Missing anterior teeth: orthodontic closure and transplantation as viable options to conventional replacements

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Introduction

Traditional replacement options for missing maxillary incisors include implants and partial dentures. Although less well known among endodontists and general dentists, orthodontic space closure and autotransplantation of developing premolars may, however, constitute relevant alternatives.

The challenge in treating patients with missing maxillary incisors and concomitant malocclusion is how to achieve the best esthetic and functional results, particularly in the long term (1). Although data for survival of single tooth implants is favorable, over time there may be significant problems associated with their use in the esthetic zone, such as infraocclusion (2, 3), gingival retraction with root exposure, and darkening of the overlying gingiva due to resorption of the buccal bone plate (4). Autotransplantation of teeth and orthodontic space closure represent viable biological approaches for replacement of incisors because of the permanence of the result, particularly in growing individuals.

Treatment decisions for young people with missing incisors should be based on a comprehensive assessment that includes several factors (1), and the ultimate treatment plan should be dictated by the diagnosis and not by a preferred methodology. From 2000 to 2003, the authors published a series of articles in the American Journal of Orthodontics and Dentofacial Orthopedics on the outcome of tooth transplantation, and of orthodontic space closure in the management of missing teeth (5–9). It is clear from the debate that followed (3, 10–16) that there are conflicting opinions, pointing to a need for further information and research in this area.

The purpose of this article is to summarize the authors’ experience over the past 40 years with transplantation and orthodontic space closure in the treatment of missing incisors. There are two main reasons for missing incisors in young people: traumatic injuries and congenital absences. Because the nature of the problems differs in these two situations, the management with regards to the two types of missing teeth will be discussed separately.

Loss of incisors from traumatic injuries

Traumatic injuries may affect one or more maxillary incisors as well as other oral tissues. The treatment plan in each situation will depend on factors such as the number of missing teeth, the status of the remaining teeth, possible concerns about the occlusion, space availability, age, facial morphology, growth pattern, and tooth morphology (1). From a preventative perspective, persons with protruding incisors are at risk for dental injuries (17) and may therefore need orthodontic treatment irrespective of whether teeth are missing or not.

Indications for autotransplantation

More than 30 years ago, Slagsvold & Bjercke (18) established a method of transplanting teeth with
incompletely developed roots. After transplantation, the root growth in such teeth continues and they maintain their capacity for functional adaptation (Fig. 1). Endodontic treatment is generally not necessary, and the long-term survival and success rates are high (5). Slagsvold & Bjercke (19) also discussed the indications for replacing missing incisors by transplanting developing premolars. This produces a normal root, but the crown will, however, need to be reshaped with either composite resin or porcelain laminate veneer (PLV) to fit esthetically into its new arch position (Figs 1f, g and 2b, c, e, f).

An important prerequisite for transplantation is a donor tooth with 2/3 to 3/4 root length that can be sacrificed without detrimental effects to the donor site. Careful surgery to avoid any damage to the surface of the root is essential. The treatment plan must take into account the need for orthodontic intervention pre- and post-transplantation by:
- creating sufficient space at the recipient site;
- managing the residual space at the donor site (usually comprised of orthodontic space closure);
- correcting the malocclusion, if any; and
- orthodontic adjustment of the transplanted tooth’s position to achieve an optimal esthetic result.

Premolars are usually the preferred graft because dental injuries frequently happen at the time when premolar root development has still not been completed, root morphology is favorable by being straight and conical, and the extraction space may be utilized to relieve crowding. The morphology of the lower first premolar in particular provides a good opportunity for the restorative dentist to simulate maxillary incisor morphology by a minimally-invasive recontouring and veneering approach. The palatal cusp of a transplanted premolar may be ground into dentin (20) and covered with porcelain or resin to protect against pulpal injury from plaque.

### Indications for orthodontic space closure

The maxillary central incisor is the most frequently avulsed tooth, and the following conditions favor orthodontic space closure:
- overjet, open bite, proclined incisors;
- general crowding;
- large lateral incisors, small canines;
- adjacent healthy teeth;
- young individuals, vertical facial growth direction; and
- general need and desire for orthodontic treatment.

If more than one tooth is missing in the same quadrant, orthodontic space closure alone usually cannot resolve the situation. A combination of orthodontic tooth movement and tooth transplantation may be used (Fig. 2).

### Treatment

**One maxillary central incisor missing**

If the missing tooth is to be replaced by autotransplantation, the timing of treatment is determined by root development of the donor tooth. The surgical positioning of the transplant is to some degree dictated by the bone volume at the recipient site. A bony socket
has to be made which adapts and covers the root to ensure an optimal prognosis for the transplanted tooth. This implies that there may be a need to adjust the position of the transplant before the crown is reshaped to simulate incisor morphology (Fig. 2).

