CHAPTER 1

INTRODUCTION

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CHAPTER OUTLINE

Dental traumatology is the branch of dentistry that encompasses the epidemiology, etiology, prevention, assessment, diagnosis, and management of trauma to the jaws and surrounding tissues[15,48,50] (Fig. 1-1). It also embraces posttraumatic sequelae, such as root resorption and its treatment[4,13,47] (Figs. 1-2 and 1-3). Because dental trauma can be simple or complex, its management may be interdisciplinary or multidisciplinary. Timely care is as important as the care itself because most adverse posttraumatic sequelae are a consequence of inefficient or inappropriate emergency care.[1,18,21,51]

With this first edition of *A Clinical Guide to Dental Traumatology,* we have presented the comprehensive topics pertaining to dental trauma in an organized and evidence-based approach. Each of the following chapters has been written by leading authorities in the field who have offered their expertise in describing the various types of traumatic dental injuries, with detailed explanations of how to optimally manage the various types of injuries and posttraumatic sequelae. Traumatic injuries are typically *quick, sudden, and unexpected;* this is why clinicians must be prepared to render appropriate emergency care at any time.

Injuries are not necessarily accidents; this is why throughout this text, the term *accident* has been replaced with the terms *incident, injury,* or *trauma.*[16,30]

Therefore trauma can be divided into two main categories:

- **Nonintentional injury:** includes domestic, recreational, sports, work, vehicular related injuries, and other such injuries that are not inflicted on purpose by one's self or another person.
- **Intentional injury:** includes suicide, homicides, domestic abuse, war, terrorism, and other such injuries that are purposefully inflicted.[30]

A

B

C

D

E

F

Figure 1-1 Sixteen-year-old female sustained multiple hard and soft tissue injuries following an automobile crash. **A,** Note the extensive scarring 4 months after injury. **B,** Closer view of the mandibular area. **C,** Avulsed maxillary left canine with attached bone found in the automobile. Particles of glass were also found in the bone. **D,** Avulsion of maxillary right incisors. Extrusive luxation of maxillary left central incisor with horizontal fracture of crown cervically. Complicated crown fracture and subluxation of maxillary left lateral incisor. Avulsion of maxillary left canine *(arrow).* Yellow stains on teeth are secondary to prolonged rinsing with chlorhexidine. Uncomplicated oblique crown fracture in maxillary left first premolar *(arrow).* Note red scar in mucosa secondary to deep wounds and extensive loss of bone secondary to trauma. **E,** One month posttrauma, panoramic radiograph reveals mandibular fractures with synthetic bone augmenting the alveolar defects resulting from avulsed teeth. Note that the patient also suffered avulsion of the lower right lateral incisor and canine. **F,** One year after the initial consult. Plastic surgery is scheduled to minimize the scarring and disfigurement.

A

B

Figure 1-2 Fourteen-year-old male fell, hit his mouth, but did not report to dental office until 6 months after trauma. **A,** Lateral luxation of maxillary right lateral incisor, extrusive luxation of maxillary right central incisor, and intrusive luxation of maxillary upper left central incisor. **B,** Note severe inflammatory root resorption of maxillary left central incisor and the replacement resorption of maxillary right incisor. Endodontic therapy with calcium hydroxide was initiated for the maxillary right lateral incisor. Splint was applied 6 months posttrauma because of severe mobility secondary to root resorption.

A

B

C

Figure 1-3 Fourteen-year-old male sustained avulsion of both maxillary central incisors while playing in a swimming pool. He presented to dental office 2 years after trauma. **A,** Note the infraocclusion of both maxillary central incisors. **B,** Preoperative radiograph reveals replacement resorption of roots from both teeth. Note the remnants of gutta-percha apically. **C,** Extracted teeth.

DEFINITION AND CLASSIFICATION OF INJURIES

There are basically two types of injuries to the dentition:

- **Hard tissue injuries:** involving the teeth, alveolar bone, and other facial bones (see Chapters 3 to 7).
- **Soft tissue injuries:** involving the facial skin, lips, mucosa (cheeks and periodontium), soft tissues of the hard and soft palate, and tongue (see Chapter 8).

Since so many different types of injures can occur to the dentition, the various classifications are defined below and elaborated upon in the subsequent chapters.

Hard Tissue Injuries

Tooth Injuries

Crown fractures

Crown fractures are the most common type of dental trauma.[5,17,43] The type of injury that may occur depends on the age of the patient and the severity and direction of the trauma. These injuries are described in great detail in Chapter 3, and are summarized below:

- **Enamel infraction:** presents as a crack or *craze line* in the enamel. It is usually hairline thin in appearance and is often only noticeable when light is transilluminated through the crown. There is a tendency for these cracks to retain stains, which may create cosmetic concerns (Fig. 1-4).
- **Uncomplicated crown fracture:** this is a fracture of the crown that involves only the enamel or the enamel and dentin, with *no* pulp exposure (Fig. 1-5).
- **Complicated crown fracture:** this is a fracture of the crown that involves enamel and dentin, which is deep enough to result in a *pulp exposure* (Fig. 1-6).

Root fractures

Occasionally, there may be an injury of the tooth that does not directly affect the crown of the tooth, but rather causes a fracture through the root. This fracture may be vertical, horizontal, or oblique in relationship to the long axis of the root. These injuries are elaborated on in Chapter 4, and are summarized below:

- **Crown-root fracture:** this fracture involves both the crown and the root at the same time. Typically there is a horizontal or oblique cervical fracture, which extends just below the attachment apparatus or into the alveolar bone. Often the crown is separated completely from the root; in some cases, it is held in place only by the attachment apparatus (Fig. 1-7).
- **Intraalveolar root fractures:** these injuries involve a fracture of the root that is completely encased within bone. The fracture may be horizontal (also called *transverse*) or more diagonal (also called *oblique*), and typically divides the root into two *fragments:* a *coronal* fragment and an *apical* fragment (Fig. 1-8).

A

B

Figure 1-4 Eleven-year-old male with concussion trauma to both maxillary central incisors. **A,** Enamel fracture of maxillary left central incisor *(arrow).* **B,** Preoperative radiograph appears within normal limits.

