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Fall/Winter 1998

ENDODONTICS

COLLEAGUES FOR EXCELLENCE

KEEP IT ALIVE

Intensive care for the immature pulp

Maintaining pulp vitality after a traumatic injury

Nine-year-old Josh is racing down a hill on his mountain bike. The bike hits a rock and Josh lands on the trail. His mouth is bloody. His front tooth feels funny. He gets up, dusts himself off and rides home to tell his mother. She sees Josh's broken tooth and immediately calls the dentist.

Are you ready to take care of Josh?

Josh has fractured his tooth and exposed the pulp. Although repairing the injury is the immediate problem, ensuring that the tooth will continue to thrive is the real challenge. Understanding the impact of trauma on the pulp and the importance of pulp vitality to sound tooth development is essential for optimum patient care. Endodontics, the dental specialty most concerned with the physiology and pathology of the dental pulp, can offer a unique perspective. Endodontic therapy generally involves removing the pulp to save a tooth, but for young people like Josh, keeping the pulp alive will help the tooth survive.

This issue of *ENDODONTICS: Colleagues for Excellence* explores factors that affect pulp vitality following fracture and luxation injuries to immature teeth.

Who gets hurt?

Anyone can be injured. Automobile accidents, sports mishaps, altercations or a bad fall may bring a patient to your office. A teen-age boy with an incisal overjet is the most likely victim. About one out of three boys and one out of four girls injures a tooth before completing high school.

Forty-nine to 60 percent of dental accidents happen at home. Chipped teeth account for 90 percent of all dental traumas. The remaining 10 percent represent more serious problems, such as severe crown fractures involving the pulp, tooth displacements or avulsions. Eighty percent of injuries are to the maxillary central incisor.

The examination of trauma patients

Accurate diagnosis of traumatic injuries depends on assessing many details. Documentation is as important as observation. Baseline information is necessary for other medical or dental professionals, at follow-up examinations and for legal or insurance purposes. Careful recording can be difficult in an emergency. A form that outlines the protocol for examining trauma patients may help you proceed methodically and avoid missing important details in evaluating the patient's chief concerns. A sample form is enclosed with this newsletter.

A **medical history** is the essential first step. Questions must be detailed enough to reveal significant facts that could impact further decision-making. Evaluate the form your office uses to ensure that it is comprehensive. A **neurologic assessment** should be performed to rule out the need for medical care. The **history of the injury** such as when, where and how the trauma occurred, also provides diagnostic clues. If an accident happened outside or in unsanitary conditions, a tetanus booster may be necessary.

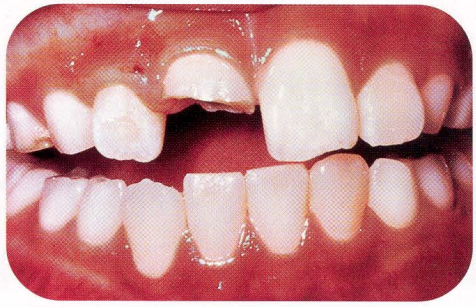
The **clinical examination** should include an extraoral, intraoral and dental examination with a pulpal evaluation. **Radiographs** taken from a variety of views and angles help to identify changes caused by the injury. The maturity of the root and the size of the apical foramen is of special radiographic significance in cases involving young people. Apical closure and root development normally continue for three to four years after a tooth has erupted. Josh presents with a fractured crown, a cut on his lip and a pulp exposure. Evaluating the status of Josh's root development will influence all further treatment decisions.

A vital pulp promotes root development

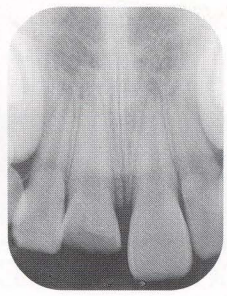
Radiographs reveal that Josh's injured tooth has an immature root with an open apex. The apical opening is greater than 1 mm. Maintaining pulp vitality is a primary concern in the treatment of an immature tooth.

