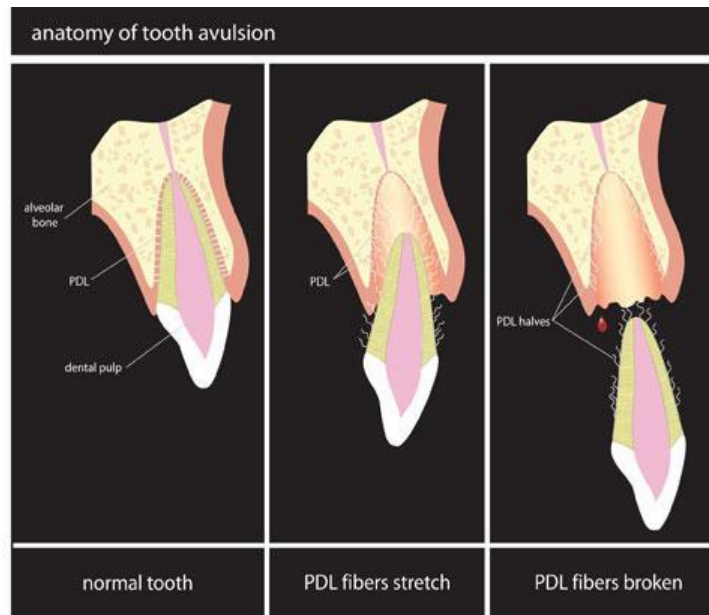


Tooth Avulsion

Tooth avulsion is the complete displacement of a tooth from its socket in alveolar bone owing to trauma.¹ The treatment for permanent teeth consists of replantation, immediately if possible. Deciduous teeth should not be replanted due to the risk of damaging the permanent tooth germ. Immediate replantation ensures the best possible prognosis but is not always possible since more serious injuries may be present. Studies have shown that teeth that are protected in a physiologically ideal media can be replanted within 15 minutes to one hour after the accident with good prognosis. The success of delayed replantation depends on the vitality of the cells remaining on the root surface. In normal conditions, a tooth is connected to the socket by means of the periodontal ligament. When a tooth is knocked out, that ligament stretches and splits in half.² Maintaining the vitality of the cells that remain attached to the root surface is the key to success following replantation. Years ago, it was thought that the key to maintaining root cell vitality was keeping the knocked-out tooth wet,³ thus giving rise to storage media recommendations such as water, the mouth and milk. Recent research has shown that one of the



key elements for maintaining vitality is storing the tooth in an environment that closely resembles the original socket environment. This environment is one that has the proper osmolality (cell pressure), pH, nutritional metabolites and glucose. There are scientifically designed storage media that provide this environment. These storage media are now available in retail products. Use of devices that incorporate the ideal storage media and protective apparatuses have increased the success rate of replanted knocked-out teeth to over 90% when used within sixty minutes of the accident.

¹ Zadik Y, Levin L (February 2009). "Oral and facial trauma among paratroopers in the Israel Defense Forces". *Dent Traumatol.* **25** (1): 100–102. [PMID 19208020](https://pubmed.ncbi.nlm.nih.gov/19208020/). [doi:10.1111/j.1600-9657.2008.00719.x](https://doi.org/10.1111/j.1600-9657.2008.00719.x).

History

The first reported cases of knocked-out teeth being replanted was by Pare' in 1593. In 1706, Pierre Fauchard also reported replanting knocked out teeth.

Wigoper in 1933 used a cast gold splint to hold reimplanted teeth in place.

In 1959, Lenstrup and Skieller² declared that the success rate of replanted knocked out teeth should be considered a temporary procedure because the success rate of less than 10% was so poor.

In 1966^{3 4} In a retrospective study, Andreasen theorised that 90% of avulsed teeth could be successfully retained if they were replanted within the first 30 minutes of the accident. In 1974, Cvek⁵ showed that removal of the dental pulp following reimplantation was necessary to prevent resorption of the tooth root.