Luxation injuries

When a traumatic injury to a tooth seems to cause its displacement from the socket, it is termed a *luxation* injury. The *type* of luxation injury relates to the direction and severity of the injury. Although elaborated in great detail in Chapters 5 and 6, the luxation categories are summarized below:

- **Concussion:** when the tooth is traumatized by an impact, but does not change from its normal position.

A

B

Figure 1-5 Eight-year-old female fell and hit her face. **A,** Uncomplicated crown fractures of both maxillary central incisors. **B,** Radiograph reveals immature apices.

- **Subluxation:** when the tooth sustains an impact that causes slight mobility with no significant displacement from its socket (Fig. 1-9).
- **Lateral luxation:** implies that the tooth has been displaced within its socket in a buccal-lingual or labial-palatal direction.
- **Intrusion:** when the tooth is displaced in an apical direction within the alveolus.
- **Extrusive luxation:** when the tooth is displaced from its socket in a coronal direction.
- **Avulsion (or exarticulation):** when the tooth has been completely dislodged out of its alveolar socket (Fig. 1-10).

Figure 1-6 Eight-year-old female fell and hit her mouth, resulting in complicated crown fractures (exposed pulps) of both maxillary central incisors. Note pulp hyperplasia in the maxillary left central incisor.

Alveolar Injuries

There are several types of fractures that can occur to the bone secondary to dental injuries. *Comminuted* fractures are multiple small fractures of the alveolar socket that can typically arise from luxation injuries. Likewise, there can be lateral, facial, or lingual fractures of the alveolar socket. In more severe injuries, there may also be fractures of the alveolar bone with or without any involvement of any tooth socket. The classification, assessment, and management of these fractures are described in Chapter 7.

Soft Tissue Injuries

Concomitant with most dental injuries is trauma to the surrounding soft tissues, including the facial skin, lips, oral mucosa, gingiva, frenum, hard and soft palate, and the tongue. Recognition and management of these injuries is imperative and is detailed extensively in Chapter 8.

ETIOLOGY AND EPIDEMIOLOGY

Many studies have investigated the etiology and epidemiology of dental trauma.[5,8,39,41] They report on the type, location, prevalence, and cause of the injuries. However, there is a certain amount of variability between the quantitative findings of many of these studies. This is not surprising since many of the studies have gathered information from vastly different subpopulations, with varying factors such as environmental, geographic, climatic, and socioeconomic conditions.[5,36] For example, retrospective data gathered from a hospital-based dental treatment center might reveal facial

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D

E

Figure 1-7 Twenty-five-year-old male was seen subsequent to an automobile crash. **A,** Crown-root fractures of both maxillary central incisors. **B,** Palatal view. **C,** Preoperative radiograph revealing fracture lines. **D,** Immediately after coronal fragment removed from maxillary left central incisor. **E,** Posttreatment radiograph revealing extent of the pulp exposures.

Figure 1-8 Radiograph showing intraalveolar root fractures of both maxillary central incisors.

injuries with a greater severity than those injuries that are reported by a dental clinic outside of a hospital.[29] Since various subpopulations may give conflicting data as to when, where, and how various traumatic injuries typically occur, an evaluation of the many retrospective and prospective studies can only give us general *trends* and *predetermining factors.*

TRENDS

Cause of Injury

The most common cause of dental injuries is falls, comprising between 26% and 82% of all sustained injuries, depending on the subpopulation investigated.[1,7,37,39,51]

Sports-related injuries are generally the second most common cause of dental injuries.[14,34,38]

Occurrence of Injury

Because of where young children tend to spend most of their time, it is not surprising that injuries to primary teeth tend

A

B

C

Figure 1-9 Seven-year-old male fell on his face while playing, came to dental office 1 day after the trauma. Note sulcular bleeding of maxillary left central incisor as a result of subluxation. **A** and **B,** Both maxillary central incisors presented with uncomplicated crown fractures (no pulp exposures). The blood at the site of the crown fracture (maxillary left central incisor) was spread from the sulcular bleeding. **C,** Pretreatment radiograph reveals immature apices.