When **orthodontic space closure** is the preferable alternative, treatment may be started immediately if the central incisor is avulsed in the early mixed dentition (Fig. 3). The treatment principles include the following:

- move lateral incisor to the midline immediately upon loss of central;
- extract upper second deciduous molars to guide first permanent molars mesially;

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**Fig. 2.** Following traumatic loss of two adjacent maxillary incisors (right central and lateral incisors), the mandibular right second premolar was autotransplanted to the position of the missing central incisor (a, b). The transplanted tooth was reshaped to incisor morphology by a temporary composite resin build-up (c). The remaining spaces were closed orthodontically and the malocclusion was corrected (d). Then, the build-up on the transplanted premolar was replaced with a porcelain veneer (e, f). Also the canine (C) and right first premolar (P) were restored with porcelain veneers to an improved lateral incisor and canine morphology, respectively (e, f).

**Fig. 3.** Orthodontic space closure after traumatic loss of the maxillary right central incisor in an 8-year-old boy (a). The remaining teeth were moved mesially (b) and their vertical positions were adjusted by making arch-wire bends (c) to obtain more harmonious gingival margins (d). The lateral incisor (L), canine (C), and first premolar (P) were restored by porcelain veneers or composite resin build-ups (e). Multi-stranded wires have been bonded for long-term retention (f).
extract deciduous canine to change the eruption path of the permanent canine (Figs 4 and 5); and
- completion of orthodontic treatment in the early permanent dentition.

The approach to treatment (21) is illustrated in Fig. 3. Depending on occlusion and space conditions, compensatory extractions may be necessary (see Table 1). Attention to detail during treatment is important; at the end of treatment, midlines should coincide, the mesialized lateral should be upright with the gingival margin at the same level as the natural central incisor, and the reshaped crown should have the same morphology and color as the in situ adjacent central incisor (Fig. 5e).

**More than one incisor missing**

When two maxillary central incisors are missing, the space may be managed by moving both laterals mesially according to the principles above (Figs 4 and 5). For more comprehensive injuries, a combination of tooth transplantation and orthodontic space management may be appropriate (Figs 2 and 6). Careful planning and timing of treatment will then be necessary and interdisciplinary team-work from an early stage is important.

**Teeth and bone are missing**

Severe injuries to the oral region may lead to bony fractures and alveolar bone loss (Fig. 6), which may represent a serious obstacle to the rehabilitation of the patient. Teeth have the potential to induce formation of alveolar bone, and this potential can be used to an advantage both by tooth transplantation and orthodontic tooth movement. The re-establishment of a normal alveolar process by the movement of tooth transplants is demonstrated in Figs 1, 2, and 6. Another
option is to move teeth into an area with insufficient bone for placement of an implant. The implant may then be inserted in the initial position of the tooth that has been moved (22).

### Results

Systematic analysis of the result after transplantation of premolars to replace incisors has demonstrated...
long-term (> 25 years) survival rates of more than 90% (23, 24). Publications from teams in Scandinavia (25) and Japan (26) contain examples of premolars successfully transplanted to replace incisors. We found that compared with natural incisors, the overall status of the transplanted premolars and surrounding tissues is similar (6). The esthetic results were also generally satisfactory (7), particularly when adjunctive orthodontic treatment ensured optimal positioning of the transplant (Fig. 2b–f). When patients expressed dissatisfaction, the reason usually was related to the suboptimal appearance of the composite resin build-ups being made to reshape the lateral incisor to the central incisor shape and color. Teamwork with the restorative dentist is therefore important, and meticulous attention to detail should be exercised at all stages of treatment.

**Congenitally missing maxillary lateral incisors**

**Indications for orthodontic space closure**

Several factors should be considered in the assessment of indications for orthodontic space closure, including

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**Fig. 6. Mandibular fractures, loss of four teeth and alveolar bone after injury. Trauma at the age of 10 resulted in fracture of the mandibular body and condyles, open bite, and loss of maxillary right central and lateral incisors (a, b). Left central incisor and right first premolar had to be extracted later because of pulp necrosis and ankylosis. Crowding in the posterior segments allowed for transplantation of premolars: the left maxillary second premolar to the area of the right first premolar, the mandibular left second premolar replaced the maxillary right central incisor, and the mandibular right first premolar replaced the maxillary left central incisor (c, d, f). Occlusion and tooth position were corrected orthodontically. The premolars transplanted to the incisor area were restored to incisor morphology by composite resin build-ups (d, f). The alveolar bone that had been lost because of the injury (e) was re-established when the transplanted teeth were moved orthodontically into the area and thus induced development of new bone (c, f).**
amount of crowding and spacing, size and shape of the teeth, and the occlusal relationships. Transplantation of teeth is rarely indicated for absent lateral incisors. The indications for space closure are summarized by Rosa & Zachrisson (27, 28):

- a tendency toward maxillary crowding;
- a well-balanced profile and normally inclined incisors;
- canines and premolars of similar size;
- dentoalveolar protrusion;
- Class II molar occlusion; and
- mandibular crowding or protrusion.

