Planning esthetic treatment after avulsion of maxillary incisors

Björn U Zachrisson

Abstract

Background: When a young patient accidentally loses two neighboring maxillary incisors, the choice of treatment plan is difficult. Although implant restorations are a popular option, they cannot be placed until skeletal growth is finished. Furthermore, the use of two neighboring implant crowns represents a considerable challenge from an esthetic point of view. This case report describes an innovative solution that combined autotransplantation of a developing premolar and orthodontic space closure. Case Description: An 11-year-old girl sought treatment for avulsion of both her maxillary right lateral incisor and her central incisor, which occurred as a result of a horseback-riding accident. Replantation by her general dentist was unsuccessful. An oral surgeon transplanted the mandibular right second premolar to the injury site, and the author moved the maxillary right quadrant mesially to close all spaces. The first premolar was intruded, and the canine extruded, to provide normal marginal gingival contours. A prosthodontist, working with his dental technician, restored the “abnormal” crowns with three porcelain veneers. The outcome was almost indistinguishable from a natural dentition.

Conclusions and Clinical Implications: When faced with treating severe traumatic injuries in growing patients, even after avulsion of incisors, clinicians working in cooperation can optimize the outcome. A combination of transplantation and space closure may represent the best treatment option, particularly when coupled with elements of esthetic dentistry. The advantage of this approach is that a concomitant malocclusion can be treated simultaneously, and that the treatment result is permanent. Interdisciplinary cooperation between orthodontists and other dentists, such as oral surgeons, prosthodontists and general practitioners, appears to be of increasing importance in achieving high-quality treatment results in such cases.

Key Words: Autotransplantation; traumatic injuries; avulsion; orthodontic space closure; esthetic dentistry; porcelain veneers. JADA 2008;139(11):1484-1490.

One of the most challenging problems in dentistry is the choice of treatment for replacement of one or more maxillary incisors that have been lost as a result of traumatic injuries. The problem of restoring esthetics and function varies significantly according to the age of the patient, the location of the traumatic injury and the extent of the trauma. To produce an optimal treatment result, it frequently is necessary to use the combined efforts of an interdisciplinary team of experts, representing pediatric dentistry, endodontics, oral surgery, orthodontics, restorative dentistry and dental technology. The skills of such a team sometimes can recreate the beauty and function of the natural dentition even in cases of severe trauma.

Most traumatic dental injuries occur in childhood and adolescence.1,2 Researchers have estimated that 70 to 90 percent of all traumatic dental injuries sustained in a lifetime take place before the age of 19 years.2,3 Avulsion (also known as exarticulation or total luxation) of teeth affects mostly the maxillary central incisors and generally occurs in children from 7 to 9 years of age, when the permanent incisors are erupting.2,4 At this age, the loosely structured periodontal ligament and low mineralized bone that surround erupting teeth provide only minimal resistance to an extrusive force.2 Most frequently, avulsion involves a single tooth, but multiple avulsions also occur.

1 DDS, MSD, PhD. Professor II, Department of Orthodontics, University of Oslo, Norway, and maintains a private orthodontic practice in Oslo.
Address reprint requests to Dr. Zachrisson at Stortingsgaten 10, 0161 Oslo, Norway. E-mail zachris@odont.uio.no

Abbreviation Key
PLV: Porcelain laminate veneer.
Clinical

Replantation of an avulsed tooth is indicated when the tooth is without obvious contamination and advanced periodontal disease and the alveolar socket is sufficiently intact to provide a seat for the exarticulated tooth. However, if a mature incisor is subjected to an extraoral dry period of more than 60 minutes, the prognosis for a successful outcome of replantation is remote. Complications may include replacement resorption (ankylosis) or inflammatory resorption. The treatment of replacement resorption may be either decoronation, in cases in which the ankylosed tooth has progressive infraclusion and in which residual alveolar growth is anticipated, or preservation of the tooth in situ in the interim before final treatment. Inflammatory resorption should be treated with root canal therapy. The case report included here describes the successful interdisciplinary treatment of a difficult traumatic injury case with avulsion of two neighboring maxillary incisors in a young girl. The team included specialists in oral surgery, orthodontics and prosthodontics.

Case Presentation

A girl aged 11 years, 5 months experienced a severe traumatic dental injury in falling from a horse she was riding, a situation similar to that described by Caglar and Sandalli. The maxillary right lateral and central incisors were avulsed (Figure 1), and her general dentist replanted them about 60 minutes after the accident. Both teeth had ankylosed a few weeks after the accident, demonstrated a high percussion sound and were judged by trauma experts (a pediatric dentist and an endodontist) to have a hopeless longterm prognosis. It was apparent that both incisors had to be extracted. The patient had a Class II, Division 2 malocclusion with deep overbite and moderate mandibular crowding in the incisor area.