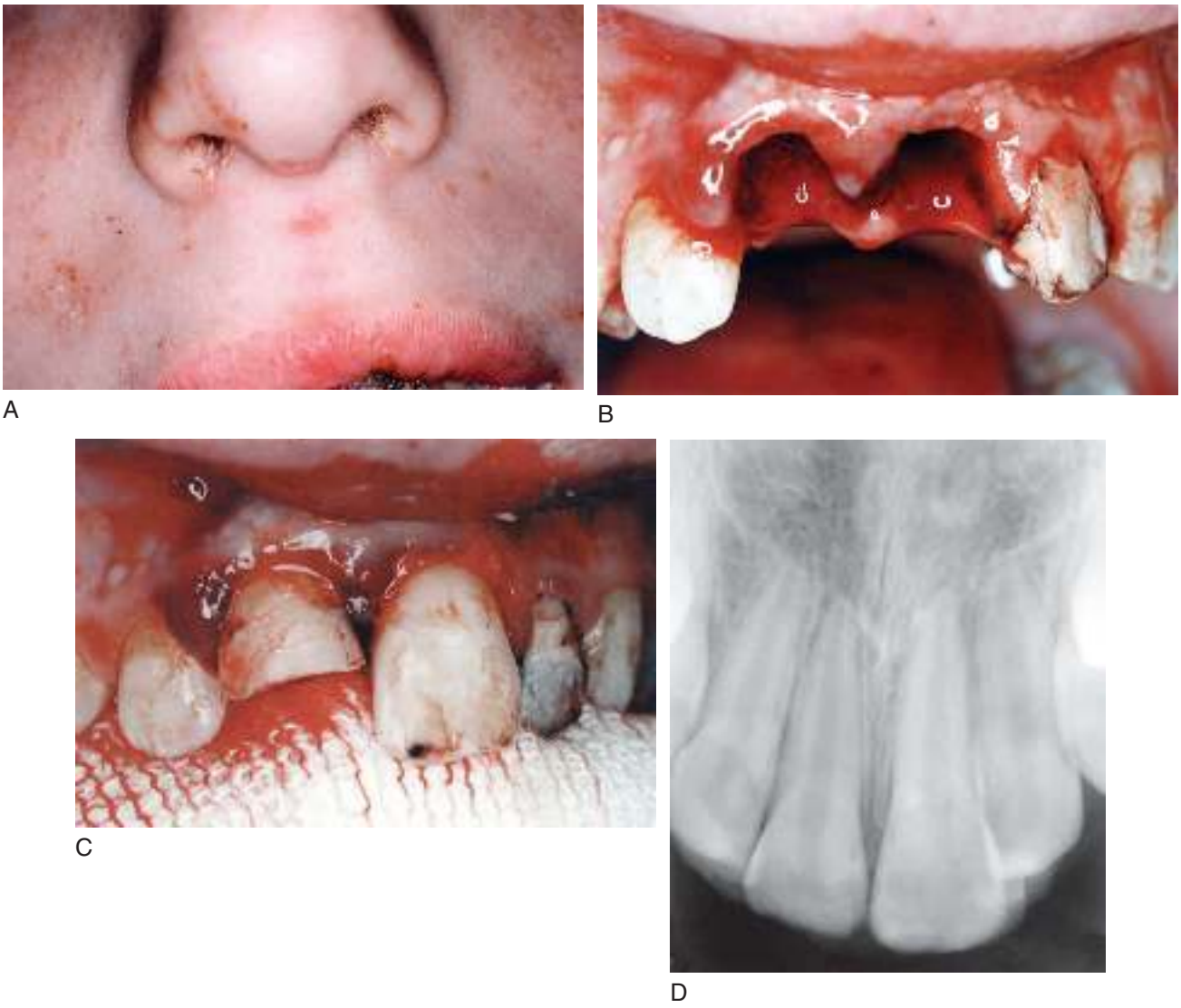

Figure 1-10 Eleven-year-old male fell while running, causing avulsion of both maxillary central incisors. He presented to the dental office 1 hour after trauma with the teeth soaking in a water container. **A,** Note the facial lacerations. **B,** Copious alveolar and gingival bleeding. **C,** Both incisors were immediately replanted; patient is biting on gauze while the splint is being fabricated. **D,** Post-treatment radiograph after replantation.

to happen more at home, whereas injuries to permanent teeth tend to occur most often outside the home.[18,32,39] These injuries tend to be from bicycle falls, motor vehicle crashes, and fights.[15,29,48]

Gender Significance in Injuries

For older children, boys tend to have more dental injuries than girls.[1,26,27,35,36] These findings could be a result of typically more aggressive play from boys and an earlier introduction to competitive sports. However, in younger children, there is not much of a difference in the frequency and severity of dental injuries between the sexes. This is not surprising because at a younger age, the type of play is very similar between boys and girls.[12]

Type of Injury

For permanent teeth, *uncomplicated crown fractures* tend to be the most common type of dental injury.[2,24,39] The types of injuries of highest frequency for primary teeth tend to be *luxations.*[19,24,39] This is not such a surprising finding since primary teeth are rooted in more resilient and elastic supporting structures. When an injury is sustained to these teeth, there is a tendency for these teeth to become displaced rather than fractured.[3,39]

Dental Location of Injury

Epidemiological studies have shown that the most common tooth to become traumatized is the maxillary central incisor followed by the maxillary lateral incisor.[5,8,51]

A

B

Figure 1-11 Twelve-year-old male was seen with protrusion of maxillary central incisors. **A,** Right profile. **B,** Left profile.

PREDETERMINING FACTORS

Because most dental injuries occur to maxillary central incisors, it is understandable that *malocclusion* and the lack of *natural protection* to these teeth will predispose them to injury. Severe overjet of the upper central incisors (i.e., overjet greater than 3 mm) will predispose these teeth to up to five times the risk of trauma compared with a normal overjet.[6,40,44] The natural protection for these teeth involves the adequate coverage by the patient's upper lip. It has been shown that incompetent lip coverage tends to precipitate more severe injuries to the teeth[9,11,22] (Figs. 1-11 and 1-12).

A

B

Figure 1-12 Nine-year-old female was seen with oral breathing. **A,** Incompetent, hypotonic lips. **B,** Parafunctional habits including atypical swallowing with interposition of the tongue between maxillary and mandibular teeth.

Socioeconomic background may also have some impact. Typically there are more severe injuries in children of a lower socioeconomic subpopulation.[28,31] This may have to do with inadequate supervision, an increase in assault frequency, and/or the lack of adequate patient education pertaining to prevention.

Orthodontic appliances may create more soft tissue injuries when trauma presents, potentially causing increased injury to the gingiva and lips.[46]

Acute medical problems, such as seizures, heart attack, or stroke, may predispose the patient to falling and traumatically injuring the dentition.[10,23]

General anesthetic may also predispose the patient to intraoral trauma from the placement of an endotracheal

tube. It has been reported that dental trauma may occur in as many as 18% of patients who are intubated. [20,33,42]

PREVENTION

Traumatic injuries to the dentition are difficult to anticipate. However, the exercising of good judgment and prevention is the best defense. Helmets, seat belts, and properly constructed mouthguards have had a tremendous impact on diminishing the severity of dental injuries. For example, it has been shown that bicycle helmets have reduced the incidence of facial trauma by more than 60%.[25,34,45,49] Chapter 11 elaborates on other areas pertaining to the protection and prevention of dental trauma.

CONCLUSION

Each of the above topics and more is described in great detail in the subsequent chapters. It is the editors' and authors' intention that with this information the clinician will be able to efficiently assess a traumatic injury to the dentition and use the treatment plan that will most effectively result in the best prognosis for the patient.

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CHAPTER 2

PATIENT ASSESSMENT

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CHAPTER OUTLINE

Traumatic dental injuries are typically emergencies that the clinician must be able to rapidly assess and appropriately manage.[43,46,53,79] The prognosis for each case depends on how immediately and accurately the patient's injuries are diagnosed and treated.[27,78] The importance of proper documentation cannot be overemphasized, not just for medicolegal considerations (see Chapter 9), but also as a detailed reference regarding the traumatic injury. Any complications that may arise in the future will be better managed when accurate documentation is detailed during patient assessment of the traumatic injury.

