With the Right Procedures, EPs Can Save Avulsed Teeth

By Paul Krasner, MD

Although the exact percentage of the general population that experiences dental trauma each year is not known, the incidence of dental trauma in children and adolescents is well documented. In school-aged children, 25 percent will sustain some form of dental injury each year. By the time students complete high school, it is estimated that 33 percent will have experienced a dental injury. With the increase in girls' participation in sports, dental injuries have dramatically increased. These can occur at any place at any time. When dental injuries occur after hours, many patients present at emergency departments for treatment.

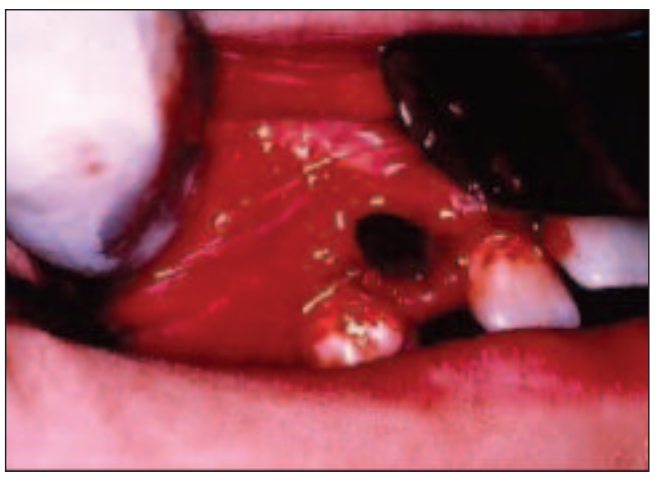
The frequency of dental emergencies seen in EDs ranges from four percent to seven percent of all emergency patients, and include everything from dental abscesses to jaw fractures, but the incidence of tooth trauma is 26.8 percent. Of these, the most serious and only injury considered urgent is the avulsed tooth. The percentage of avulsed teeth ranges from 0.5 percent to 16 percent of all dental trauma. The average number of avulsed teeth seen in EDs after hours ranges between 26 and 39. Nearly 43 percent of dental trauma involved one tooth, 38.5 percent involved two, and 11.4 percent involved three or more. Dental trauma research has shown that the best prognosis for an avulsed tooth is when the tooth is properly treated within the first 15 minutes following the exarticulation or if stored in an optimum biologic storage medium within the first hour of the accident. Because patients presenting to EDs are rarely seen within this period of time, there are protocols that must be established to ensure that the best prognosis is available to patients with avulsed teeth.

Saving Knocked-out Teeth

Every tooth is connected to its surrounding bone by the periodontal ligament. The tooth receives its nourishment through this ligament. When it is knocked out, this ligament is stretched and splits in half; half stays on the tooth root and half stays on the socket wall. If these two halves can be kept alive, the tooth can be replanted and the halves of the ligament will reattach and the tooth will remain vital. The half that stays on the socket wall, because it remains connected to the bone blood supply, is naturally kept alive. (See photograph.) Ligament cells that remain on the tooth root, however, must be artificially maintained and reconstituted. (*Oral Surg Oral Med Oral Pathol* 1995;79[5]:616.)

Although some dentists say the best treatment for an avulsed tooth is immediate replantation, once an avulsed tooth reaches the ED, it has been extraoral for varied amounts of time and the root cells need to be treated properly to create the best possible chances of replantation success. The time needed to treat the avulsed teeth properly also can be utilized by the physician to treat other injuries that have been sustained. When a tooth is avulsed, this is rarely the only injury that occurs during the accident. The force that knocks out the teeth may cause facial lacerations or fractures. These other injuries may need to be treated before the teeth can be replanted due to bleeding obscuring the tooth sockets or simply because the patient's pain needs to be controlled before a replantation can be performed.

