontic treatment provided by Dr Amanda Law, Endodontist, Sydney).


**Fig. 4** Severely displaced dentoalveolar fracture. (a)–(b) Severe displacement of upper anterior teeth, loss of supporting alveolar bone and degloving gingival injury. (c) Teeth repositioned and composite resin and wire splint placed. (d) Postoperative follow-up showing stable dentition and healthy soft tissues. (e) Immediate postoperative periapical radiograph after endodontic treatment. (f) 4-year follow-up showing external replacement resorption (endodontic treatment provided by Dr Amanda Law, Endodontist, Sydney).

and support of attached bone and soft tissue for healing of the alveolar tissues. It is much more difficult once there is a vertical and horizontal defect to reconstruct for dental implant placement which may require complex bone and soft tissue grafting procedures. Bone grafting for horizontal loss is reasonably predictable but vertical augmentation is almost impossible.[15] Therefore, proper initial management of the bone and tooth trauma is the most important step in the successful management of these injuries and needs to be done with the future in mind to reduce the complexity and need for secondary reconstruction.

## Treatment sequence

The previously mentioned principle is to 'treat inside out'. Start by reducing the fracture, splinting the teeth and bone fractures, followed by suturing of the gingival tissues and then lastly, suture any lacerations of the lip. The exception will be if there is significant

bleeding from the lips which may require initial basic suturing for haemostasis.

### Closed reduction

Closed reduction is possible even when the dentoalveolar segment is significantly displaced but there is minimal bone comminution or bone exposure.

#### *Closed reduction technique*

(1) **Bi-manual pressure:** pressure from a finger of one hand is placed at the apical part of the teeth/bone fractured unit and another finger is placed on the incisive or occlusal surface of the teeth. Downwards pressure from the labial disengages the apices from the labial plate which then allows vertical seating of the displaced fractured segment. This may take time as there may be some consolidation around the fracture – which depends on the time of fracture presentation – placing resistance to reduction and careful persistence may be required (Fig. 2a–c).
(2) **Check occlusion:** on successful reduction of the fracture, the occlusion should be checked as a guide to ensure correct positioning of the fragments.
(3) **Splinting:** the segments should be splinted with a rigid wire and composite splint or with titanium and composite splint for 6 weeks (Fig. 2d).

The technique described is illustrated in Case Report No. 1 below.

### CASE REPORT No. 1

### Closed reduction and splinting

A 19-year-old male sustained dentoalveolar fractures of his lower incisor teeth (31, 41 and 42) following an assault less than 24 hours earlier. He presented with severe displacement vertically and lingually of teeth 31, 41 and 42 with lower lip swelling and abrasion (Fig. 2a). The panoramic radiograph excluded mandible fracture, and periapical radiographs excluded root fractures. There were no other injuries and his tetanus immunization was up to date. He was treated in the dental chair under local anaesthetic and sedation. Closed reduction of the fracture was performed by manually reducing the fracture. The bi-manual technique was used with downward pressure with one finger and the second finger on the apical region simultaneously reducing the buccal plate displacement by pushing lingually (Fig. 2b–c). Once reduced, the segment was splinted to the adjacent teeth with a titanium trauma splint and flowable light cured composite resin (Fig. 2d). The splint was shaped and cut to the correct length ensuring at least three teeth on each side were splinted for stabilization. Composite resin was used to attach the splint to the adjacent non-injured teeth on each side first. Then the fractured segment was bonded to the splint ensuring it was reduced completely in all three dimensions and asking the patient to close into occlusion to ensure it was in correct vertical and horizontal position. In cases that have soft tissue lacerations, these should then be sutured. As these teeth have closed apices, the patient was referred for endodontic treatment to be commenced as soon as possible. The splint was removed after 6 weeks.

### Open reduction

In more severe injuries, where there is bone comminution, bone exposure, severely displaced, fractured and avulsed teeth, open reduction may be required to successfully reposition the segments and teeth. It is often not possible to fixate the bone fracture directly with bone plates or screws due to the presence of underlying tooth roots (Fig. 3c). Unlike the basal bone of the mandible, the alveolar bone is not a supporting bone and so the bone fragments can be manually repositioned and sutured into place with the soft tissues and the teeth secured with a rigid dental splint. Often there may be fractured teeth associated with an alveolar fracture that have poor prognosis and require extraction (Fig. 3b). In these cases, it is preferable to delay the extraction until after bone healing as extraction of the associated tooth or teeth may cause further displacement or damage to the alveolar fracture (Fig. 3d). If possible, these teeth should be temporised until bone healing is complete and then they can be extracted after splint removal (Fig. 3e–f). These principles are illustrated below in two cases – Case Reports No. 2 and No. 3.