MEDICAL EMERGENCY CONSIDERATIONS

The medical status of the patient plays a vital role in the comprehensive management of traumatic injuries. The patient may have been medically compromised before the injury or as a result of the injury. Not only will these medical issues have an impact on the overall dental treatment of the patient, but also a compromised medical status can be life threatening when proper assessment and referral are not made in a timely manner. Therefore a medical evaluation is imperative before any initial dental treatment. Usually a thorough evaluation is made by a physician. However, the clinician should be aware of the general medical issues that may affect emergency dental care.

A thorough medical history should be taken as soon as possible. Details regarding systemic diseases, allergies, and recent hospitalizations are good screening questions.[6,11]

Essential vital signs, such as blood pressure, pulse, and respiration, are important preliminary evaluations. Immediately confirm unimpeded breathing and circulation. Pulse rate and blood pressure should be recorded. Cool, pale skin, perspiration, hypotension, tachycardia, and mental status changes are reliable indicators of shock. In the traumatized patient, shock is due to hypovolemia from hemorrhage in most cases.[83] The incidence of severe hemorrhage

Figure 2-1 Periorbital hematoma and frontal laceration following a bicycle fall.

secondary to facial fractures is rare; however, it can be life threatening.[14] Decreased pulse rate along with hypertension may indicate a rise in intracranial pressure.[80,86] Gross physical injuries and facial asymmetry should also be noted, which could help in the detection of alveolar and orbital fractures (Fig. 2-1).

Following a traumatic incident, removable prostheses, avulsed teeth, and tooth fragments may become aspirated and cause partial or complete airway obstruction.* Close observation of the patient is the best way to diagnose an aspirated foreign body.[26] Common findings of foreign body aspiration are coughing, cyanosis, dyspnea, and fever.[54] Any patient suspected of having partial airway obstruction should have chest radiographs taken as quickly as possible to rule out a foreign body within the lungs.[26,44] Abdominal radiographs should also be considered when teeth are missing during the clinical examination.[61]

On presentation, a patient's clinical status is grossly assessed with the Glasgow Coma Scale (GCS) (Table 2-1) to determine the presence and extent of traumatic brain injury.[84] Numerical values for eye opening, motor responses, and verbal responses that indicate the level of consciousness and degree of dysfunction are evaluated. Scores range from 3 to 15; lower scores indicate more severe brain injury.[39,84] With regards to the posttrauma evaluation, questions pertaining to loss of consciousness, dizziness, headache, nausea, and vomiting should be discussed since their presence could indicate possible intracranial injury requiring immediate medical attention.[28,56,65,66]

The aim of a cursory neurological examination is for the clinician to quickly recognize signs of a potential neurological crisis and to determine whether the traumatized patient should be referred to a physician for emergency care. Failure to recognize a medically compromised state may precipitate intracranial hypertension, systemic hypotension, hypoxemia, hypercapnia, or infection.[20,28,56,65,66] Difficulty with communication, unusual motor activity, signs of disorientation, loss of consciousness, seizures, headache, amnesia, and nausea or vomiting could indicate intracranial injury, which will require immediate referral for emergency medical treatment.[39,59]

*References 24, 26, 44, 50, 71, 82.

TABLE 2-1 GLASGOW COMA SCALE FOR EVALUATION OF THE PRESENCE AND EXTENT OF TRAUMATIC BRAIN INJURY

Eye opening	Spontaneous	4
	To verbal command	3
	To pain	2
	None	1
Verbal responsiveness	Oriented	5
	Confused	4
	Inappropriate words	3
	Incomprehensive sounds	2
	None	1
Motor response	Obeys	6
	Localizes	5
	Withdraws (pain)	4
	Flexion (pain)	3
	Extension (pain)	2
	None	1
Total: _____		

Lower scores indicate more severe brain injury.

Clear cerebrospinal fluid through the nose (rhinorrhea) or the ear (otorrhea) may indicate fractures of craniofacial osseous structures. Specifically the patient may have disruption of the anterior cranial base, most commonly at the cribriform plate of the ethmoid bone associated with nasoorbitoethmoid fractures, or disruption of the posterior wall of the frontal sinus.[29]

The inability of patients to open their eyes may also indicate an underlying neurological injury.[39] Diplopia (double vision), caused by extraocular muscle imbalance, is a common complication of fractures of the zygomaticomaxillary complex (Fig. 2-2),[91] with blow-out fractures of the orbit as the most common cause.[42] The presence of monocular diplopia (double vision of one eye due to detached retina or lens dislocation) could indicate injury to the globe.[1] Both pupils should be equal in size and reactive to light, otherwise underlying brain injury should be suspected.[77]

Discomfort or paresthesia of the extremities during head movement may indicate cervical vertebral fractures. When vertebral injury is suspected, the patient should not be moved and medical referral should be made immediately.[20,38]

Inability of the patient to protrude the tongue suggests possible damage to the hypoglossal nerve. The patient's ability to hear and maintain a postural balance will confirm normal auditory and vestibular function.[20]

The presence of localized areas of anesthesia or paresthesia on the patient's face, although not necessarily a medical

A

B

Figure 2-2 **A,** Zygomatic complex fracture visualized by 3-D CT reconstruction. **B,** Right exophthalmos due to zygomatic complex fracture.

emergency, could indicate damage to the trigeminal nerve with concomitant alveolar bone fractures[29] (Table 2-2).

Once confirmed that there are no major medical issues, the patient can be evaluated for injuries to the dentition.