In 1974, Cvek showed that storage of knocked out teeth in saline could improve the success of replanted teeth.

In 1977, Lindskog et al⁶ showed that the key to retention of the knocked-out teeth was to maintain the vitality of the periodontal ligament.

In 1980, Blomlof showed that storing the periodontal ligament cells in a biocompatible medium could extend the extra oral time to four hours or more. He found that the best storage medium was a medical research fluid called Hank's Balanced Solution. In this study, it was serendipitously discovered that milk could also maintain cell viability for two hours.

² Lenstrup K, Skieller V. A follow-up study of teeth replanted after accidental loss *Acta Odontol Scand* 1959;17:503-9

³ Andreasen JO, Hjørtting-Hansen E. Replantation of teeth: I. Radiographic and clinical study of 110 human teeth replanted after accidental loss. *Acta Odontol Scand* 1966;24:263-86

⁴ Andreasen JO, Hjørtting-Hansen E. Replantation of teeth: II. Historical study of 22 replanted anterior teeth in humans. *Acta Odontol Scand* 1966;24:287-306.

⁵ Cvek M, Granath L-E, Hollander L. Treatment of non-vital permanent incisors with calcium hydroxide: III. Variations of occurrence of ankylosis of reimplanted teeth with duration of extra-alveolar period and storage environment. *Odont Revy* 1974;25:43-6

⁶ Lindskog S, Peirce AM, Blomlof L, Hammarstrom L. The role of the necrotic periodontal membrane in cementum resorption and ankylosis. *Endod Dent Traumatol* 1985;1:96-101

In 1981, Andreasen⁷ showed that crushing of cells on the tooth root could cause death of the cells and lead to resorption and reduction in prognosis.

In 1983, Matsson et al.^[51] showed that soaking in Hank's Balanced Solution for thirty minutes prior to reimplantation could revitalise extracted dog's teeth that were dry for 60 minutes.

In 1989,⁸ a systematic storage device was developed to optimally store and preserve knocked out teeth.

In 1992, Trope et al.⁹ showed that extracted dog's teeth could be stored in Hank's Balanced Solution for up to 96 hours and still maintain significant vitality. In this study, *milk was only able to maintain vitality for two hours.*

Prevention

The best method for the prevention of knocked-out teeth is the use of helmets and mouth protectors.

Mouth protectors can be very inexpensive, however, the compliance rate for their use is poor.

Studies have shown that, even when mandated, athletes and other high risk individuals often will not use them. Also, even with their use, mouth guards can be knocked-out, leaving the user unprotected.

Management

⁷ Andreasen JO, Kristersson L. The effect of limited drying or removal of the periodontal ligament: periodontal healing after replantation of mature permanent incisors in monkeys. Acta Odontol Scand 1981;39:1-3.

Andreasen JO. A time-related study of root resorption activity after replantation of mature permanent incisors in monkeys. Swed Dent J 1980;4:101-10.

Andreasen JO. Relationship between cell damage in the periodontal ligament after replantation and subsequent development of root resorption: a time-related study in monkeys. Acta Odontol Scand 1981;39:15-25.

⁸ Krasner P, Rankow H, Ehrenreich A. Apparatus for storing and transporting traumatically avulsed teeth. Compend Cont Dent Educ 1989;10:232-7.

⁹ Trope M, Friedman S. Periodontal healing of replanted dog's teeth stored in ViaSpan, milk, Hank's balanced salt solution. Endo Dent Traumatol 1992;8:183-8.

Dental avulsion is a real dental emergency in which prompt management (within 20–40 minutes of injury) affects the prognosis of the tooth. The avulsed permanent tooth should be gently but well rinsed with saline, with care taken not to damage the surface of the root which may have living periodontal fibre and cells. Once the tooth and mouth are clean an attempt can be made to re-plant in its original socket within the alveolar bone and later splinted by a dentist for several weeks.

