Avulsed maxillary central incisors: The case for autotransplantation

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Traumatic dental injuries most often occur in childhood and early adolescence. The most serious of these injuries is complete tooth avulsion. The incidence of avulsion is greatest for the maxillary central incisors and usually occurs when they are erupting between the ages of 7 and 10 years. A critical decision for the dentist at this time is whether to replant the avulsed tooth. There are many biologic considerations with varying outcomes. At the time of the injury, it is often a difficult conversation to have with the parents. Also, since these types of injuries can have a negative effect on the child’s psychological and social development, it seems reasonable to proceed with replantation. Options can then be reviewed, and a favorable long-term treatment plan can follow.

Dr. David Steiner clearly illustrated the indications for replantation. I believe that the management of avulsed teeth is a continuum of care, rather than an all-or-none therapy. Replantation does not preclude autotransplantation. It can maintain the alveolar ridge dimensions until transplantation of a tooth can be performed. This article will review tooth autotransplantation as an option to replace traumatized maxillary central incisors.

ROLE OF AUTOTRANSPLANTATION

Tooth autotransplantation is a surgical procedure in which a tooth is extracted from 1 site and replanted to another site, or repositioned in the same socket. It can be used in the treatment of displaced or impacted teeth and unilateral agenesis of premolars, and for the replacement of traumatized maxillary incisors. When an avulsed tooth is not retrieved or a replanted tooth develops replacement root resorption, a decision must be made about alveolar ridge management and tooth replacement. A dental implant cannot be placed until the child has completed growth. This could be for a period of 10 years. Alveolar ridge atrophy could continue during this time.

Autotransplantation can provide a natural functional tooth replacement during a period of growth (Fig). It differs from replantation, because it is performed under controlled conditions. This increases the chance of maintaining periodontal ligament vitality. A vital periodontal ligament has an osteoinductive ability. The transplanted tooth can help develop and maintain the alveolar ridge as it erupts along with the adjacent teeth. They can be moved orthodontically to improve both occlusion and esthetics. Autotransplanted teeth can also stimulate bone grafts that might be needed to rebuild a deficient ridge or congenital cleft.

SUCCESS RATES

The success of both replantation and autotransplantation depends on favorable periodontal ligament healing. Although autotransplantation has higher published success rates, the outcome can vary over a wide range. Success is influenced by factors such as patient age, developmental stage of the graft, type of donor tooth, complexity of removing the transplant, type of storage media used for the graft, and the surgeon’s experience.

When tooth donor types were compared, similar results were observed in larger long-term studies. Canines have the lowest success rates at 50% to 69%. This is attributed to their ectopic positions and challenging surgical harvesting that can lead to damage of the

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periodontal ligament. Molar transplantation has a slightly better prognosis with success rates at 60% to 74%. This is attributable to the root shape. A multi-rooted tooth has an increased risk of periodontal ligament injury during harvesting and requires a larger recipient site. Premolar transplants have higher success rates at 80% to 87%. Single-rooted teeth in favorable positions allow for ease of harvesting. Schwartz et al\textsuperscript{12} stated that the challenge of removing ectopic deeply impacted canines leads to unfavorable results; otherwise, canines would have a prognosis that is similar to premolar transplantation. Along with the surgeon’s experience, the most important factors that influence the outcome of tooth autotransplantation are the type of donor tooth and the anatomy of the recipient site.\textsuperscript{5}

To replace avulsed maxillary incisors, the appropriate tooth for transplantation is a premolar. Studies that are limited to the evaluation of premolar transplants report higher success and survival rates. Success criteria differ between studies and include root length, esthetics, and degree of root resorption. To simplify the comparison, survival rates can be used to understand the potential of this treatment modality. Andreasen et al\textsuperscript{15,16} with a sample of 370 premolars, reported survival of 98% up to 13 years after transplantation. Jonsson and Sigurdsson\textsuperscript{17} reported 97.5% survival up to 17 years with a group of 40 patients. Tanaka et al\textsuperscript{18} transplanted 28 premolars with a 100% survival rate up to 14 years. The procedure originally developed by Slagsvold and Bjercke\textsuperscript{19} demonstrates a high success rate because of the factors discussed. Their original patients were recently reexamined 17 to 41 years after transplantation. A remarkable 90% survival rate was reported.\textsuperscript{20}

**SURGICAL CONSIDERATIONS FOR AUTOTRANSPLANTATION**

Tooth autotransplantation for the replacement of maxillary incisors requires careful and deliberate planning to optimize the outcome of the therapy. Surgical considerations include appropriate timing of the transplantation and meticulous execution of the procedure. Unique for the anterior maxilla is a consideration for esthetic and functional transformation of the premolar.