TABLE 2-2 Summary of Neurological Evaluation of the Traumatized Patient and Possible Cranial Nerve Injuries

CLINICAL SIGNS	POTENTIAL DAMAGE TO CRANIAL NERVE
Loss of the sense of smell	Olfactory nerve (I)
Apparent loss of the sense of taste	
Diplopia (double vision)	Optic nerve (II)
Blurred vision	Oculomotor nerve (III)
Pupils do not react to light	Trochlear nerve (IV)
Pupils are not equal in size	Abducens nerve (VI)
Areas of paresthesia on the face and upper neck	Trigeminal (V)
Loss of sensation on anterior tongue	
Inability to wrinkle forehead and nose	Facial nerve (VII)
Inability to squeeze the eyes	
Inability to elevate upper lip	
Impaired hearing	Vestibulocochlear nerve (VIII)
Inability to maintain postural balance	
Difficulty in swallowing	Glossopharyngeal (IX)
Abnormal speech with hoarse voice	Vagus (X)
Inability to protrude the tongue	Hypoglossal (XII)
Ipsilateral tongue deviation	

ORAL EMERGENCY CONSIDERATIONS

Patient History

Assessment of the traumatized patient begins with a careful history regarding *where, when,* and *how* the trauma occurred. *Where* the trauma occurred (location) can provide useful information as to the degree of bacterial contamination and the need for tetanus prophylaxis. For a clean wound, a tetanus booster is necessary if the last one was more than 10 years ago; for contaminated wounds, if more than 5 years ago (Fig. 2-3).[76,83]

When the injury occurred is also important to determine the necessary treatment and to assess the future prognosis of treatment.[27] Time between the trauma and immediate treatment plays an important role in dental avulsion and luxation cases. As discussed in Chapters 5 and 6, delayed treatment of a luxated or avulsed tooth makes placement or manipulation of the tooth back to its original position difficult. The overall prognosis is decreased by situations that increase the potential for various types of root resorption.[7,33]

As discussed in Chapter 3, a longer period between a traumatic pulp exposure and treatment may result in an increased possibility of pulp necrosis, thus compromising cases of teeth with immature root development.[8]

Clues for identifying other related injuries may be provided by questioning the patient on *how* the traumatic injury occurred. For example, trauma to the cheek may cause a zygomatic fracture, temporomandibular joint (TMJ) disorder, or possible tooth fractures in this area.[11] As discussed in Chapter 7, falling, either as the cause or the result of the primary injury, may cause maxillary and/or mandibular alveolar bone fractures or injury to other proximal areas of the dentition. The pattern of tooth injury depends on the site, direction, and resilience of the periodontal structures surrounding the tooth.[25]

A

B

Figure 2-3 **A** and **B,** Facial soft tissue trauma secondary to fall in street.

The clinician must also be aware of intentional injuries. Abused children or victims of domestic violence have resulted in an increased incidence of facial, head, or neck injuries.[25,88] Often these injuries are first detected by visible soft tissue trauma, as described in Chapter 8.

Figure 2-4 Twelve-year-old girl with mandibular angle fracture and extensive swelling and bruising of the overlying soft tissue.

SOFT TISSUE CLINICAL EXAMINATION

Extraoral Examination

Lacerations, abrasions, and contusions of facial soft tissues are generally associated with trauma and are readily seen on external clinical examination. Where soft tissue injury is observed, the area should be washed gently with mild detergent, and the location of any bleeding noted. When hemorrhage is present, finger pressure should be applied to the site for several minutes until excessive bleeding is stopped. For extensive hemorrhage, a suture may be necessary proximal to the laceration. Asymmetry, flatness of the face, and changes in facial height or width should be noted. These soft tissue changes could indicate underlying skeletal trauma (Fig. 2-4). Ecchymosis seen behind the ear *(Battle's sign)* or bilaterally in the periorbital areas *(raccoon eyes),* concomitant with rhinorrhea or otorrhea, may indicate a basal skull fracture that requires immediate medical attention.[43,73]

Intraoral Examination

Complete intraoral examination begins with visual observation of the intraoral soft tissues. Signs of lacerations or penetrating injuries should be evaluated. Careful irrigation and suctioning of the intraoral tissues, using warm water of the triple syringe, will allow better viewing of these tissues without provoking pain from potentially injured teeth. When there is major bleeding present in the oral cavity, immediate detection of origin is crucial followed by arresting the bleeding by manual pressure with iced gauze (if available). When digital (manual) pressure is not sufficient,

A

B

Figure 2-5 Bleeding from the sulcus can indicate displacement injuries from luxation or crown-root fracture.

Figure 2-6 Laceration and swelling of lip can indicate foreign body embedded in the soft tissue.

Figure 2-7 Hematoma indicative of underlying alveolar fracture.

administering a local anesthetic with a vasoconstrictor (1:50,000) and, if necessary to stop the bleeding, suturing mesial to the bleeding vessel. Unless bleeding is controlled, diagnosis of the extent of the injury will be difficult to assess. Further treatment options for the management of soft tissue injuries are presented in Chapter 8.

Soft tissues of the periodontium should also be examined. Bleeding from the sulcus (Fig. 2-5) may indicate a crown-root fracture (see Chapter 4), tooth displacement (see Chapters 5 and 6), or an alveolar fracture (see Chapter 7).

Palpation of the oral mucosa is also essential. Soft or hard swelling may indicate the presence of an embedded foreign body (Fig. 2-6).

The sublingual area should be examined for signs of ecchymosis suggesting a mandibular fracture. Maxillary fractures may be observed by palpable moveable segments or facial edema.[29]

Soft Tissue Radiographic Examination

Radiographs of the soft tissue are not typically considered in a clinical examination. However, in the event of traumatic injury to the dentition, a simple periapical radiograph may help detect embedded tooth fragments or foreign bodies in the soft tissues of the oral cavity, such as the lips and cheek (see Chapter 8).[18,23]

Hard Tissue Clinical Examination

Alveolar Bone

Visual observation may easily detect alveolar bone fractures that protrude through the overlying mucosa. However, visualization for hematoma and gentle palpation may detect covered fractures when the overlying mucosa is not lacerated (Fig. 2-7). Pain, malocclusion, and mobility of fractured segments provide additional signs of alveolar bone fractures.

A

B

Figure 2-8 **A,** Avulsed tooth and **B,** intruded tooth shows the importance of locating displaced teeth.

As a follow-up to alveolar fractures, pulpal necrosis may be a sequela to alveolar fractures when in proximity to the apical region of the root.[49,67] In areas where avulsions, luxations, or other tooth trauma is detected, the integrity of the proximate alveolar bone should be examined for any fractures. As described in Chapter 7, any suggestion of alveolar fractures should be further investigated with an appropriate radiograph.