Apexogenesis, or the normal process of root development, will not occur unless the pulp remains alive. The pulp produces dentin, and if the pulp dies before the apex closes, root wall development will be permanently arrested. A tooth with thin dentinal walls is predisposed to root fracture.

Even if the pulp cannot be maintained for the life of the tooth, it is important to preserve vitality as long as possible. The roots of immature teeth become increasingly thin and fragile near the apex. Negotiating these large canals without an apical constriction makes cleaning, shaping and obturating young teeth extremely difficult, if not impossible. The goal in Josh's case will be to allow the apex to mature and the dentin walls to thicken sufficiently to permit successful root canal therapy.



Josh arrives at the dental office with a crown fracture and pulp exposure.



Immediately after the injury, the radiograph reveals an immature open apex.

Factors affecting pulpal survival

Blood nourishes the pulp and keeps it healthy. The type of injury, the stage of root development and the degree of infection are factors that affect circulation to the injured area and impact pulp vitality. Bacteria may invade the pulp through cracks that are created or enlarged as a result of tooth trauma, causing inflammation and pulpal necrosis. Although Josh has a large pulp exposure, he received immediate care. The prognosis for the pulp, and therefore his tooth, is excellent.

Methods of pulp testing

Vitality testing will not be useful in determining the status of Josh's pulp. Until apical closure occurs, teeth do not respond normally to pulp testing. In addition, a traumatic injury may temporarily alter the conduction capability of nerve endings and/or sensory receptors in the pulp. A patient with a vital pulp may not experience any sensation, while a patient with a necrosing pulp may respond normally. Accuracy also depends on the patient's ability to describe how the tooth reacts to stimuli. Clinicians must rely on experience, radiographs, clinical signs or symptoms and their knowledge of the healing process to assess pulp vitality.

Pulp capping and pulpotomy keep the pulp alive

Pulp capping and pulpotomy are procedures that permit apexogenesis to occur and may avert the need for root canal therapy. The choice of treatment depends on the size of the exposure, the presence of hemorrhage and the length of time since the injury.

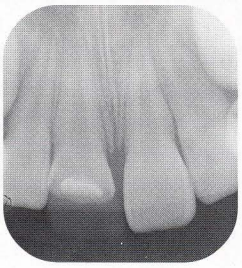
Calcium hydroxide—Calcium hydroxide plays an essential role in pulp capping and pulpotomy techniques as well as in other post-trauma therapy. Although much is understood about the material's effect on dentin and pulp, its specific biologic mechanisms of action have yet to be identified. Calcium hydroxide's alkaline pH encourages calcification, impedes resorptive responses and prevents bacterial growth. A hard-setting calcium hydroxide is used for pulp capping and pulpotomy procedures. However, in some other treatments the material is used as a non-setting soft paste.

Pulp capping—Pulp capping is an effective technique for small pulp exposures treated within several hours of the injury. As time passes, pulp tissue deteriorates, and the chances for success decrease. Initially, the fractured surface is cleaned and dried. Then the exposed pulp and dentin are covered with a dressing of hard-setting calcium hydroxide. The fractured surface is acid etched and restored with a bonded composite resin.

Pulpotomy—Josh's pulp exposure is large and there has been bleeding. His injury requires a shallow pulpotomy to remove contaminated pulp tissue. After anesthesia, Josh's tooth is isolated with a rubber dam. The exposed dentin is cleaned and any extruding pulp tissue is removed with a spoon excavator. Using a small diamond bur accompanied by copious water spray, pulp tissue is gently removed to a depth of about 2 mm below the exposure. Wet cotton pellets are used to stop hemorrhage, and a hard-setting calcium hydroxide dressing is placed over the exposed pulp. The fractured tooth surface is acid etched and restored using a bonded composite resin. The pulpotomy procedure can also be used to treat an injured pulp that has been exposed for several hours or days.

