

Dental Surgery Department, Medical University of Lublin

WITOLD KUROCZKO, ANNA M. SZYSZKOWSKA

Teeth reimplantation

One of the main goals in dentistry is to preserve the greatest possible number of teeth during the human lifetime. This task is realized through prophylactic measures, preventive and restorative treatment of dental caries and teeth trauma sequel and also through periodontal and surgical procedures. The latter ones are of particular significance in cases of chronic apical periodontitis, when endodontic treatment proved ineffective. Surgical methods also create a chance for teeth translocation in the dental arch in order to replace a singular edentulous space as a complement for orthognathic surgery, or as an alternative for prosthetic and implant treatment. The temporary method of replacing singular tooth loss in patients during the developmental stage creates convenient conditions for the final or permanent replacement of these spaces after the end of skeletal development. Autogenous tooth transplantation is a procedure during which a tooth in derent dental developmental stages is transplanted into the same alveolar socket from which it was extracted, avulsed or into a surgically prepared space. The possibility of complications leading to the tooth loss is the basic factor which limits the popularity and universality of these procedures. Such complications include progressive root resorption, ankylosis, epithelial ingrow deep into the periodontal ligament space, periodontitis and infections. Increasing understanding of the biological basis of surgical procedures, knowledge of the requirements of the correct course of regeneration and reparation processes, improvement of procedure techniques, access to new materials and technology lead to a conclusion that autogenous tooth transplant is becoming the method of choice available and used in different clinical situations as a practical and predictable method.

This category of procedures from the point of view of similar integration process includes:

1. Replantation (reimplantation), which is the reinsertion of the tooth into the alveolus, from which it was dislocated or avulsed as a result of a trauma, accidental or unintentional extraction.

2. Autotransplantation, in which a tooth is extracted form one location and inserted into another to replace a missing tooth, in the mandibular or maxillary alveolus.

3. Intra-alveolar tooth transplantation, in other words, surgical repositioning of a tooth in its alveolar socket. It includes: a) surgical extrusion in which the tooth is pulled out from the alveolar socket and fixed in the new position, b) surgical uprighting and rotating of inclined tooth to bring into prominence the submerged subgingival margin (mesial and distal), c) segmental tooth repositioning (surgical extraction) of impacted tooth and fixation in the correct position in the dental arch after surgical preparation (correction) of the alveolar socket.

4. Intentional replantation, which means deliberate tooth extraction for treatment and reinsertion into the same alveolar socket: a) extra-alveolar tooth resection, b) extra-alveolar repositioning and fixation of fragments of the fractured tooth.

Replantation (reimplantation) is a procedure carried out after tooth avulsion caused by trauma, less frequently caused by iatrogenic effects such as: accidental extraction following orthodontic indications, or unintentional extraction during the replacement of temporary prosthesis. Tooth avulsion accounts for 0.5–16% of traumatized permanent teeth and 7–13% of traumatized deciduous teeth, frequently accompanied by lips and soft tissues injuries or laceration, as well as alveolar bone fracture, therefore requiring radiographic evaluation. Tooth avulsion is more common in patients aged 7 to 10 years. It usually affects individual teeth, especially the upper central incisor. Sometimes avulsion of two or more teeth can occur simultaneously.

Causes of dental trauma are: accidental falls, hitting a hard object, beating or epileptic seizure. This type of trauma occurs most often during sport activities. No doubt that malocclusion is the promoting factor of dental trauma, particularly disto-occlusion with protrusion of maxillary incisors (10,14). Tooth and alveolar socket preparation, replantation process, fixation and protection of the replanted tooth influence the prognosis of the procedure, but must be adopted to already existing conditions. These conditions are not always typical and easy, obliging the doctor into recognition of undertaken solutions as temporary, transitional – the patient and his/her guardian should be informed about it. It may take 4 to 7 years on average for the patient with replanted teeth to grow up and be ready for implant and prosthodontic treatment. The replanted tooth, which serves as a space maintainer, provides functional, phonetic, and esthetic benefits (3). Root ankylosis, however, can occur in a young patient as a complication of these procedures. The tooth remains in an immobile position, therefore disturbing and preventing the growth of the alveolar process (ridge). In such a case the tooth has to be extracted. Patients must be under constant planned control and observation including both oral hygiene instructions and control, because failure can also be a result of hygienic mistakes such as replanted tooth caries (2).