Teeth

Observation

Clinical evaluation of the teeth subsequent to traumatic injury begins with the search for any missing, displaced, or fractured teeth (Fig. 2-8). For an avulsed tooth, treatment should be initiated immediately. The tooth is replanted according to the guidelines recommended in Chapter 6. Delay in this treatment will significantly reduce the prognosis of the tooth (Fig. 2-9).

Occasionally a tooth may undergo a change in color weeks, months, or years after a traumatic injury (Fig. 2-10, *A* and *B*). This could be due to pulpal hemorrhage into the dentinal tubules, excessive pulp chamber calcification secondary to the injury, or internal or cervical resorption (Fig. 2-10, *C* and *D*). Color change does not necessarily indicate that the tooth is nonvital. As described later, pulp vitality must be ascertained to assure proper treatment.

When there is evidence of tooth damage, further evaluation should be made to determine whether pulp exposure or enamel cracks are present. In case of pulp exposure, its size and location should be documented (Fig. 2-11, *A* and *B*). Although pulpal inflammation does not progress rapidly after traumatic exposure, approximately 2 mm after 48 hours,[22] treatment should be prompt to prevent bacterial contamination and preserve pulpal vitality,[41] especially when the remaining vital pulp is associated with an immature root (Fig. 2-11, *C*) (see Chapter 3).

Enamel cracks or infractions occur in 10.5% to 12.5% of acute traumatized incisors[75] and may account for various symptoms, especially hypersensitivity to cold or inhaled air. To improve visualization of potential cracks, fiber optic light is helpful via transillumination. The light source is placed just above the gingival sulcus parallel to the tooth surface to illuminate the clinical crown[57] (Fig. 2-12). Enamel cracks can be best observed with magnification, particularly with the dental operating microscope[17] that permits visualization from 4× to 25× magnification.

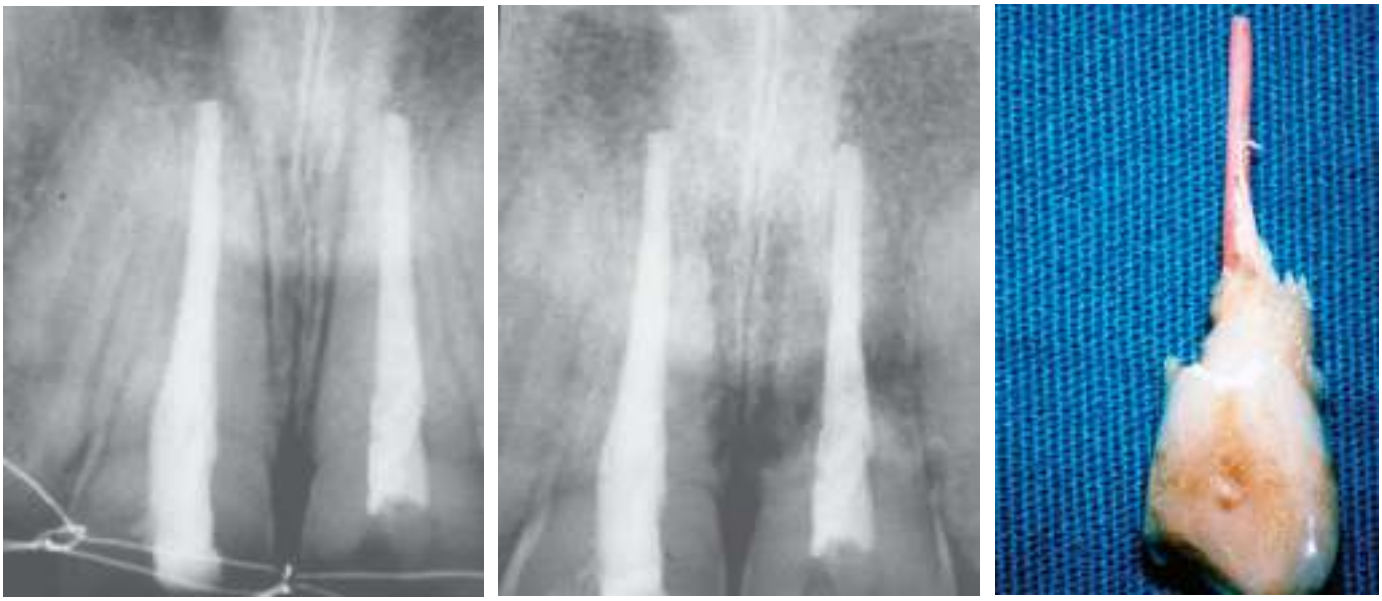
Symmetry of the observed teeth should be specifically noted, with special attention directed towards any abnormal positioning of any tooth (or teeth), including rotation, malocclusion, dislodgment, infraposition, or extrusive positioning (Fig. 2-13).[11]

Mobility

Tooth mobility is observed by objectively moving the tooth, using two instruments (typically the back ends of dental mirror handles), with one instrument on the facial and the other on the palatal of the tooth (Fig. 2-14). An effort is made to move the tooth in all directions; abnormal mobility most often occurs facio-lingually.[16] Degree of mobility is recorded as:[11]

0 = no mobility
+1 = less than 1 mm of horizontal movement
+2 = more than 1 mm of horizontal movement
+3 = more than 1 mm of horizontal movement and depressible within the socket

Increased mobility indicates subluxation and lateral luxation, with an associated alveolar bone fracture. The total lack of mobility may indicate the presence of an intrusive luxation. A tooth may become ankylosed (fused to the bone, also known as *replacement resorption*) weeks or months after the trauma (described in greater detail in Chapter 6). When tooth mobility is evaluated, care must be taken to see



A B C

Figure 2-9 **A,** Avulsed and replanted tooth as seen just after trauma and endodontic treatment and subsequent radiograph 6 months later **(B)** revealing extensive resorption. **C,** Following extraction, virtually all that remained was gutta percha.