Success is determined over time

Follow-up examinations are essential to monitor the continued health of the pulp. Josh's tooth should be watched closely over a two-year period and then annually examined over the next few years. Pulp capping and partial pulpotomy with calcium hydroxide are successful in almost 96 percent of trauma cases. Treatment is considered effective if there are no signs of clinical or radiographic pathosis and if the root continues to develop apically and thicken laterally. Although Josh's pulp may not remain healthy indefinitely, with a mature root his tooth should be strong enough to undergo root canal therapy, if necessary, and to support a restoration.



A shallow pulpotomy is performed on Josh's tooth.

The tooth is restored using a bonded composite resin.

Apexification—Josh was fortunate to receive prompt treatment. Allowing the root to develop is always preferable to performing root canal treatment on an immature tooth. However, apexogenesis will not occur unless some vital pulp tissue remains in the root canal. If the pulp tissue is necrotic and must be removed, **apexification**, a process which stimulates the formation of a calcified barrier across the apex, is an alternative. The root will not mature but, if treatment is successful, a hard-tissue bridge will form across the apical opening.

To induce apexification, the entire root canal system is cleaned, then filled with a soft non-setting calcium hydroxide paste to the level of the open apex. After six to 12 months, a calcific barrier usually forms. Follow-up examinations should occur every three months. If there are any signs or symptoms of infection or pathosis, the canal is recleaned and refilled with calcium hydroxide. Radiographs should be taken at three, six and 12-month intervals to monitor apical development. When it can be clinically and radiographically confirmed that the apex has closed or a bridge has formed at the level of the calcium hydroxide, the canal is ready to be filled with gutta-percha.

Table 1. Classification of dental injuries (based on the World Health Organization system)

Enamel fracture: Involves the enamel only and includes enamel chipping and incomplete fractures or enamel cracks.

Crown fracture without pulpal involvement: An uncomplicated fracture involving enamel and dentin; no pulpal exposure.

Crown fracture with pulpal involvement: A complicated fracture involving enamel, dentin and exposure of the pulp.

Root fracture: Fracture of root only: cementum, dentin and pulp. Also referred to as horizontal root fracture.

Crown-root fracture: Tooth fracture that includes enamel, dentin and root cementum, and may or may not include the pulp.

Luxation: The following subcategories make up luxation injuries.

1. Concussion. The tooth is sensitive to percussion but has not been displaced and is not abnormally mobile.
2. Subluxation. Increased mobility but no displacement.
3. Lateral luxation. The tooth has been displaced and may be very firm.
4. Extrusive luxation. The tooth is very mobile because of partial displacement out of the socket.
5. Intrusive luxation. The tooth having been forced apically is firmly embedded in bone.

Avulsion: Complete displacement of a tooth from its socket.

Fracture of the alveolar process (mandible or maxilla): Fracture or comminution of the alveolar socket or of the alveolar process; if the fracture involves a tooth socket, the blood supply to the tooth pulp may be compromised.

Chart taken from Andreasen JO and Andreasen FM, *Textbook and Color Atlas of Traumatic Injuries to the Teeth*, 3rd ed. Mosby, Copenhagen, Munksgaard and St. Louis, 1994.

Luxation injuries threaten pulp vitality

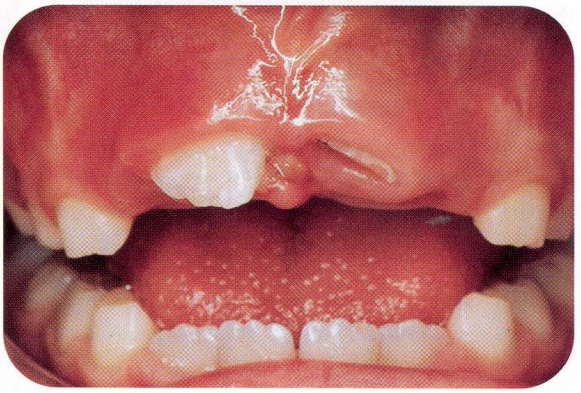
Luxation injuries pose the greatest risk to pulp vitality. Tooth displacement traumatizes the supporting structures and can sever blood vessels entering the apical foramen. There are five types of luxation injuries—concussion, subluxation, lateral luxation, extrusive luxation and intrusive luxation. (See the World Health Organization chart for the distinguishing characteristics of these injuries.)