Having evaluated different treatment options to be discussed below, I decided to attempt a combination of autotransplantation and orthodontic space closure to replace the two missing neighboring incisors. At that initial visit, I referred the patient to an oral surgeon for extraction of the maxillary left first premolar, which would leave the first molar in distal relation to the mandibular molar. I planned to eliminate the mandibular crowding via extensive mesiodistal enamel contouring from the right first premolar to the left first premolar (in a technique described by Tuverson and Zachrisson and colleagues).

Two weeks after the patient’s initial consultation with me, I referred the patient to an oral surgeon for the transplantation of the mandibular right second premolar to the anterior region. During the procedure, the oral surgeon noticed evident ankylosis changes on both the central incisor and the lateral incisor. He had to move the alveolar preparation somewhat distally to include more labial bone, and he had to tip it labially to prevent premature contact against the mandibular incisors owing to the deep overbite. There was a small apical perforation to the nasal floor. The root development of the autotransplanted premolar tooth had progressed slightly more than optimally, but the apex was clearly wide open (Figure 2). The oral surgeon placed the mandibular premolar and sutured it in a high position (Figure 3).

I began the orthodontic treatment six months after the operation, after a pediatric dentist had made a temporary resin-based composite build upon the natural premolar crown (Figure 4). By then, the teeth in the maxillary right quadrant had drifted mesially. Both canines and all premolars had a marked lingual tilt (Figures 3 and 4), resulting in a notably constricted smile. The treatment objectives were these:

- close all spaces;
- obtain a normal high-low-high marginal gingival contour for the three “new” anterior teeth in the maxillary right side;

![Figure 1: Frontal facial view of 11-year-old patient who had lost both the maxillary right lateral incisor and the maxillary right central incisor in an accident.](image)
- widen the smile, mainly by adding marked lingual root torque to the maxillary canines and posterior teeth, with little lateral expansion;
- treat the deep bite with mandibular incisor intrusion only, as the maxillary incisor display at rest was optimal;
- improve the crown inclination of the anterior teeth;
- resolve the mandibular crowding.

I bonded brackets to all teeth in both dental arches, except for the maxillary first molars, which I banded and provided with a custom-made transpalatal arch.\textsuperscript{13} After an initial placement of a superelastic leveling arch wire (Figure 4), I used rectangular stainless steel arch wires to move and torque all teeth into proper axial inclinations (Figure 5). I extruded the canine and intruded the first premolar via bracket positioning and arch wire bends. During the two-year, five-month treatment period, the patient had another traumatic sports injury, resulting in a horizontal crown fracture on the right canine (Figures 5 and 6). After removal of the orthodontic appliances (Figure 6), a prosthodontist and his dental technician made three ultrathin porcelain veneers for the location of the injury (Figures 7 and 8). The treatment result was retained with a flexible gold-coated five-stranded .0215-inch lingual retainer bonded to six teeth (Figure 9). The final result was almost indistinguishable from a natural dentition, with intact full gingival papillae and normal contours (Figures 7, 8 and 10) and a full smile (Figure 10). The result remained satisfactory and was stable at the five-year follow-up in February 2008.

**Replacement of Maxillary Teeth: Treatment Options**

If replantation is unsuccessful, and an avulsed tooth is lost prematurely, several treatment possibilities exist:
- replacement of the lost incisor via autotransplantation of a developing premolar (or another suitable donor tooth);
- use of a single-tooth implant prosthesis;
- orthodontic closure of the space;
- after loss of multiple maxillary anterior teeth, treatment with a combination of transplantation and orthodontic space closure;
- maintenance of the space by means of a removable denture with a single-tooth prosthesis.

These options will be discussed below.

**Replacement of missing maxillary incisors with a premolar transplant.**

The surgical technique for tooth transplants requires utmost care;\textsuperscript{13,14} the clinician can best learn it by observing operations conducted by an experienced transplant surgeon (J. Janakievski, DDS, MSD, e-mail communication, September 2007). The optimal time for autotransplantation of premolars to the maxillary anterior region is when the root development has reached two-thirds to three-quarters of the expected final root

*Figure 2: The developing mandibular right second premolar was autotransplanted to the injury site. Note immature root development of mandibular second premolars with open apex.*

*Figure 3: Autotransplanted premolar tooth in position. Note mesial drift and excessive lingual crown inclination of maxillary canines and premolars, constricting the smile.*