There are other difficulties that can prevent an immediate replantation. The first is that teeth are often covered with debris. This debris must be washed, not scrubbed, with a physiological solution. The patient may be in severe pain and may not allow replantation of the teeth into the sockets without anesthesia. The emergency physician may want to refer the patient to an on-call dentist for the actual replantation. Avulsed teeth must be protected from two potentially destructive processes that can occur while the physician prepares for treatment: root cell crushing and loss of normal cell metabolism. All treatment of the teeth between the time of the accident and the ultimate replantation must be focused on preventing these two possibilities.



Because it remains connected to the bone blood supply, the half of a tooth that stays on the socket wall is naturally kept alive. Ligament cells that remain on the tooth root, however, must be artificially maintained and reconstituted.

Preventing Cell Crushing

When teeth are avulsed, they end up on an artificial surface, the floor, the ground, or material such as carpeting. If the surface is hard, the tooth root cells will receive trauma. Because the cells remaining on the tooth root are very delicate, additional trauma to the tooth root cells must be avoided. This damage can occur while picking up the tooth and the method used to transport to the ED.

When a tooth is picked up, it should always be grasped by the enamel on the crown. Finger pressure on the tooth root cells will cause cell crushing. Debris should be gently washed off with a physiologic saline. Even with the use of a physiologic saline, the scrubbing of the tooth root to removed debris must be avoided. When placed in a physiologic solution, the tooth should be gently agitated to permit cleaning the tooth root. At the same time that this agitation occurs, bumping the tooth root against a hard surface such as glass, plastic, or even cardboard must be avoided. (*Endod Dent Traumatol* 1990;6:37.)

For the same reasons, the method in which the knocked-out teeth are transported must be carefully selected. Placing the knocked-out teeth in tissues, handkerchiefs, or glass or cardboard containers can be damaging to the cells. (*Oral Surg Oral Med Oral Pathol* 1995;79[5]:616.) In addition to the potential damage that the hard surface can cause, these types of containers have the added possibility of breakage or leakage. If the container does not have a tightly fitting top, then during the transportation, the physiologic solution can spill out and the teeth can fall again on the floor, and the physiologic environment can be lost.

When knocked-out teeth arrive at the ED for replantation, the emergency physician is faced with the task of removing them from the container, a task more difficult than might initially be realized. First, if the tooth has been retrieved from a muddy or dirty accident site such as a grass field or sand, the solution in which it has been transported will become murky and opaque. This makes it difficult for the physician to see the teeth and retrieve it by the crown only. If the tooth cannot be clearly seen, the physician will have to feel around for the tooth with either fingers or forceps and perhaps inadvertently crush the tooth root cells. If the knocked-out teeth were placed in a carton of milk, for example, there would be no other recourse for removing the teeth except spilling out the milk. Spilling it out, whether it's in a glass or a container is fraught with problems. Catching the teeth with latex-gloved hands while spilling out the liquid without the teeth falling on the floor is very challenging.

The device used to transport the teeth should be a shatterproof container with a tightly fitting top. The container should be large enough to hold one to eight teeth and should have some sort of non-abrading, cushioning apparatus that will prevent the teeth from bumping into each other or striking the sides of the container, and permit atraumatic removal of the teeth by the emergency physician or dentist.

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Maintaining Cell Metabolism

Normally metabolizing tooth root cells have an osmolality (concentration) of 280-300 mOs and a pH of 7.2. When there is an uninterrupted blood supply, all of the metabolites and glucose that the cells require are provided. When the tooth is knocked-out, this normal blood supply is cut off, and within 15 minutes, most of the stored metabolites have been depleted and the cells will begin to die. (*Endod Dent Traumatol* 1990;6:37.) Within an hour or two, so many cells will die that the body will reject the tooth. The method by which the body rejects the replanted tooth is through a process called replacement root resorption.

During this process, the tooth root cells become necrotic, and are viewed by the surrounding bone as not-self. The immunologic mechanism of the body attempts to remove this necrotic not-self, and literally eats away the tooth root. It is a slow but non-painful process that is sometimes not observed by x-rays for years. Once this process starts, it is irreversible and the tooth eventually will fall out. In growing children, it is particularly problematic because the replacement resorption (also termed ankylosis) impedes normal jaw growth.