Concussions and subluxations generally cause minimal displacement and rarely result in damage to the pulp. Lateral, extrusive and intrusive luxations, on the other hand, involve major vascular disruption as well as damage to the periodontal ligament. Although these injuries compromise healing, immature teeth have a significant advantage. The open apex improves access to the blood supply and promotes conditions that enhance the pulp's natural capacity to revascularize. Intrusive luxations create the most serious challenge to maintaining pulpal vitality but, in the case of an immature tooth, intervention is not always necessary.

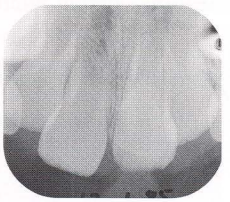
KEEP IT ALIVE

When six-year-old Sara fell off a swing, her mother brought her to the dentist two days later. The maxillary central incisors had erupted just a few weeks before the accident. Sara's left central incisor was intruded subgingivally. The right central incisor was not traumatized nor was it sensitive to percussion. Radiographs indicated that the injured tooth had an apical diameter of 3 mm. Sara's tooth was evaluated over a 12-month period and during that time the tooth re-erupted and the root continued to develop.

Problems often follow severe luxations, especially intrusive injuries. Tooth discoloration, sensitivity, mobility and swelling are signs of trouble. Therefore, short and long-term monitoring are essential to detect changes in the status of the pulp. Examinations should be scheduled three weeks after an accident, at three, six and 12 month intervals and then annually for at least five years. Follow-up evaluations should include percussion, palpation, pulp testing (when feasible), mobility and radiographs.



Sara's left central incisor was intruded subgingivally.

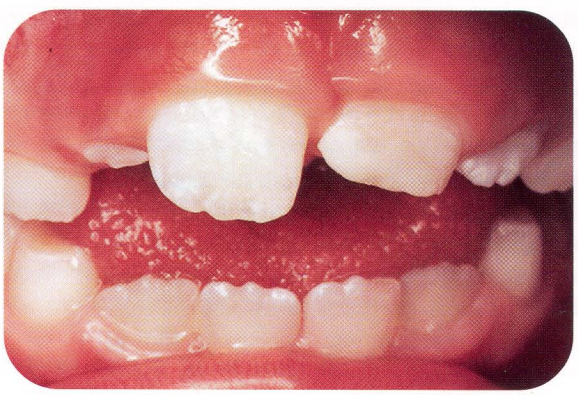


Sara's tooth is very immature with an apical opening of 3 mm.

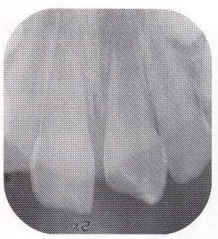
Not all patients are as lucky as Sara. The healing process is a race in which revascularizing pulp competes with invading bacteria. Despite having an open apex and a more abundant blood supply, immature teeth do not always fare well in this contest. If the pulp becomes necrotic, apexification will be necessary.

Tooth resorption, or the loss of dentin and cementum, is a more serious problem. Resorption may occur **internally** in the pulp chamber or **externally** in the periodontium. In traumatized teeth with immature root development, this challenging condition happens approximately 58 percent of the time. While resorption is still not completely understood, the presence of infection often plays a key role in stimulating adverse cellular responses. Multinucleated clastic cells destroy dental hard tissues which are then replaced with chronic inflammatory tissue or bone.

Internal resorption occurs when multinucleated clastic cells appear in the pulp and destroy dentin, possibly creating a perforation. Removing the pulp will stop this process. In the immature tooth, an apexification procedure will be necessary to encourage root-end closure.