A B

Figure 2-10 **A,** Crown discoloration after trauma may be more yellow or gray **(B).** *Continued*

whether the *tooth* moves, or the *surrounding alveolar segment* moves. Extensive tooth mobility could also indicate a root fracture[9,10,58] (described further in Chapter 4). Recently, *Periotest*™ (Siemens, Gulden-Medizintechnik, Bensheim, Germany) has been introduced to evaluate tooth mobility (Fig. 2-15).[58] This is an electronic device that provides a non-invasive objective measurement of the reaction of the periodontium to a defined impact load applied to the tooth crown. Two readings, with 15 minute intervals, should be taken to allow the periodontium time to recover.

Percussion

Tooth percussion should initially be performed using a gentle touch with the fingertip, followed by a light percussion with the fingertip. If no pain is elicited, the next test is with a mirror handle, tapping laterally and then vertically on the tooth crown. Sensitivity to percussion is an indication of damage to the periodontal ligament,[19] which could be a sign of an alveolar fracture, a root fracture, or pulpal necrosis with an acute periradicular abscess. Occasionally the audible *sound* of the percussion may be significant. An intruded or ankylosed tooth may have a dull, metallic, higher-pitched sound relative to the adjacent teeth when percussed.[2,15]

Pulp vitality

Tooth vitality is determined by the integrity of its vascular supply to the pulp. Vitality tests generally suggest the health and integrity of the intrapulpal sensory nerve fibers. Teeth

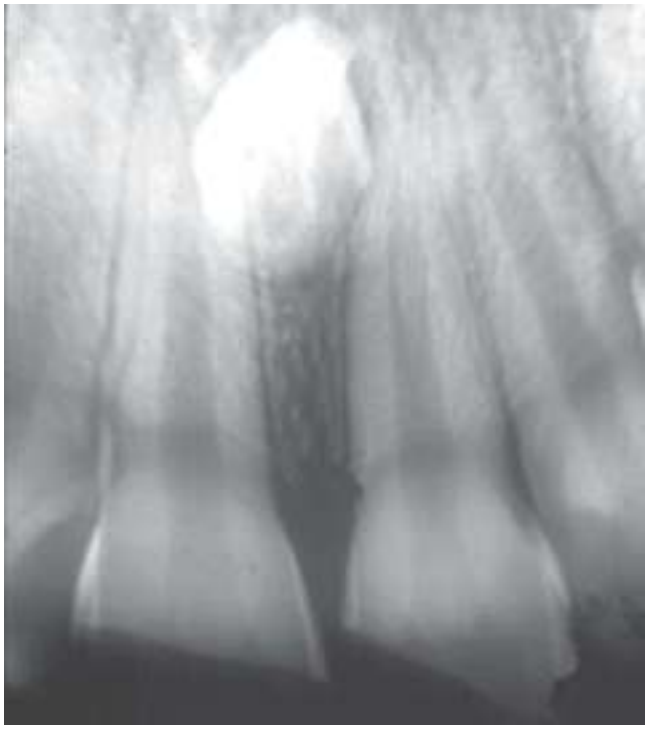
C

D

Figure 2-10, cont'd The crown discoloration may originate from cervical resorption as seen clinically **(C)** and radiographically **(D).**

A

B



C

Figure 2-11 **A** and **B,** Pulp exposure after complicated crown fracture. **C,** Radiographic evidence of mature root development.

Figure 2-12 Transillumination with fiber optic lights can visualize enamel cracks.

with immature root development do not provide a reliable response because the Raschkow plexus is not completely developed. Furthermore, the sensitive A-delta nerve fibers responsible for acute pain and response to vitality tests only mature approximately 4 years after the tooth develops.[40]

Reactions of the dental pulp to traumatic injury can be extremely variable.[30] Although it is not possible to determine the histopathological status of the pulp on the basis of vitality tests alone, there is usually a statistically significant relationship between the lack of response to these tests and pulp necrosis.[45,69,81] When nerve fibers can be stimulated by thermal or electrical means, the pulp vasculature is assumed to be intact.[32] However, the severity of the trauma can have a great impact on whether the pulp survives the injury.

The stage of root development can also be a major factor on how well the pulp will react. Immature root development provides a greater possibility of maintaining pulpal vitality subsequent to the injury, occasionally with a revascularizing pulp.[5,51] In any event, the response of the tooth to pulp vitality tests may provide a false negative response, with an incorrect diagnosis of pulpal necrosis. Repetition of pulp vitality tests every 4 to 6 weeks has been suggested to obtain better determination of pulp vitality.[70] It has also been recommended to delay pulp vitality tests for a year or more because the pulp may maintain its vitality, even though pulp testing suggests otherwise.[3,35]

Often, pulp vitality tests can be so subjective that symptoms and radiographic evaluations over time are the only way to objectively determine pulpal vitality. Radiographically, root development should be compared with the adjacent or contralateral tooth, and the periradicular area must be examined to visualize the development of periapical pathosis or resorption.[6,47] The importance of preserving pulpal vitality is to allow normal tooth development and to achieve sufficient dentin wall thickness, thus strengthening the tooth against possible future root fractures.[21]

A

B

Figure 2-13 **A,** Clinical evidence of an intruded tooth with radiographic evidence of replacement resorption **(B)** whereby the root structure is replaced with bone and the loss of the lamina dura.

Thermal and electric pulp tests are generally used to evaluate pulp vitality. The most reliable thermal pulp test is probably the cold test.[32,69] Because ice can melt when applied to the tooth and give potentially false readings, a refrigerant spray (dichlorodifluoromethane), ice water sprayed on a tooth isolated with a rubber dam, and CO_2 snow are more reliable.[32]

Electric pulp tests may not be reliable in young patients (9-13 years old).[32] The electrode should be placed in proximity to the incisal edge.[12,31] Again, this sensitivity test may be of little value immediately following injury.

Figure 2-14 Tooth mobility evaluation using handles of two instruments.

Figure 2-15 Periotest™ device for the objective evaluation of tooth mobility.