Research has shown that the critical factor for reduction of replacement resorption following replantation of avulsed teeth is maintaining normal cell physiology and metabolism. To maintain this normalcy, the environment in which the teeth are stored must supply the optimum osmolality, cell nutrients, and pH. (*Dent Traumatol* 2003;19:299.)

Storage Media

Patients often choose one of many storage media for knocked-out teeth: water, ice, saliva, physiologic saline, milk, and pH-balanced cell-preserving fluids. Water and ice, although appealing to common sense, actually have been shown to be damaging to the tooth root cells. (*Swed Dent J* 1981;Suppl. 8.) The

reason for this is that the osmolality (concentration) and pH of water and ice is very low. When avulsed teeth are placed in water, the cells attempt to equalize with the surrounding environment and burst.

Saliva, that is placing the teeth under the accident victim's tongue, also has been recommended. Saliva as a storage medium is twice as problematic. Its osmolality is very low, causing cell bursting. Because saliva is filled with its normal flora of microorganisms, it can severely infect the tooth root. When the teeth are replanted, not only will the cells be necrotic, but they can infect the bone socket.

Physiologic saline has a fairly compatible osmolality, and will not cause cell structure swelling, but it lacks the metabolites and glucose necessary for maintaining normal cell metabolism.

Milk also has been recommended as a storage medium for avulsed teeth because it has a compatible osmolality, and is thought to be readily available. Like physiologic saline, however, it lacks the necessary metabolites and glucose for normal cell physiology. (*Oral Surg Oral Med Oral Pathol* 1995;79[5]:616.) Milk is not readily available in an ED, and even if it is in the hospital refrigerator, it may be sour, and sour milk will cause tooth root cell damage. Powdered milk and non-refrigerated milk also have been tested and have not shown good success rates.

The optimum storage media are pH-balanced cell-preserving solutions. The best known and most extensively tested is called Hank's Balanced Salt Solution (HBSS). It has all of the metabolites such as Ca, $P0^4$, K+, and glucose that are necessary to maintain normal cell metabolism for long periods of time. HBSS has been extensively tested in dental and medical research for the past 20 years. (*J Am Dent Assoc* 1992;123:80.) This research has shown that 90 percent of cells stored in HBSS for 24 hours and 70 percent stored for four days maintain their normal viability. Dog's teeth that have been placed in HBSS for four days can still be replanted with little signs of resorption. (Cohen S, Burns R. eds. *Traumatic Injuries.* "Pathways of the Pulp." 8th Ed. Mosby, 2002 St. Louis, pp. 636-7.)

HBSS also has the capability of reconstituting lost cell metabolites. Because a cell that has been cut-off from its blood supply depletes its stored metabolites after 15 minutes, a tooth that has been extraoral for one hour has 45 minutes less vital cells to reconnect with the bone ligament cells. This tooth has a significantly greater possibility of replacement resorption if it is replanted immediately.

It has been shown in dental research that physicians can reduce the amount of root damage to avulsed teeth by soaking them in HBSS for 30 minutes prior to replantation. In these studies, dog's teeth were extracted and left to dry for 30, 45, and 60 minutes and then soaked in HBSS for 30 minutes. (*Endod Dent Traumatol* 1990;6:37.) These teeth showed 50 percent less root damage following replantation. HBSS also has the capability of reconstituting lost cell nutrients. Because a cell that has been cut-off from its blood supply depletes its stored metabolites after 15 minutes, a tooth that has been extraoral for one hour has 45 minutes less vital cells to reconnect with the bone ligament cells. By soaking these teeth in HBSS, some of the lost metabolites will be replaced, increasing the chance of a successful replantation.

By having optimum storage devices available for avulsed teeth storage and transportation, emergency physicians will have the best possible condition for the replantation procedure. The physician will be able to prevent cell crushing while providing atraumatic cleansing and replenish lost cell metabolites for up to 24 hours. This will allow them to preserve avulsed teeth until more serious injuries are treated and until a dentist can be called to replant the teeth.

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