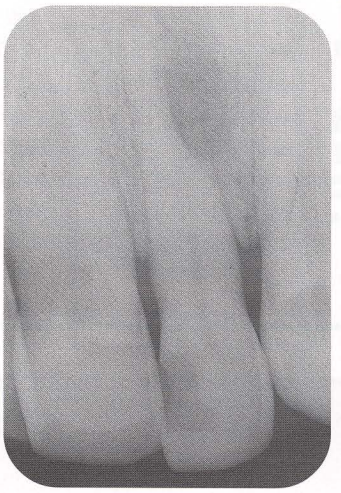


Four months after Sara's accident, the tooth is re-erupting.

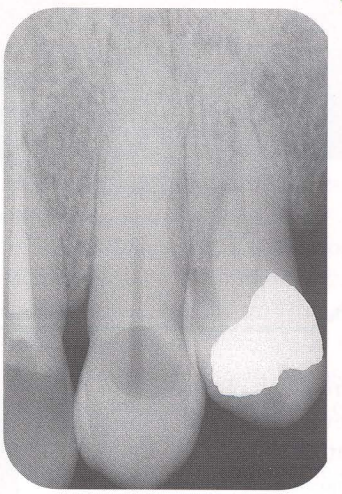


After 12 months, the tooth has re-erupted and the root has continued to develop.

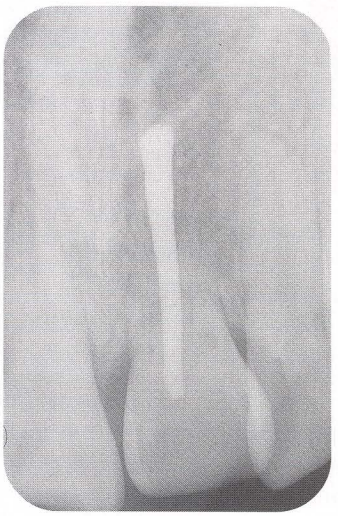
External resorption occurs when multinucleated clastic cells appear in the periodontium and attack the root surface. There are several types of external resorption. **Inflammatory** and **replacement** are the most closely associated with luxation injuries. Both are destructive. **Inflammatory resorption** can be recognized when the resorptive defect on the root surface is separated from the bone by a radiolucency. In the immature tooth, this indicates that the pulp is infected and the resorption-causing bacteria or their by-products have moved through the wide dentinal tubules to the root surface. This process progresses rapidly and immediate treatment is required. Removing the pulp will halt resorption. When radiographs indicate that resorption has ceased and the apex has closed, a permanent root filling material can be placed.



Inflammatory root resorption following a history of trauma. Root canal treatment will arrest inflammatory resorption.



Lateral incisor on left side of radiograph shows arrested inflammatory resorption six years after treatment.



A replanted avulsed tooth shows replacement resorption. Root canal treatment will not *arrest this process.*

Inflammatory resorption can be arrested. In contrast, when **replacement resorption** or ankylosis has started, its progress can be delayed but it cannot be stopped. When replacement resorption occurs, trauma to the periodontal ligament triggers a reaction in which clastic cells begin to destroy cementum and dentin and the root structure is replaced by bone. Replacement resorption can be recognized on radiographs by the absence of a periodontal ligament separating the bone and the root structure. There is no known relationship between pulp vitality and replacement resorption. This complication can occur whether the pulp is vital or necrotic. Therefore, in the absence of adverse signs or symptoms, no pulpal treatment is indicated, but radiographic follow-up is essential.

CONCLUSION

Traumatic dental injuries pose a special risk for immature teeth. If the pulp does not survive, the tooth will not continue to develop. Understanding the relationship of a healthy pulp to strong tooth structure is critical in the care of young people. Endodontists welcome the opportunity to share their expertise with colleagues and to expand the scope of care for all dental patients.