FACTORS AFFECTING THE PROGNOSIS OF REPLANTATION

The extra-alveolar period from the moment of trauma until the moment of insertion into the alveolar socket. Generally, it is assumed that the smaller the extra-oral period of the tooth the greater the chance of healing. A number of authors suggest that it should not exceed a 30-minute-limit. Adreassen considered that if the replantation was carried out within 30 minutes after avulsion, root resorption would occur in 10% of cases. This percentage increases however up to 95% if the replantation was carried out after more than 2 hours from the moment of trauma (1, 4, 13). The vitality of the periodontal ligament (PDL) cells on the root surface depends on the extra-oral period. It guarantees the regeneration of its scanning elements as well as the healing of bone and epithelial attachment. According to the American Association of Endodontists (AAE) the tooth with an extra-oral time of less than 2 hours, should be replanted immediately after rinsing it with physiologic saline. In case of extra-oral time exceeding 2 hours the tooth should be stored in a sodium fluoride solution for 5–20 minutes, and then inserted into the alveolar socket after rinsing it with saline (8,11). The vitality and regeneration of the root surface PDL cells depend on the storage media. The extra-alveolar dry storage provokes permanent damage to the PDL cells. Root resorption and ankylosis are the result of the death of PDL cells. A posttraumatic extra-oral dry time of less than 30 minutes causes death to more than half of the root surface PDL cells, and an extra-oral dry time of more than 120 minutes causes the death of the majority of the PDL cells. The prognosis for avulsion is best if the tooth is inserted immediately after trauma into the alveolar socket. It must be done by the patient himself or by his/her guardian. However, if that is not possible, the tooth must then be placed in a physiological storage media which must be moist with a pH and osmolarity compatible with that of the vital cells (pH 7.2; osmolarity 320 mOsm/kg) and must contain ions essential for the PDL cells metabolism (4).

1. Isotonic sodium chloride solution is the most recommended one because of its availability. A sterile gauze moisten with saline or salt water container.

2. Avulsed tooth may be stored under the tongue or in the buccal vestibule of the patient or the guardian. However, danger of swallowing or aspiration into the respiratory tract exists. Studies show that when the tooth is kept too long in the saliva, it causes swelling and death to the PDL cells (2–3 hours). Some authors consider saliva to be an unfavorable storage media because of the presence of bacteria which may lead to infection of the PDL cells.

3. Pasteurized milk is easy to obtain, it has a compatible pH and osmolarity and is relatively bacteria free. The disadvantage is the acidity developing with the time passing.

4. Antibiotic solution, for example Ringer's solution with an addition of antibiotics like penicillin, amoxicillin, bacitracin, neomycin sulfate.

5. Tap water is not advised because it results in undesirable and hypotonic rapid cell lysis of the PDL cells.

6. Dentosafe – a tooth rescue box containing a physiologic nutrients enriched in antibiotics and antifungal drugs, Save-A-tooth, Biologic Rescue Products, ETPS (Emergency Tooth Preserving System) – containing a plastic box and a basket immersed in Hank's solution.

7. Storage solutions for contact lenses (Soft Wear, Opti Free, Solo Care) are also used in less than one hour before replantation (4).

Storage media, temperature, contamination level, damage extent undergone by the avulsed tooth have a direct influence on the success of the procedure. The greater the damaging factors the smaller the chances for success of replantation. If the tooth shows signs of considerable damage and contamination, and the PDL tissues are dry and necrotic, then the tooth must not be replanted. Even if acute or subacute inflammatory response does not occur after a short period, the survival time of the tooth will be no longer than 1–3 years. The second essential factor is the extent of damage to the bone structures and soft tissues. Destruction of the alveolar socket walls significantly impedes the preservation of the replanted tooth. Its stability in the first period is necessary for the progress of reparation and regeneration procedures, which is provided primarily by the immobilization due to the alveolar socket walls. Restoring tissues to their original position, accurate and precise surgical provision of soft tissues guarantee proper healing of the alveolar socket and periodontium. The status of the root apex is also a prognostic factor for replanted teeth. The younger the patient with immature permanent vital teeth and open apices, the better will be the prognosis of the replantation procedure. Immature permanent teeth with open apices and an apical foramen diameter $> 1\text{mm}$, replanted within 2 hours of the trauma, have better chances of revascularization, healing of the pulp and later on apexogenesis. Replanted teeth must be splinted for 3–4 weeks for secondary revascularization to occur in comparison with a shorter splinting time for teeth with developed roots and closed apex. Radiographic control 2–3 weeks after the trauma is advised to check if root resorption or bone inflammation has occurred. Endodontic treatment should be initiated, and calcium hydroxide $\text{Ca}(\text{OH})_2$ should be placed in the prepared root canal to encourage the apexification, whenever there is radiographic evidence of root resorption. Calcium hydroxide $\text{Ca}(\text{OH})_2$ compounds reveal perfect antibacterial and odontotropic properties. They promote bone healing and regeneration and prevent root resorption by stimulating the pulp and periodontal tissues to form a mineralized tissue barrier closing the apical lumen. Treatment by means of calcium hydroxide should last for about a year or less until apical closure or apical development takes place. Gutta percha is used for definitive root canal filling (5, 6, 7).