### CASE REPORT No. 2

### Open reduction, bone repositioning, splinting with delayed tooth extraction

An 18-year-old male sustained trauma to three upper anterior teeth – the 11, 21 and 12 – following a skateboard accident. He was taken to his local general hospital where some temporary splinting of the teeth with composite resin was carried out and he was then referred for specialist treatment. The 11 was avulsed and was replanted after being left out of the mouth for over an hour. The 12 had a horizontal root fracture with a hopeless prognosis (Fig. 3b). The 21 had a fracture of the incisal edge. There were gingival lacerations and exposure of bone with displaced buccal plate above the 11 and 12 teeth (Fig. 3a). He presented with an anterior open bite

due to inadequate repositioning of the teeth. There was a lingual orthodontic retainer in place from previous orthodontic treatment. The proposed treatment plan was for open reduction to reposition the displaced teeth to proper position and occlusion, to reduce the displaced buccal bone fracture and obtain soft tissue coverage over the exposed bone (Fig. 3c–e). Extraction of the fractured 12 tooth which had a hopeless prognosis was delayed until complete healing of the displaced buccal bone fracture was evident (Fig. 3f). Extraction of this tooth at the time of surgery may destabilize the reduction, complicate reduction of the displaced buccal plate and hinder ideal healing of the alveolar bone. The existing composite splint was removed and the wound debrided. A gingival sulcular incision was made and the dentoalveolar fracture was exposed. The 11 was repositioned to its original position. A titanium splint was then bonded from 13 to 22 to secure the 11 in position. The buccal plate fracture was manually reduced by repositioning it palatally into position. A resorbable collagen membrane was placed over the bone fracture and under the buccal flap to protect the bone and allow soft tissue healing due to the overlying mucosal laceration (Fig. 3d). Closure was with 5/0 monocryl sutures. The patient was treated by an endodontist approximately 3 days later. The 12 tooth had an intracanal dressing placed and was left *in situ* until bone healing and splint removal after 6 weeks. On splint removal, the mucosal laceration had healed well and there was no longer any bone exposure (Fig. 3e). The 11 was stable and periodontal probing was 1–2 mm. A periapical radiograph was taken and this indicated good bone healing. The 12 was then surgically extracted in pieces due to the root fracture. The socket was augmented with a bovine bone/collagen block and a collagen membrane was placed to protect the site from resorption for future implant replacement (Fig. 3f). Implant replacement was delayed due to his age and risk of vertical growth in an aesthetic site. This time will also provide an opportunity to review the progress of the 11 which had an uncertain long-term prognosis (Fig. 3g).

## CASE REPORT No. 3

### Open reduction, replacement and repositioning of multiple severely displaced teeth and bone fractures

A 38-year-old female sustained trauma to her upper and lower teeth from a bicycle accident. The 12, 11 and 21 teeth were displaced out of the alveolus with severe comminution of the alveolar bone and gingival soft tissue degloving and laceration of the upper lip (Fig. 4a–b). Treatment was performed under nasotracheal general anaesthesia. Intubation was challenging in order to avoid further displacement of the mobile anterior teeth. Exposure of the displaced teeth revealed comminuted alveolar buccal bone adjacent to the 12, 11 and 21 (Fig. 4b). The 22 was mobile but the buccal bone wall supporting this tooth was not displaced and this was used as a guide to reposition the other teeth. The palatal alveolus and gingival tissues were engorged and displaced palatally. A palatal flap was not raised to preserve vascularity to the segments and the palatal wall fracture was manually reduced. The teeth were repositioned and bonded with a rigid wire and composite splint from the 15 to 25 (Fig. 4c). The gingival tissues were sutured and the lip laceration was debrided and sutured. Antibiotics, mouthrinses and a soft diet were prescribed. One week later, root canal treatment was commenced with pulp removal and placement of a calcium hydroxide dressing. The splint was removed after 6 weeks. The teeth remained stable and periodontal probing depths were 1–2 mm (Fig. 4d). The root canal filling was completed (Fig. 4e). Radiographic follow-up was performed at 6 months, 12 months and thereafter every 12 months. At 4-years follow-up, while the teeth remained clinically stable, replacement resorption was noted to have commenced (Fig. 4f).

### Soft tissue injuries

Due to the excellent blood supply, regeneration and good healing of severely damaged gingival tissues is often possible. Resorbable fine sutures – e.g. 4/0 or 5/0 chromic gut or monofilament sutures such as 'moncryl' – can be used. The needle should preferably have a tapered point. However, if this is not available, then a reverse cutting needle is acceptable. Do not use a cutting needle as these are very aggressive, designed for skin, and will tear and pull through the delicate gingival tissues. The skin of the lip should be sutured with fine non-resorbable sutures (5/0, 6/0 nylon or polypropylene) on a cutting needle to reduce scarring. If there is a through and through laceration, the lip should be closed in layers – muscle layer first, mucosa next and then the skin. Steps in suturing are important, and placing judicious 'key stitches' is important to prevent lip distortion or a cosmetic lip deformity.