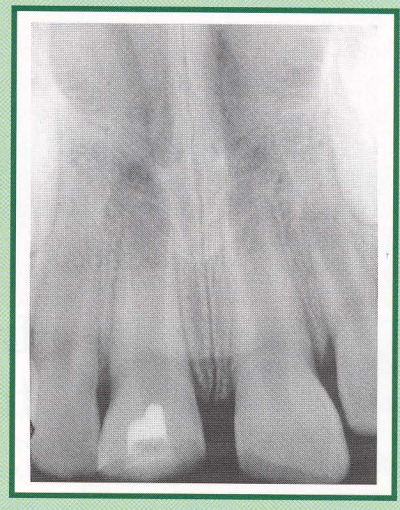
On the horizon—MTA

Recent scientific advances promise significant improvements in promoting the healing of the pulp and periradicular tissue.

Imagine that you could try something completely new the next time you perform vital pulp therapy. You could use a material that would prevent bacterial leakage, would be effective in a moist environment and would also be biocompatible. When placed over pulp tissue, this substance would actually stimulate the formation of dentin. It could also be used for perforation repair or as a root-end filling. If that scenario sounds like science fiction, then the future is almost here.

Mineral Trioxide Aggregate or MTA appears to demonstrate all of these remarkable biological responses. This material, developed by researchers in the Department of Endodontics at Loma Linda University, can also be used in place of calcium hydroxide for apexification, apexogenesis and to create an immediate apical barrier. Over the last five years, MTA has undergone rigorous scientific scrutiny. It has been tested *in vitro* and *in vivo*. Articles documenting the progress of this research have been published in the *Journal of Endodontics* and other periodicals. Long-term clinical studies are planned and MTA should be commercially available within the next year.

Preoperative radiograph of a central incisor with a traumatic pulp exposure and an open apex.



Postoperative radiograph after a shallow pulpotomy with MTA.

Postoperative radiograph one year later showing continuing root development.

The information in this newsletter is meant to aid dentists. Practitioners must always use their best professional judgment, taking into account the needs of each individual patient. The AAE neither expressly nor implicitly warrants any positive results nor expressly nor implicitly warrants against any negative results associated with the application of this information.

If you would like more information, call your local endodontist or contact:

American Association of Endodontists

211 East Chicago Avenue, Suite 1100, Chicago, Illinois 60611-2691

Examination Form for Trauma Patients

Patient Name _____

Clinicians should use their standard office form to record medical history.

Neurologic Assessment

Does the patient have or has the patient had any of the following symptoms since the injury?

❒ nausea ❒ headache ❒ vomiting

Did the patient lose consciousness? ❒ Yes ❒ No If so, for how long? _____

Can the patient remember what happened ❒ before ❒ during ❒ after the accident?

Is there: ❒ double vision ❒ limited eye movement ❒ abnormal pupillary reflex

History of the Injury

Date: _____ Time: _____ Place where injury happened: _____

How did the injury occur? _____

_____

Was treatment provided elsewhere? ❒ Yes ❒ No If so describe: _____

_____

Chief complaint: _____

Pain ❒ Yes ❒ No Location of pain (tooth/teeth): _____

Type of pain (percussion, biting, cold) _____

Characteristics of pain (constant, episodic) _____

Were the teeth avulsed? ❒ Yes ❒ No

If so:

Where were the teeth found? _____

When were the teeth found? _____

Were the teeth dirty? ❒ Yes ❒ No

How were the teeth stored? _____

Were the teeth rinsed prior to replantation? ❒ Yes ❒ No If so, with what _____

When were the teeth replanted? _____

Was tetanus antitoxoid given? ❒ Yes ❒ No

Were antibiotics given? ❒ Yes ❒ No If so, type and dosage _____

_____

Extraoral Examination

Is the patient's general condition affected? ❒ Yes ❒ No

Pulse and blood pressure _____

Objective findings within the head and neck? ❒ Yes ❒ No If yes, type and location: _____