MTA (Mineral Trioxide Aggregate) is used as an alternative method, placed at the end of the canal during 1 month of $\text{Ca}(\text{OH})_2$ application, with simultaneous obturation with Gutta Percha (9).

METHODS FOR TOOTH REPLANTATION AND FURTHER TREATMENT

To provide long-term survival of the avulsed tooth, skilful and delicate handling is needed. Right before insertion into the alveolar socket, it is advised to clean the tooth by immersion, rinsing with physiologic saline, being careful not to damage the periodontal ligament. Manipulation, mechanical cleaning or disinfection is not allowed. The tooth should only be held by the crown, without touching the root surface. After the application of local anesthesia, the alveolar socket, as well as the alveolar bone, should be thoroughly examined. If the tooth was contaminated with dirt, then tetanus prophylaxis is required. Before insertion into the alveolar socket, blood clot should be removed by gentle aspiration and careful irrigation with physiological saline. The socket must not be curetted in order to preserve what has left of the periodontal ligament tissue. The avulsed tooth can be stabilized using different materials. Non-rigid splinting must be used to allow for physiologic tooth mobility, which provides proper healing of the periodontium, and promotes fibrous instead of osseous junction with the alveolar socket. Splinting of the avulsed tooth is accomplished by use of an acid-etch/composite resin restorative material that adheres to both the flexible, medium rigidity wire (for example braided orthodontic wire) and the enamel labial surface of teeth directly adjacent to the avulsed tooth; the number of splinted teeth must be as small as possible. The splinting system should allow for proper oral hygiene; the splint should not be placed too close to the gingival margin or near the roots. Ligature wire splints should not be used because they slide towards the gingiva and damage the cementum and the

periodontium; the same applies for extensive acrylic or composite splints because they worsen the oral hygiene conditions. The immobilization system should be easy to remove. Removal should be done with extreme caution without damaging the injured periodontal tissues (12, 14).

Recommended splinting periods after replantation. According to the majority of authors, a period of 7–14 days is required for teeth replanted immediately after the trauma. Teeth with immature (undeveloped) roots require a period of 3–4 weeks, to ensure tissue revascularization. In cases of extra-oral dry time longer than 30 minutes, the necrotic periodontal ligament should be gently removed without damaging the cementum and the vital remains of the PDL, the tooth is then treated chemically (immersed for 5 minutes consecutively in sodium hypochlorite, citric acid, stannous fluoride and doxycycline-antibiotic solution and then splinted for 4–6 weeks. This technique aims not only to destroy the PDL, which has a little chance of regeneration and reparation, but also to protect the cementum from excessive resorption caused by micro-cavities of the PDL.

A period of 6–8 weeks is indicated in case of alveolar socket walls fracture, mobility, and fracture of the alveolar bone. A tooth splinted for too long in an unfavorable position using a rigid splinting device can traumatize the PDL and cause root resorption. Provoked alveolar socket trauma to the periodontal ligament, by pressure mechanism, necrosis, and later on inflammatory processes, lead to the destruction of the protective root barrier composed of decalcified organic layer of the cementum (cementoid) in direct contact with Sharpey's collagen fibers. Damage to the unprotected root surface barrier leads to the mobilization and activation of the resorption cells, which activate the resorption process leading to the failure of the replantation procedure (4, 8, 15).

It is of great importance for each replantation procedure to check the occlusal conditions in order to eliminate any possible interference of the tooth with jaw movements and occlusion. The occlusion is regularly checked at every check-up visit, incorrect and undesirable contacts are eventually eliminated. In reasonable cases for example multiple teeth avulsion, occlusal splint of the opposite dental arch is required, effective especially during sleep.