Failure to re-plant the avulsed tooth within the first 40 minutes after the injury may result in a less favourable prognosis for the tooth. If the tooth cannot be immediately replaced in its socket, follow the directions for Treatment of knocked-out (avulsed) teeth and cold milk or saliva and take it to an emergency room or a dentist. If the mouth is sore or injured, cleansing of the wound may be necessary, along with stitches, local anaesthesia, and an update of tetanus immunisation if the mouth was contaminated with soil. Management of injured primary teeth differs from management of permanent teeth; an avulsed primary tooth should not be re-planted (to avoid damage to the permanent dental crypt).¹⁰

Although some dentists advise that the best treatment for an avulsed tooth is immediate replantation,¹¹ For a variety of reasons this can be difficult for the non-professional person. The teeth are often covered with debris. This debris must be washed off with a physiological solution and not scrubbed. Often multiple teeth are knocked-out and the person will not know which socket an individual tooth belongs to. The injured victim may have other more serious injuries that require more immediate attention or injuries such as a severely lacerated bleeding lip or gum that prevent easy visualisation of the socket. Pain may be severe and the person may resist replantation of the teeth. People may, in light of infectious diseases (e.g. HIV), fear handling the teeth or touching the blood associated with them. If immediate replantation is not possible, the teeth should be placed in an appropriate storage solution and brought to a dentist who can then replant them. The dentist will clean the socket, wash the teeth if necessary, and replant them into their sockets. He will splint them to non-knocked-out teeth for a maximum of two weeks for teeth with normal alveolar process and bone support. Properly handled, even replantation of periodontally compromised permanent teeth in older patients under good maintenance have been reported, with splinting extending for over 4 weeks due to the reduced support structure for

¹⁰ Flores MT, Malmgren B, Andersson L, et al. (The International Association of Dental Traumatology) (August 2007). "Guidelines for the management of traumatic dental injuries. III. Primary teeth". *Dent Traumatol.* **23** (4): 196–202. [PMID 17635351](#). [doi:10.1111/j.1600-9657.2007.00627.x](#).

¹¹ American Association of Endodontists. Recommended guidelines for the treatment of the avulsed permanent tooth. Chicago, Ill: 2008.

the root due to periodontal disease.^[13] One week to ten days after the replantation, the dental pulps of the replanted teeth should be removed and a root canal treatment completed within two months.

In addition, as recommended in all dental traumas good oral hygiene with 0.12% chlorhexidine gluconate mouthwash, a soft and cold diet, and avoidance of smoking for several days may provide a favourable condition for periodontal ligaments regeneration.

Biologic basis for success of replantation following avulsion

Every tooth is connected to its surrounding bone by the periodontal ligament. The tooth receives its nourishment through this ligament. When a tooth 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, since it remains connected to the bone blood supply, is naturally kept alive. However, the ligament cells that remain on the tooth root lose their blood and nutrition supply and must be artificially maintained. They must be protected from two potentially destructive processes: cell crushing and loss of normal cell metabolism. All treatment between the time of the accident and the ultimate replantation must be focused on preventing these two possibilities.

Prevention of cell crushing

When teeth are knocked-out, 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 be traumatised. Since the cells remaining on the tooth root are very delicate, additional trauma to the tooth root cells must be avoided so as to avoid more tooth root cell crushing. This damage can occur while picking the tooth up and/or during transportation to the dentist.

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. Any attempt to clean off any debris should be avoided. Debris should always be washed off gently with, at the very least, a physiologic saline. Even with the use of a physiologic saline, the “scrubbing” of the tooth



root to remove debris must be avoided. When placed in a physiologic solution, the tooth should be gently agitated to permit the cleansing of the tooth root. At the same time that this agitation occurs, the bumping of the tooth root against a hard surface such as glass, plastic or even cardboard must also be avoided. For the same reasons, the method in which the knocked-out teeth are transported must be carefully selected. Placing the knocked-out teeth in transporting vehicles such as tissues and handkerchiefs can be damaging and transporting them in glass or cardboard containers can also be potentially damaging to the cells. In addition to the potential damage that the hard surface can cause, glass containers have the added possibility of breakage or leakage of the physiologic storage fluid. If the glass container does not have a tightly fitting top, then during the transportation, the physiologic storage solution can spill out and the teeth can fall, once again, on the floor and, at the same time, be out of a physiologic environment.