Accordingly, planning begins with the selection of the transplant tooth.\textsuperscript{21} The maxillary anterior alveolar bone can accommodate the mandibular premolars easily. Measuring the edentulous space or the contralateral incisor dimension will assist in selection of the mandibular first or second premolar. The diminutive lingual premolar cusps will not interfere with the occlusion; this makes these teeth an ideal fit for a central incisor site. The maxillary second premolar has a wider orofacial root dimension. It will often require some alveolar expansion to fit in the incisor sites. In addition, the large palatal cusp might pose a challenge when orthodontically finishing the anterior tooth position. The maxillary first premolar has a prominent buccal root and is not considered for transplantation. Consultation with the interdisciplinary dental team is important to discuss esthetics, occlusion, and orthodontic mechanics as it relates to the tooth selected for transplantation.

When harvesting a tooth, injury occurs to the dental pulp and periodontal ligament. Compromised healing of these tissues leads to 2 main complications: replacement root resorption and inflammatory root resorption.\textsuperscript{5,16,21} Inflammatory root resorption is caused by pulpal necrosis and subsequent migration of these tissue disintegration by-products through dentinal tubules to the root surface. This can be resolved by endodontic therapy as in the case of a traumatized, replanted tooth. The root resorption will be halted, and periodontal ligament repair will follow.

Replacement root resorption develops from a damaged periodontal ligament that fails to heal. This is termed ankylosis: fusion of the alveolar bone to the
tooth root. If ankylosis occurs early after the transplantation, then a similar decision process follows as with the replanted ankylosed central incisor. Extraction or de coronation of the transplanted premolar is recommended to prevent the development of a vertical ridge defect. In contrast, a transplanted tooth that develops ankylosis when the child has completed growth can continue to function for an indefinite amount of time. The prognosis will depend on the rate of replacement root resorption. As a natural interim tooth replacement, the transplant helped develop and preserve the alveolar ridge. Furthermore, it can be considered a natural form of ridge augmentation as the root continues to be replaced with bone. When the clinical situation is appropriate, it can be restored with a dental implant.

To minimize possible complications, how can the surgeon approach the transplantation procedure? Research has evaluated both pulpal and periodontal ligament healing as they relate to the stage of premolar root development. Healing of these tissues after tooth transplantation is best when the roots of the donor tooth are two thirds to three quarters formed. This corresponds approximately to 9 to 12 years of age. Interestingly, this is the same age range for the greatest incidence of trauma to the maxillary incisors. This is therefore a clinical problem with a timely and opportune solution. Transplanting the premolars at about three quarters of their root length with an open apex allows for pulpal revascularization and optimal periodontal ligament healing with a greater than 95% survival rate.

A review of the literature shows a progression in the development of the surgical techniques used for autotransplantation. Detailed descriptions of techniques have been published and are recommended for a thorough review. Overall, the emphasis is on meticulous attention to detail to minimize trauma to the periodontal ligament. This is achieved in 2 ways: preparation of the recipient site and harvesting of the donor tooth.

The recipient site must be evaluated and prepared accordingly. The dimension of the alveolar ridge must be sufficient to accept the transplanted tooth. In the anterior maxilla, we might encounter several scenarios. I have classified patients into 3 categories, reflecting the condition of the recipient site.

The first is termed delayed autotransplantation. These patients have had a maxillary incisor avulsed and not replanted. The alveolar ridge is healed and will require osteotomy preparation with burs or ridge expansion.

The second is termed immediate autotransplantation. This group includes patients who have had a maxillary incisor avulsed and replanted with subsequent ankylosis. The recipient site is prepared with careful extraction of the tooth, removing the ankylosed root remnants while preparing the osteotomy site. After confirming complete removal of the root, transplantation into the new socket can follow.

The third and most challenging are patients with deficient alveolar bone. This can be a result of trauma, cleft palate, or previous pathosis. Alveolar ridge augmentation is required to create an appropriate ridge dimension before tooth autotransplantation. Although each of these groups requires a different approach, there is 1 common element to the preparation of the recipient site. It must be larger than the donor tooth root to ensure minimal trauma to the periodontal ligament when transferring it to the osteotomy site.

The donor tooth is harvested with an approach that avoids contact with the periodontal ligament and damage to Hertwig’s epithelial root sheath. The tooth follicle is released from the bony walls of the socket, and the tooth is elevated gently and removed from the donor site. It is transferred immediately to the recipient site or kept in physiologic saline solution while any adjustments are made to the artificial socket. There should be no extraoral dry time. Once transplanted, it can be secured with either sutures or a wire splint for several weeks. In contrast to the replantation of an avulsed tooth, the surgical management during autotransplantation controls many of the variables that can compromise healing. The selection of the appropriate tooth, the timing of the transplantation, and careful manipulation of the donor graft all contribute to a more predictable outcome.