*Figure 4: After restoration with resin-based composite buildup on the transplanted premolar, orthodontic treatment was begun with superelastic leveling wire.*

*Figure 3:* A utotransplanted premolar tooth in position. Note mesial drift and excessive lingual crown inclination of maxillary canines and premolars, constricting the smile.
The prognosis for complete periodontal healing at this stage of root development is better than 90 percent. After transplantation, root growth continues and the teeth maintain their capacity for functional adaptation. Endodontic treatment usually is not necessary. Patients suited for autotransplantation of premolars to the maxillary anterior region are about 9 to 12 years of age, which corresponds with the period when most serious traumatic dental injuries occur in children. It is remarkable that tooth transplants have inherent potential for alveolar bone growth and re-establishment of a normal alveolar process (Figures 3-8).

**Long-term survival and success rate.**

Czochrowska and colleagues evaluated the longterm outcome of 33 transplanted premolars for 17 to 41 years after their transplantation (mean, 26.4 years). Both the survival rate (teeth still present at the examination) and the success rate (teeth fulfilling defined success criteria) were high – 90 percent and 79 percent, respectively. Thus, transplantation of teeth with partly formed roots compares favorably in a long-term perspective with other treatment modalities for substituting missing teeth.

**Orthodontic and restorative treatment for transplanted premolars.**

Because the root of a transplanted premolar continues to develop and a normal periodontal ligament is re-established, such teeth can be moved orthodontically like any other tooth that has erupted into occlusion. Premolar crowns (Figure 3) can be reshaped to resemble incisor morphology with a porcelain laminate veneer (PLV) (Figures 7 and 8). The two main reasons to avoid placing cemented crowns in adolescents – that the large pulp chambers limit preparation and that the gingival retraction across time could lead to unesthetic root display – are not valid for minimally invasive PLVs. The reflection of light will not be stopped by an enamel-
bonded veneer, and any later root exposure will display a normal color without darkening.\textsuperscript{21} In a 2000 study, my research colleagues and I\textsuperscript{17} evaluated 45 premolars transplanted to the maxillary incisor region, after restoration, with a mean observation period of four years. The clinical variables for transplants did not differ from those of the natural incisors, except for some increased mobility and more plaque in a few autotransplanted premolars.\textsuperscript{17,18} Notably, the interdental gingival papillae adjacent to all transplanted teeth were normal or slightly hyperplastic, and we found no interdental gingival recession (“black triangles”).

\textbf{Esthetic outcome and patient satisfaction.}
In a 2002 study, my research colleagues and I\textsuperscript{18} compared 22 transplanted premolars reshaped to incisor morphology with their natural, contralateral incisors. Most transplanted teeth matched the contralateral incisors, and a majority of patients were satisfied with the appearance of the transplant. However, the color and the crown width along the gingival margin were scored as different from those of the natural incisor when the restorations were made with resin-based composite. Thus, because of limited width in the gingival area, PLVs rather than composite buildups are the preferable alternative for restoration of the premolar crowns.

\textbf{Conclusion.} Premolar autotransplantation represents an attractive, and probably the best, solution to difficult treatment planning problems when a young patient, such as the one described in this article, loses a maxillary incisor to trauma (Figures 7-10). The transplanted tooth represents a normal root with a normal periodontal membrane, and it can be moved orthodontically like any other natural tooth. The “abnormal” crown should be restored with a porcelain veneer. Transplantation represents a biological approach in which the transplanted tooth germ retains the potential to induce alveolar bone growth.

\textbf{Replacement of missing maxillary incisors with single-tooth implants.}
Within the last two decades, the use of osseointegrated implants to replace missing maxillary central and lateral incisors has become a common treatment solution for patients 20 years and older. Experience gained to date with single-tooth implants is favorable, with survival rates of about 90 percent after 10 years in multicenter studies.\textsuperscript{22} However, filling an anterior space with an implant-supported porcelain crown is a major challenge from both esthetic and functional aspects. Clinical success depends not only on persisting osseointegration but also on harmonious integration of the crown in the dental arch.\textsuperscript{23} An implant crown placed in a young adult should have an expected life span of 50 or more years. Research indicates that the esthetic result for single implants in the esthetic zone sometimes is suboptimal, even in adults and elderly patients.\textsuperscript{22-25}

\textbf{Esthetic problems with implant crowns.}
There are several potential esthetic problems associated with the long-term use of implant-supported crowns, including age changes in tooth position,\textsuperscript{26} leading to progressive infraocclusion of the implant crown and uneven marginal gingival contours (this may particularly create an esthetic problem in patients showing a great deal of tooth eruption—high-angle face types and open bite tendency—and in “gummy” smiles);\textsuperscript{12,25} labial alveolar bone loss and gingival dark discoloration;\textsuperscript{22,27} lack of gingival papilla fill, particularly on the distal side;\textsuperscript{28} and