_____

Bleeding from the: ❒ nose ❒ ear

Palpable signs of fracture of facial skeleton? ❒ Yes ❒ No If yes, location of fracture _____

_____

Intraoral Examination

Injury to the oral mucosa ❒ Yes ❒ No Location _____

Injury to the gingiva ❒ Yes ❒ No Location _____

Tooth fracture ❒ Yes ❒ No Location _____

Alveolar fracture ❒ Yes ❒ No Location _____

Tooth discoloration ❒ Yes ❒ No Location _____

Dental Examination

General condition of dentition ❒ Good ❒ Fair ❒ Poor

Caries ❒ Minimal ❒ Moderate ❒ Extensive

Periodontal status ❒ Good ❒ Fair ❒ Poor

Horizontal occlusal relationship ❒ Underbite ❒ Overbite ❒ Normal

Vertical occlusal relationship ❒ Deep ❒ Open ❒ Normal

Evaluation of the Injured Tooth

Tooth #				
Date				
Heat (+/-)				
Cold (+/-)				
Percussion (+/-)				
Ankylosis tone				
Mobility				
Palpation				
Color				
EPT (#)				
Occlusal contact (+/-)				

Tooth #				
Date				
Heat (+/-)				
Cold (+/-)				
Percussion (+/-)				
Ankylosis tone				
Mobility				
Palpation				
Color				
EPT (#)				
Occlusal contact (+/-)				

Radiographic Examination

Types of films	Observation
❒ Periapical	❒ Root fracture
❒ Angulated periapical	❒ Bone fracture
❒ Occlusal	❒ Pulp canal obliteration
❒ Soft tissue film	❒ Root resorption
❒ Panoramic	❒ Immature root, open apex. Size of apical foramen _____ mm.

Injuries

Tooth #	Fractures
_____	Crown fracture/no pulp exposure
_____	Crown fracture/pulp exposure
_____	Crown-root fracture/no pulp exposure
_____	Crown-root fracture/pulp exposure
_____	Root fracture (apical, middle, coronal 1/3)
_____	Alveolar fracture
_____	Mandibular fracture
_____	Maxillary fracture
_____	Additional remarks: _____

Tooth #	Luxations
_____	Concussion
_____	Subluxation
_____	Lateral luxation
_____	Extrusion
_____	Intrusion
_____	Avulsion
_____	*Additional remarks:* _____

Location	Abrasions/Contusions/Lacerations
_____	Skin abrasion
_____	Skin laceration
_____	Skin contusion
_____	Mucosal abrasion
_____	Mucosal laceration
_____	Mucosal contusion
_____	Gingival abrasion
_____	Gingival laceration
_____	Gingival contusion
_____	Additional remarks: _____

Treatment Plan

At time of injury		Follow-up	
Repositioning		Restoration	
Fixation/splinting		Fixation/splinting	
Pulpal therapy		Pulpal therapy	
Dentinal coverage		Soft tissue suture removal	
Soft tissue suturing		Endodontic referral	
Prescription		Oral surgery referral	
Emergency room/ physician referral		Orthodontic referral	

Prognosis

Tooth # _____ ❒ Good ❒ Fair ❒ Poor

Tooth # _____ ❒ Good ❒ Fair ❒ Poor

Tooth # _____ ❒ Good ❒ Fair ❒ Poor

Follow-up

3 weeks Date of visit _____

Remarks: _____

3 months Date of visit _____

Remarks: _____

6 months Date of visit _____

Remarks: _____

12 months Date of visit _____

Remarks: _____

2 years Date of visit _____

Remarks: _____

3 years Date of visit _____

Remarks: _____

4 years Date of visit _____

Remarks: _____

5 years Date of visit _____

Remarks: _____

For Further Reading
***ENDODONTICS: Colleagues for Excellence*, Fall/Winter 1998**
"Keep It Alive"

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