Laser Doppler flowmetry

Laser Doppler flowmetry (LDF) may be an objective and reliable test of the blood supply to the pulp, enabling the clinician to accurately differentiate between a pulp that is regaining its vitality and one that is becoming necrotic.[62] It uses Doppler shift principles, using a beam of infrared light produced by a laser directed onto and through the tooth crown. The device detects moving red blood cells in the pulp vasculature so as to differentiate vital from nonvital pulp.[36] The LDF has also been used to assess the vitality of traumatized teeth (Fig. 2-16).[35,55,62] However, two different laser Doppler flowmeters were found to detect artificial blood flow in extracted teeth, but the signals representing the concentration of moving blood cells were unreliable in both instruments. The information provided by LDF can be ambiguous and should be interpreted with care.[87] LDF is very costly, often rendering it impractical for most dental clinics. *Pulse oximetry,* which measures the blood's oxygen saturation level, may also have some future potential in determining pulp vitality. It has been reported as a possible objective and atraumatic clinical alternative to the present electrical and thermal methods of assessing pulp vitality.[37]

Figure 2-16 Laser Doppler flowmetry device for the possible detection of pulpal blood flow and vitality.

HARD TISSUE RADIOGRAPHIC EXAMINATION

Teeth

Periapical and/or occlusal radiographs should be taken to evaluate injured teeth. Alveolar fractures, along with crown and root fractures and dental luxations, can best be observed with these radiographs (Fig. 2-17). To detect a root fracture, the central x-ray beam must be directed through the fracture line. Multiple radiographs should be taken from several different angles to be more predictable in visualizing fractures.[4,90]

Today, digital radiography is an excellent alternative to conventional radiography, providing an almost instantaneous image, with significantly less radiation, outstanding diagnostic quality, and no processing errors. The storage of the images is only limited by hard drive space. The radiographic image displayed for the patient may allow for better communication regarding diagnosis and treatment plan.[72] Digital radiography is more sensitive than conventional

A

B

Figure 2-17 **A,** Radiographic evidence of a root fracture of the maxillary right central incisor and **(B)** the maxillary left central incisor.

radiography in the detection of simulated external root resorption lesions.[52,89]

The following should be considered by the clinician during the radiographic examination of a traumatic injury:

- stage of root development
- possible crown and/or root fractures
- relative proximity of the distance between a fractured crown and the pulp

Figure 2-18 Radiographic evidence of internal root resorption.

- any radiographic abnormalities of the pulp, including pulp calcification or internal resorption (Fig. 2-18)
- possible intraalveolar root fractures
- possible fracture of the alveolar bone
- degree of dislodgment of a luxated tooth from its dental alveolus
- variations in thickness of the periodontal ligament
- signs of root resorption

Alveolar Bone

As described in Chapter 7, radiographs are invaluable when assessing the presence of an alveolar fracture. The panoramic radiograph is an outstanding screening tool for this. It may be necessary to take other radiographs to visualize more details.

PEDIATRIC CONSIDERATIONS

The clinical approach to a child or adolescent may require different attitudes and considerations than for an adult. Moreover, the clinician should be aware of possible intentional injuries that may have occurred, especially when evaluating traumatic injuries in children.

Although treatment and care are directed to the child, other family members should be included (parents, grandparents, guardian), not just for understanding and permission of the treatment plan, but also for psychological support for the child and for legal reasons (see Chapters 9 and 10). Examination and treatment begin with the clinician using a

Figure 2-19 Panoramic radiograph reveals avulsion of primary tooth "c" and central incisor.

gentle and considerate approach with the child. This also helps the parents to overcome their fear and anxiety.

The principles of examination are the same for adults and children, but there are additional considerations for children that require specific attention. The main goal for injured primary teeth is to evaluate for possible damage to the permanent tooth buds. Consideration must also be given to the location of the tooth buds when injury involves the facial bones. The pending treatment must assure that no damage to the tooth buds will occur.

Primary incisors loosen more readily following trauma than permanent teeth because of the resilience of the alveolar bone in young children.[6] Furthermore, physiological resorption reduces the crown-root ratio as the tooth approaches the time of natural exfoliation. Only mild trauma may be necessary to loosen these teeth and facilitate an avulsion.[44] During clinical examination of the child with mixed dentition, special attention should be given as to whether the primary tooth was avulsed, intruded, trapped in the mucosal tissues, or previously missing before the traumatic injury (Fig. 2-19).

For young permanent teeth, especially with open apices, preservation of vitality is of utmost importance.[6,21] As discussed, unfortunately the reaction to pulp vitality tests may be misleading and is often of limited value.[32]

With children, the occlusal radiograph may be the only intraoral radiograph possible because of patient compliance. Another radiograph useful for children with compliance issues is an *extraoral* radiograph, using an occlusal film (Fig. 2-20). Cooperation of a parent to support the child may be helpful (Fig. 2-21).

Figure 2-20 Extraoral radiograph using occlusal film.

Figure 2-21 Cooperation of a parent to support the child while taking a radiograph.

GERIATRIC CONSIDERATIONS

Special considerations should be given to the medical history when examining an older patient with dental trauma. Aging mostly influences cardiovascular, respiratory, and central nervous systems.[68,74,85] Osteoporosis resulting in loss of bone mineral density is common in the elderly, affecting primarily women, which could predispose them to bone fractures.[60]

Older adults typically take more medications.[48,63] For the elderly, there is an "accentuated response of soft tissues to trauma, including ecchymosis, edema, and tissue laxity."[34] The clinician should also be aware of a potentially missing fixed or removable prosthesis, which may potentially cause airway obstruction.

Fewer nerve branches and reduced vascular supply in aged pulps[13,64] should also be considered when evaluating the vitality of traumatized teeth in elderly patients.

CONCLUSION

Proper management of the traumatized patient starts with a comprehensive patient assessment and correct diagnosis so that an adequate and timely treatment plan can be implemented. This is important in establishing the most ideal and *safest* dental treatment option. The patient's medical status should be evaluated to ensure that no urgent medical treatment is necessary before managing the dental trauma. A thorough tissue evaluation is imperative, both clinically and radiographically. Proper documentation is necessary with regard to the events that initiated the traumatic injury and for recording all significant findings of the clinical exam. Finally, all patients with traumatic injuries to the head and neck region should be contacted several hours after treatment and again on the following days to check on their status. Patients should be seen if there are any complications, and a referral to their primary care physician is advisable in the event of any adverse change in their medical status.

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