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure9.png}
\caption{The treatment result was maintained with an .0215-inch gold-coated wire retainer bonded lingually to six teeth.}
\end{figure}
gingival recession occurring for different reasons with increasing age, resulting in dark margins along porcelain crowns. But the major disadvantage of planning esthetic treatment with implants in adolescents is, of course, that the young patient has to wait until completion of facial growth before receiving the final prostheses. During the interim period, which may last several years, the patient has to wear either a removable retainer or a fixed resinbonded prosthesis that may be prone to fracture.

**Conclusion.** The single-tooth implant may be a useful treatment option in adults when maxillary incisors have been lost accidentally or are missing congenitally. Implants normally should not be placed until the skeletal growth is completed. Independent studies indicated that progressive infraclusion over time (even in mature adults) of single implants replacing maxillary incisors sometimes may make the replacement crown esthetically suboptimal. Extended long-term evaluations are needed.

**Replacement of missing maxillary lateral incisors with canines during orthodontic space closure.**

When a maxillary canine is moved mesially to substitute for a missing lateral incisor, and the first premolar is used in place of the canine, esthetic and functional concerns may arise. However, when careful orthodontic treatment is combined with clinical techniques adapted from esthetic dentistry, the outcome with space closure can be satisfying and almost indistinguishable from a natural dentition. Such methods may include the following:

- individualized extrusion and intrusion during mesial movement of the canine and first premolar, respectively, to obtain an optimum level for the marginal gingival contours of the anterior teeth;
- careful correction of the crown torque of a mesially relocated canine to mirror the optimal crown torque of a lateral incisor, along with the provision of optimal torque for the mesially relocated first and second premolars;
- esthetic recontouring of a mesially relocated canine to a more ideal lateral incisor shape and size with a combination of grinding and resin buildups or porcelain veneers;
- increasing the width and length of mesialized and intruded first premolars with buildups or veneers to achieve optimal esthetics and functional occlusion;
- intentional vital bleaching of a yellowish canine that has been moved mesially into the lateral incisor position;
- using simple minor surgical procedures to achieve localized clinical crown lengthening.

**Figure 10: The final result, with the patient showing a full smile.**
Long-term periodontal and occlusal studies regarding congenitally missing lateral incisors have shown that space closure with premolar substitution for canines may lead to an acceptable functional relationship, with modified group function on the working side.29 Another study (mean, seven years after treatment) concluded that orthodontic space closure produced results that were well-accepted by patients, did not impair temporomandibular joint function and encouraged periodontal health in comparison with prosthetic replacement.29

**Replacement after loss of multiple maxillary anterior teeth.**

Multiple loss of anterior teeth represents a significant increase in the number of esthetic problems. This is caused primarily by the associated alveolar bone loss, which may require both horizontal and vertical bone augmentation.2 Fortunately, in children, the autotransplantation of developing premolars may induce alveolar bone growth and thus make it possible to restore the dental arch form using a combination of transplantation and orthodontic space closure after severe accidents involving the loss of several maxillary incisors.2,37

In adults, a significant esthetic problem will occur when two implants are placed next to each other. In these instances, it generally is not possible to create a satisfactory gingival papilla between the two implants.28,39 One treatment principle to reduce this problem may be to combine orthodontic space closure and one implant.39

**Conclusion.** When two or more maxillary incisors are lost in young patients, tooth transplantation should be the treatment of choice. This treatment has the potential to restore both the dentition and the alveolar bone.

**Maintaining the space by means of a removable denture with a single-tooth prosthesis.**

The basic problem in using a removable denture with a tooth (or a resin-bonded bridge) to replace a lost maxillary incisor is, of course, the progressive increase of alveolar bone resorption that takes place at the same time as the continued eruption of the neighboring teeth.

**Conclusion**

A combination of premolar transplantation, orthodontic space closure and porcelain laminate veneers may be the best treatment option after severe traumatic dental injuries with avulsion of one or more incisors in growing patients. Any concomitant malocclusion can be treated at the same time, and the treatment outcome is permanent (Figures 7-10).

**Disclosure**

The author did not report any disclosures.

The author gratefully acknowledges the skillful efforts of Dr. Bjorn Album, oral surgeon, Oslo, Norway, during the transplant operation. The author also thanks Dr. Sverker Toreskog, prosthodontist, Göteborg, Sweden, and Mr. Claes Myrin, master dental technician, Göteborg, Sweden, for making the porcelain veneers.

**References**