ORTHODONTIC AND RESTORATIVE CONSIDERATIONS FOR AUTOTRANSPANTATION

As was discussed, successful autotransplantation requires positioning of the donor tooth root within bone. This can result in a tooth position that is not favorable from both esthetic and functional perspectives. So when can the orthodontist place a bracket on the transplanted tooth and begin to apply a force? To answer this question, we must understand how a periodontal ligament heals.

When an avulsed tooth is replanted into a socket, healing of the periodontal ligament occurs by reattachment in a short time, usually several weeks. Periodontal ligament cells are present on the root surface and on the wall of the socket. There is an intimate fit. This is in contrast to the autotransplantation of teeth. An artificial socket is usually created, and it is larger than the transplanted tooth root. Without a periodontal
ligament lining the socket, granulation tissue forms in this space around the root and then develops into bone. This requires more time for periodontal ligament formation and attachment. Typically, this is completed at 3 to 6 months. Tooth movement can begin at 3 to 4 months after transplantation. Early orthodontic tooth movement might even help stimulate periodontal ligament healing and prevent ankylosis of autotransplanted teeth.

Along with successful biologic integration of the transplanted tooth, we must plan for an optimal esthetic outcome. However, the morphologic transformation of a premolar into a central incisor can be a challenge. In a recent study that evaluated the esthetic appearance of autotransplanted premolars replacing maxillary incisors, 29% of the patients were not satisfied with the appearance of the transplanted tooth. In a bilateral comparison of the transplant with the contralateral incisor, a disparity was noted for both the color and the gingival width asymmetry in 60% of the patients. The authors noted that a combination of suboptimal tooth positioning and restorative techniques was responsible for the esthetic discrepancies.

It is clear that improved communication is required between the clinicians. Our group has developed interdisciplinary guidelines to achieve better esthetic outcomes with autotransplantation. After surgery, the next phase of treatment involves coordination between the orthodontist and the restorative dentist.

Since a premolar is usually smaller than a central incisor, it must be positioned to allow for minimal preparation and ideal application of restorative materials. There are 3 dimensions to consider. First is the inciso-gingival position. A useful guide is the cementoenamel junction of the contralateral incisor. A similar situation, which is familiar to the orthodontist, is the positioning of 2 central incisors, one with more attrition than the other. Lining up the cementoenamel junctions allows for a conservative enamel bonded restoration and minimizes the risk for developing uneven gingival margins as passive eruption occurs. The next dimension to consider is the mesiodistal position. Positioning of the transplant is similar to a peg lateral incisor. The restorative dentist will find it helpful to have the space distributed with approximately a third mesially and two thirds distally of the transplanted tooth. This allows for development of a natural emergence profile, since a central incisor has a straighter mesial contour and a more curved distal contour. Lastly, the orofacial position requires the tooth to be placed slightly palatally on the ridge. This helps to minimize the amount of enamel reduction that must be done on the facial aspect to make space for the restorative material.

When the transplanted tooth is in the ideal position, the restorative procedure is simplified. Using various restorative techniques, the dentist can restore the facial aspect of this tooth to mimic the morphology of the adjacent central incisor. The decision on what material to use depends on several factors. These are cost, ease of fabrication, repairability, and strength. In growing patients, it is wise to use a material such as a composite resin with either a direct or an indirect technique, since it is the most cost-effective and allows for ease of repair. The restoration is essentially a facial veneer that overlaps the buccal aspect of the premolar. The lingual cusp can be rounded without exposing the dentinal layer, and the occlusal grooves can be sealed to help prevent future caries. Having a different tooth anatomy on the palatal aspect is not a problem for our young patients, who adapt easily to this new tooth form. The composite veneer restoration can last until growth is complete. Then the restoration can be replaced with a porcelain veneer if the patient desires.

CONCLUSIONS

This article reviewed tooth autotransplantation as an option to replace traumatized maxillary central incisors. The following conclusions can be made.

1. Replantation of an avulsed tooth provides an immediate solution and allows for interdisciplinary discussion to develop a long-term plan.
2. Autotransplantation is an option if ankylosis of a replanted tooth occurs.
3. The replacement of maxillary incisors with transplanted premolars has a high rate of success.
4. Biologic variables are better controlled by the surgeon.
5. An interdisciplinary approach to autotransplantation can provide a functional and esthetic natural tooth replacement for growing patients.

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