Maintenance of normal cell metabolism

Normally metabolising tooth root cells have an internal cell pressure (osmolality) of 280-300 mOs and a pH of 7.2. When there is an uninterrupted blood supply, all of the metabolites (calcium, phosphate, potassium) 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^[16] most of the stored metabolites have been depleted and the cells will begin to die. Within one to two hours, enough cells will die that rejection of the tooth by the body at a later time is the usual outcome. The method by which the body rejects the replanted tooth is a process called “replacement root resorption”.^[4] During this process, the tooth root cells become necrotic (dead) and will activate the immunologic mechanism of the body to attempt to remove this necrotic layer and literally eats away the tooth root. This is called “root resorption” . 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 will eventually fall out. In growing children, this can cause bone development problems because the replacement resorption (also termed ankylosis) attaches the tooth firmly to the jaw bone and stops normal tooth eruption and impedes normal jaw growth.

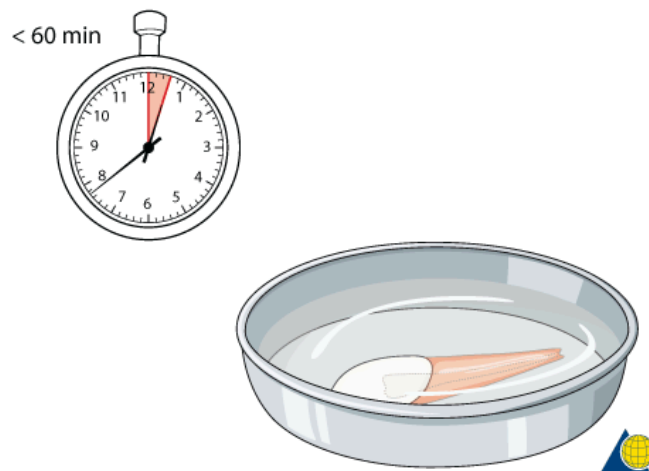
Research has shown that the critical factor for reduction of the death of the tooth root cells and the subsequent root replacement resorption following reimplantation of knocked-out teeth is maintenance of normal cell physiology and metabolism of the cells left on the tooth root while the tooth is out of the socket.^[2] In order to maintain this normalcy, the environment in which the teeth are stored must supply the optimum internal cell pressure, cell nutrients and pH.

Storage media

There are many storage media available for knocked-out tooth storage. The most often recommended are: saliva, physiologic saline, milk and pH balanced cell preserving fluids. Water and ice have been shown to damage the tooth root cells,

and as such, avulsed teeth should never be stored in them.¹² The osmolality and pH of water and ice is very low (7-17mOs) compared to normal cell pressure (280 mOs). When a knocked-out tooth is placed in water, the cells attempt to equalise with the surrounding environment, the cell fluid tries to move to the outside pressure environment and bursts. Water with table salt in it is damaging to the knocked out teeth.

Saliva, that is placing the tooth under the accident victim's tongue or in the cheek, has been



recommended. Saliva, as a storage media, causes twice as much damage as water. Its osmolality is very low, causing bursting of the tooth root cells, but additionally, because saliva is filled with its normal flora of microorganisms, it will severely infect the tooth root cells. When the tooth is replanted, not only will the cells be necrotic but they will also infect the bone socket.^[2] Physiologic saline has a fairly compatible osmolality and will not cause cell swelling but it lacks the metabolites and glucose necessary for maintenance of normal cell metabolism.^[15]

Milk has been also recommended as a storage medium for avulsed teeth. Its advantage is the high availability of fresh whole milk. Only whole milk can be used for tooth preservation. Skim milk and heavy cream do not have the correct fluid pressure and will cause damage to the root cells. Milk has no observed regenerative properties for cells on knocked out teeth.