### Antibiotic prophylaxis

In contaminated wounds, patients should be placed on perioperative antibiotics to prevent infection. The antibiotic of choice is amoxicillin, or in a patient with penicillin allergy, clindamycin.[16] If there are associated skin lacerations, then a broader spectrum antibiotic should be chosen (such as a cephlalosporin) to include coverage against staphylococcus.[16]

### Postoperative management

Chlorhexidine mouthrinses for 2 weeks and a soft diet for 6 weeks duration is required to minimize postoperative complications. The patient should be reviewed at 1 week, 2 weeks and then at 6 weeks postoperatively for splint removal.[17]

### Endodontic management

When teeth are involved in the bone fracture, they should be assessed for possible pulp removal as soon as possible after the emergency management of the bone fracture in order to optimize future outcomes.[17] It is often difficult to convince patients after sustaining severe injury and following acute management to have endodontic treatment so soon and the request is often to delay. It is important to explain the reasons and arrange for timely management.

### Long-term sequelae

Patients should be informed of the need for regular long-term clinical and radiographic follow-up and they should be warned of the possible long-term complications.[14] These include loss of teeth, gingival recession, root resorption and tooth ankyloses (Fig. 4f).[14] The challenges of tooth replacement in the alveolar fracture setting should be discussed including the potential need for future bone augmentation and the possibility of an aesthetic compromise in the future.

## CONCLUSIONS

An overview of current concepts in the management of dentoalveolar fractures has been presented to assist the general dental practitioner in the overall understanding of dental trauma.

## DISCLOSURE

The authors have no conflicts of interest to declare.

## REFERENCES


1. Panzarini SR, Pedrini D, Poi WR, Sonoda CK, Brandini DA, Monteiro de Castro JC. Dental trauma involving root fracture and periodontal ligament injury: a 10-year retrospective study. Braz Oral Res 2008;22:229–234.
2. Andreasen JO. Injuries to the supporting bone. In: Andreasen JO, Andreasen FM, Andersson L, eds. Textbook and Color Atlas of Traumatic Injuries to the Teeth. Munksgaard, Copenhagen: Wiley-Blackwell, 1994:427–453.
3. Hull AM, Lowe T, Devlin M, Finlay P, Koppel D, Stewart AM. Psychological consequences of maxillofacial trauma: a preliminary study. Br J Oral Maxillofac Surg 2003;41:317–322.
4. Fonseca RJ, Walker RV, Betts NJ. Oral and Maxillofacial Trauma. 3rd edn. St. Louis: Elsevier, 2005:427–477.
5. Elias H, Baur DA. Management of trauma to supporting dental structures. Dent Clin North Am 2009;53:675–689.
6. Auld DN, Wright GB. The initial management of dento-alveolar trauma in general dental practice. Dent Update 2010;37:286–288, 291–294.
7. Al-Jundi SH. Type of treatment, prognosis, and estimation of time spent to manage dental trauma in late presentation cases at a dental teaching hospital: a longitudinal and retrospective study. Dent Traumatol 2004;20:1–5.
8. Zhang M, Zhou GJ, Zhao S, *et al*. Delayed diagnosis of tooth aspiration in three multiple trauma patients with mechanical ventilation. Critical Care 2011;15:424.
9. Antunes AA, Santos TS, Carvalho de Melo AU, Ribiero CF, Goncalves SR, de Mello Rode S. Tooth embedded in lower lip following dentoalveolar trauma: case report and literature review. Gen Dent 2012;60:544–547.
10. da Silva AC, de Moraes M, Bastos EG, Moreira RW, Passeri LA. Tooth fragment embedded in the lower lip after dental trauma: case reports. Dent Traumatol 2005;21:115–120.
11. Scheinfeld MH, Shifteh K, Avery LL, Dym H, Dym RJ. Teeth: what radiologists should know. RadioGraphics 2012;32:1927–1944.
12. Hom DB, Hebda PA, Gosain AK, Friedman CD. Essential Tissue Healing of the Face and Neck. Shelton: PMPH-USA, 2009:26:257–258.
13. Chrcanovic BR. Open versus closed reduction: comminuted mandibular fractures. Oral Maxillofac Surg 2013;17:95–104.
14. Abbott PV, Castro Salgado J. Strategies to minimise the consequences of trauma to the teeth. Oral Health Dent Manage 2014;13:229–242.
15. Milinkovic I, Cordaro L. Are there specific indications for the different alveolar bone augmentation procedures for implant placement? A systematic review. Int J Oral Maxillofac Surg 2014;43:606–625.
16. Salmeron-Escobar JI, del Amo-Fernandez de Velasco A. Antibiotic prophylaxis in oral and maxillofacial surgery. Med Oral Patol Oral y Cirugia Bucal 2006;11:E292.
17. Diangelis AJ, Andreasen JO, Ebeleseder KA, *et al*. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations of permanent teeth. Dent Traumatol 2012;28:2–12.



*Address for correspondence:*
*Dr Lydia Lim*
*Sydney Oral and Facial Surgery*
*Suite 6, Level 2*
*6 McIntosh Street*
*Chatswood NSW 2067*
*Australia*
*Email: admin@sofs.com.au*