Endodontic treatment or root canal treatment is essential for the progress of the healing process of the replanted tooth. According to the majority of authors, best results are obtained when the tooth is immediately, without being endodontically treated, inserted into the alveolar socket. Root canal treatment is provided intra-orally only after splinting. Currently there is no doubt about the necessity of endodontic treatment of the tooth with closed apex. If the necrotic pulp is left for too long inside the root canal, it will cause inflammatory complications, and the risk of failure is bigger than the possibility of pulpal revascularization, which is practically impossible for a mature tooth. It is believed that the infection from the root canal pulp reaches the PDL tissue through the infected dentinal tubules causing irritation and inflammatory root resorption. Some authors consider that it is necessary to extirpate the pulp, prepare, and fill the canal with calcium hydroxide directly after splinting on the same day of the tooth replantation. Skilful and delicate operator can then minimize the severity of the trauma to the regenerating PDL. Others disagree and consider that tooth manipulation and useless prolongation of the treatment procedure especially when the patient is nervous, anxious and sometimes with soft tissue laceration, is unnecessary and causes the inaccuracy of the endodontic treatment. They also take notice of the undesirable mechanism of action of $\text{Ca}(\text{OH})_2$ during the first period of the PDL healing. If $\text{Ca}(\text{OH})_2$ penetrates through the apical foramen, it will interfere with the regeneration of the PDL fibers (12).

Endodontic treatment and the temporary $\text{Ca}(\text{OH})_2$ filling of the canal should start 1–2 weeks after replantation, while the tooth is still splinted and the development process of new ligaments is already at an advanced state. Scientific studies show that directly after replantation, a blood clot and signs of proliferating connective tissue cells between the two separated PDLs can be seen. One week later, a new epithelial attachment can be seen at the dentin-enamel junction; two weeks later, the presence of multiple new collagen fibers extending from the surface of the cement to the alveolar bone can be distinguished. Permanent filling

of the canal with gutta percha is carried out 1–2 months after the procedure (12). The majority of the authors prefer to provide an antibiotic prophylactic cover (Penicilline derivatives for 4–7 days) and anti-inflammatory drugs, and in case of extra-oral contamination of the avulsed tooth, antitetanus prophylaxis is necessary. The patient should be informed about the necessity of maintaining a proper oral hygiene, and to avoid touching the tooth, as well as about the use of a light diet. Follow up and check-up visits are appointed the next day after the procedure, and every 3–4 day until the removal of the splint; then, once a week for two months until the final and definitive root canal obturation, and finally once every 6 months.

Systemic complications after replantation are rare, and include bacterial infection and tetanus. Local complications occur more frequently and include: discoloration of tooth crown, pulp necrosis, internal root resorption, ankylosis, epithelial ingrow deep into the periodontal ligament space and periapical inflammations. Delayed tooth replantation after a long extra-oral period, improper storage as well as prolonged or inappropriate splinting, result in PDL cells necrosis causing root resorption. Resorption can also be a result of pulp necrosis and penetration of its toxins or its breakdown products through the dentinal tubules into the periodontal tissue leading to the formation of resorption lacunae. Resorption is the most frequently occurring complication after tooth replantation. Three types of resorption are distinguished:

1. Surface root resorption. Characterized by superficial lacunae, covering the root cementum and the exterior layer of the dentine with no signs of any inflammatory reaction in the adjacent PDL space. Superficial resorption lacunae cover the cementum as a result of reparation processes. These lesions are not noticed radiographically.

2. Replacement resorption, also known as progressive ankylosis. It occurs when the dental tissues are gradually replaced by bone tissue; two types are distinguished: progressive which constantly and slowly progresses and probably is associated with significant PDL tissue damage, and transient, when the process of ankylosis becomes slow and resorbed and healthy PDL tissue is produced. Clinical examination of the replacement resorption reveals absence of physiologic tooth mobility and a high percussion sound. It can be radiographically noticed two months after the replantation, most frequently one year after replantation.

Dentoalveolar ankylosis is also identified, which is the fusion of the tooth to the underlying alveolar bone with no signs of dental tissue destruction. Radiographically there is absence of periodontal ligament (PDL) space.

3. Inflammatory resorption. Characterized by extensive resorption lacunae. The cementum and dentine adjacent to the inflammatory lesion of the PDL undergo resorption. Its progress can be rapid and may lead to total root resorption in a matter of months, it occurs most frequently in children. Radiographically it can be noticed two weeks after tooth replantation in the apical 1/3 of the root (4, 13, 14).