¹² Blomlof L. Milk and saliva as possible storage media for traumatically exarticulated teeth prior to replantation. Swed Dent J 1981;[suppl 8]1-25

It was discovered 30 years ago that milk was less damaging to knocked out teeth than water or saliva. It was recommended because it has a compatible osmolality (fluid pressure) to tooth root cells and it is thought to be readily available. However, like physiologic saline, milk lacks the necessary metabolites and glucose necessary to maintain normal cell metabolism of the tooth root cells.^[15] The cells on knocked-out tooth roots in milk do not die immediately but are unable to replicate (mitosis) and so are less able to reform new cells when replanted.

The most optimum storage media that are available have been shown to be 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, phosphate ions, K⁺ and glucose that are necessary to maintain normal cell metabolism for long periods of time.^[15] HBSS has been extensively tested in dental and medical research for the past twenty years. This research has shown that 90% of cells stored in HBSS for 24 hours maintain their normal viability and after four days, still have 70% viable. In research studies, extracted dog's teeth that have been placed in HBSS for four days can still be replanted with little signs of resorption.^[30] Hank's Balanced Salt Solution is found in a Save-A-Tooth, a storage device for the storage, preservation, and regeneration of tooth root cells.

HBSS also has been shown to be capable of replacing lost cell metabolites. Since a cell that has been cut off from its blood supply depletes its stored metabolites after fifteen minutes, a tooth that has been extra-oral for one hour has less vital cells to reconnect with the bone ligament cells. Some studies in dental research have shown that knocked out teeth that have been dry for up to one hour will have less resorption if they are soaked in a HBSS for 30 minutes prior to replantation. In these studies, dog's teeth were extracted and left dry for 30, 45 and 60 minutes and then soaked in HBSS for 30 minutes and then reimplanted. These teeth showed 50% less replacement resorption following reimplantation. It has also been shown that keeping the teeth cold while in the HBSS does not affect success.

Many other types of storage liquids have been tested such as powdered milk, Enfamil, Gatorade, and contact lens solution. All of them have been shown to either be ineffective or damaging to the avulsed tooth.

Prognosis

The long-term prognosis of replanted knocked out teeth is very variable. The treatment for knocked-out teeth has progressed from a success rate of 10% to over 90%. However, this success rate can only be achieved with the institution of optimum care within fifteen minutes to an hour of the accident. In the case of knocked-out teeth, being prepared and knowing what to do can mean the difference between a person retaining or losing replanted

knocked-out teeth for life. Teeth that have been knocked out when they are fully matured, that is, when the root has completely formed, have a much better prognosis than those teeth that are immature and not fully formed. This is due to the fragility of the root. When teeth have not fully formed, the walls of the root are thinner and thus more fragile. Another complication for the prognosis is the length of time that the tooth has been out of its socket. Teeth that are replanted within fifteen minutes of the accident have an excellent prognosis. Teeth that have been extra-oral and dry stored for more than one hour have a poor prognosis. Teeth that have been placed in an optimal storage medium within one hour of the accident also have an excellent prognosis. All teeth that have been knocked out should be replanted but watched carefully for the development of root resorption. Teeth that do not have root canal treatment within two weeks of replantation also have a poor prognosis.

Epidemiology

Research has shown^[41] that there are five million teeth knocked-out each year in the United States.

Up to 25% of school-aged children and military trainees and fighters experience some kind of dental trauma each year.^{[1][2][2]} The incidence of dental avulsion in school aged children ranges from 0.5 to 16% of all dental trauma. Many of these teeth are knocked-out during school activities or sporting events such as contact sports, football, basketball, and hockey. It is important for anyone who is related, working, or witnessing sports that they be educated on this subject matter. Being educated could aid in minimising injuries that could do further harm to the victim. Being informed and spreading awareness of dental avulsion in the state of knowledge, treatment, and prevention could make an impact.

Why do you put an avulsed tooth in milk?

Milk has been also recommended as a storage medium for **avulsed teeth**.

It was discovered 30 years ago that **milk** was less damaging to knocked out **teeth** than water or saliva. It was recommended because it has a compatible osmolality (fluid pressure) to **tooth** root cells and it is thought to be readily available.



How long do you splint an avulsed tooth?

Verify the normal position of the replanted tooth clinically and radiographically. Apply a flexible splint for up to **2 weeks**. Administer systemic antibiotics. Tetracycline is the first choice (Doxycycline 2x per day for **7 days** at appropriate dose for patient age and weight).

What is subluxation of the tooth?

Dental subluxation is a traumatic injury in which the **tooth** has increased mobility (i.e., is loosened) but has not been displaced from its original site in the jawbone.

What is a fracture in a tooth?

Related Conditions. Teeth are remarkably strong, but they can chip, crack (fracture) or break, which can cause nerve damage and any associated discomfort. Also, based on what caused the cracked tooth, a filling or crown may have become **dislodged** or lost completely.

Can you put your teeth back in?

That is why all avulsed **teeth** will need a root canal. However, the bone **can** reattach to the root of the **tooth** once it's **put back** into place. The odds of saving a **tooth** are highest in young children, but adult **teeth can** be saved as well. Only permanent **teeth** should be re-implanted.

What do you do if you knock out a tooth?

Knocked-Out Teeth

1. More than five million teeth are knocked out every year in children and adults. ...
2. Pick up the tooth by the crown (the chewing surface) NOT the root. ...
3. If dirty, gently rinse the tooth with water. ...
4. Reposition the tooth in the socket immediately, if possible. ...
5. Keep the tooth moist at all times.

What is a dislodged tooth?

Dislodged Teeth. A **dislodged**, or luxated, **tooth** is one that has been partially pushed into or out of its socket, or sideways, during an injury. If this has happened to you, see your dentist or endodontist as soon as possible to stabilise the **tooth**.

What do you do when your tooth falls out?

Hold the **tooth** only by the crown (chewing edge). You can take the **tooth** to the dentist in 1 of these ways: Try to place the **tooth** back in **your** mouth where it **fell out**, so it is level with other **teeth**. Bite down gently on a gauze or a wet tea bag to help keep it in place. Feb 22, 2016

Why is it recommended to put a knocked out tooth in milk?

"**Milk** is a good medium for storing **knocked-out teeth** because cells from the root surface don't swell up and burst as they **do** when placed in water. It contains proteins which keep a constant acid to alkaline ratio, antibacterial substances as well as sugars to keep cells growing.

What is trauma to a tooth?

Dental **trauma** refers to **trauma (injury)** to the **teeth** and/or periodontium (gums, periodontal ligament, alveolar bone), and nearby soft tissues such as the lips, tongue, etc. The study of dental **trauma** is called dental traumatology.

Can a fractured tooth be saved?

Vertical root **fractures** are often discovered when the surrounding bone and gum become infected. Treatment may involve extraction of the **tooth**. However, endodontic surgery is sometimes appropriate if a **tooth can be saved** by removal of the **fractured** portion.

Can a fractured tooth be saved?

Vertical root **fractures** are often discovered when the surrounding bone and gum become infected. Treatment may involve extraction of the **tooth**. However, endodontic surgery is sometimes appropriate if a **tooth can be saved** by removal of the **fractured** portion.

What is a displaced tooth?

A **displaced tooth** can also be pushed forward, backward, sideways, or rotated. The sooner the dentist can splint or realign the **tooth** with orthodontic brackets and wires, the easier it can be brought back into proper alignment. Trauma significant enough to cause **tooth displacement** can also lead to pulp injury.