CONCLUSIONS

The following should be remembered if a successful replantation is to be performed: 1) The avulsed tooth must not show signs of any advanced disease processes, including periodontal diseases; 2) alveolar socket must be undamaged; 3) there must be no orthodontic contraindications, for example significant crowding; 4) the tooth must be appropriately stored in the best physiological storage media before replantation. It is unacceptable to place the tooth in a dry environment; 5) extra-oral period should not exceed the two-hour-limit; this has an unfavorable impact on the prognosis; 6) adequate evaluation of tooth development. It is possible to restore the vitality of the pulp in teeth with open apices if the replantation is performed in less than 2 hours after the trauma. 7) teeth with necrotic PDL cells are replanted after root surface preparation and root canal treatment; 8) root resorption always occurs following PDL cells necrosis of the avulsed tooth; 9) it is recommended to splint the replanted tooth directly after trauma for a period of 7–14 days. Prolonged splinting period causes ankylosis and root

resorption; 10) root canals should be temporarily filled with $\text{Ca}(\text{OH})_2$ which is the best temporary filling material, between the seventh and fourteenth days of the replantation even before the removal of the stabilizing splints; 11) replantation is an easy procedure, every dentist should be able to perform it. Referring the patient with an avulsed tooth to another doctor decreases the chances of survival of the tooth and the success of the procedure. 12) children, teenagers and teachers should be informed about the way of handling the avulsed tooth; adequate first aid procedures increase the chances of long-term survival of the tooth.

REFERENCES

1. Andersson L. et al.: Avulset human teeth replanted within 15 minutes a long term clinical follow-up study. *End. Dent. Traum.*, 1, 37, 1990.
2. Bhambhani S. M. et al.: Treatment and prognosis of avulsed teeth. *Oral Surg. Oral Med. Oral Pathol.*, 2, 223, 1993.
3. Halczyk-Kowalik L. et al.: Replantacja czterech górnych zębów siecznych u 15-letniego chłopca – opis przypadku. *Czas. Stomat.*, 4, 247, 2000.
4. Janda-Wasiluk L. et al.: Obecne poglądy na temat zabiegów replantacji zębów. *Stomat. Współ., Supl.*, 1, 40, 1997.
5. Jodłowska A. et al.: Apeksyfikacja – trudności i postępowanie. *Stomat. Współ.*, 2, 9, 2002.
6. Krasner P. et al.: New philosophy for the treatment of avulsed teeth., *Oral Surg., Oral Med. Oral Pathol.*, 5, 616, 1995.
7. Kurek H. et al.: Leczenie przewlekłych zapaleń tkanek okołowierzchołkowych preparatami wodorotlenkowowapniowymi- obserwacje własne. *Stomat. Współ., Supl.*, 1, 22, 1998.
8. Ledzion S et al.: Postępowanie w przypadku urazów górnych siekaczy centralnych – opis przypadku. *Stomat. Współ.*, 2, 97, 1998.
9. Ledzion S. et al.: Resorpcje, przyczyny postępowania oraz metody leczenia. *Stomat. Współ.*, 1, 8, 2005.
10. Marczuk-Kolada G. et al.: Leczenie wybitych siekaczy górnych stałych- opis dwóch przypadków. *Nowa Stomat.*, 32, 70, 2005.
11. Nymas S. et al.: Healing following reimplantation of teeth subjected to root planning and citric acid treatment *Clin. Periodont.*, 4, 294, 1985.
12. Piątkowska D. et al.: Resorpcja zewnętrzna w replantowanym kle. Złamanie poprzeczne korzenia zęba siecznego bocznego. Opis przypadku. *Czas. Stomat.*, 11, 703, 1995.
13. Sharma N. K. et al.: Replantation in general dental practice., *Brit. Dent. J.*, 19, 147, 1994.
14. Wieczorek P. et al.: Replantacja całkowicie zwichniętych zębów- przegląd piśmiennictwa. *Now. Stomat.*, 3, 13, 1997.
15. Witherspoon D. E. et al.: Resorpcje zębów. *Quintes.*, 1, 27, 2000.

SUMMARY

The study describes current opinions on teeth replantation. It also describes factors affecting the prognosis and the sequence of the operative procedures by justifying the need of a proper management of the replanted teeth, particularly the protection of the periodontal ligament cells (PDL cells).

Replantacja zębów

Praca opisuje bieżące opinie na temat replantacji zębów. Opisuje również czynniki wpływające na rokowanie oraz sekwencję zabiegów operacyjnych, uzasadniając potrzebę właściwego postępowania z replantowanym zębem, szczególnie ochrony komórek włókien ozębnej (komórki PDL – periodontal ligament cells).