Mesial drift of the canines during eruption frequently takes place, and this may represent an additional indication because the distribution of spaces may prevent replacement of lateral incisors by restorative methods. If orthodontic measures need to be initiated anyway, spaces may just as well be closed by mesial movement of teeth (27, 29) (Figs 7 and 8).

If only one lateral incisor is missing, removal of the contralateral incisor that is present may sometimes lead to improvement of the final result. The indications for extraction may include peg-shaped and diminutive teeth, severe crowding, and improved prognosis for obtaining symmetry and coinciding midlines. If the lateral incisor present is of, or can be made to, acceptable size and shape, unilateral space closure may be attempted (Fig. 8).

Fig. 7. Congenital absence of both maxillary lateral incisors (a). After orthodontic space closure, the canines were reshaped to incisor morphology by incisal grinding and composite resin build-ups (b, c). The first premolars were intruded (d) during orthodontic treatment for improved marginal gingival levelling and to allow incisal composite resin build-ups (e). A different case (f) demonstrates gingival leveling (arrows) simply by selective bracket positioning on the first premolar and canine.

Fig. 8. A young girl with congenitally missing right maxillary incisor and peg-shaped left lateral incisor before (a) and 10 years after orthodontic treatment (b). The right canine was moved to the position of the lateral incisor and re-shaped by grinding and composite resin build-up. The peg tooth was kept and provided with a porcelain veneer. The long-term result is esthetically satisfactory.
Treatment

Guidelines for management of orthodontic space closure for missing lateral incisors were proposed by Tuverson in 1970 (29), and are still valid. Successful treatment of patients with missing lateral incisors requires attention to a number of details:

- The difference in crown torque (inclination) between the lateral incisor and canine: sufficient lingual root torque of the canine is important (Fig. 8), otherwise it may look unnatural in the position of the lateral incisor.
- The size difference between lateral incisors, canines, and premolars: this may result in ‘lateral incisors’ appearing too wide and long and ‘canines’ that are too small and narrow. This may be prevented by extrusion and grinding of the canines (20), and intrusion of premolars and composite resin buildup of the labial cusp (27) (Fig. 7d, e). By selective bracket placement, the desired movement can be ‘built’ into the orthodontic appliance (Fig. 7f).
- Functional occlusion: long-term follow-up studies demonstrate no functional occlusion or TMJ problems in space closure patients (30, 31). Apparently the presence or absence of a canine rise is not related to periodontal status, and there is no evidence that a Class I canine relationship is the preferred mode of treatment.
- Contouring of canines/color: with today’s techniques in esthetic restorative dentistry, it is possible to transform a maxillary canine such that it has a naturally looking lateral incisor morphology (Figs 2, 3, 7 and 8). This may include orthodontic extrusion for gingival leveling, incisal grinding and interproximal stripping, composite resin ‘corners’, vital bleaching of yellowish canines, and PLVs.
- Retention and relapse: there is usually a marked tendency for reopening of spaces in the anterior maxilla, and therefore long-term retention with bonded multi-stranded wire retainers over four to six teeth should routinely be applied (Fig. 3f).

Clinical implications

Only a few systematic studies examining the results of space closure for missing maxillary lateral incisors are available (8, 30, 31). The results are encouraging, both from a biological and functional perspective. In addition, a number of treated patients have been presented in case reports (20, 27–29, 32–34), demonstrating that excellent esthetic results may be obtained. The most common arguments against orthodontic space closure have been related to the esthetic result and the potential lack of a canine-protected occlusion during function. These challenges can now be overcome by attention to detail in planning and treatment as discussed above.

Space conditions and occlusal relationships may sometimes make closure of all spaces unrealistic. An alternative may then be to open space in the posterior segments for single-tooth implants or bridges. This approach will have the same biological advantages in the anterior part of the maxilla as normal space closure and may provide better long-term stability. Restorations in the posterior area of the maxilla do not have to meet the same strict esthetic requirements as those in the anterior area. If implants are selected as the replacements for the missing teeth, they will get a favorable axial loading. As discussed elsewhere (4), a critical factor in implant therapy is the long-term appearance of the soft tissue surrounding the replacement, such as the risk for gingival recession, dark margins, and lack of satisfactory gingival papilla contour. In the anterior maxilla, such outcomes may be detrimental to the overall esthetic result, but they are much less troublesome in the posterior areas.

So far no studies are available examining the overall costs of orthodontic space closure compared with other alternatives from a long-term perspective. The validity of prospective studies is complicated by the continuous introduction of new methods and technology. This applies both to the restorative and orthodontic disciplines. As an example, space management in orthodontics may in the future be facilitated by the use of mini-screws, providing absolute anchorage.

Discussion and conclusion

The most evident advantage of replacing missing incisors with the patient’s own teeth, either by transplantation or orthodontic space closure, is the permanence and biological compatibility of the treatment result. At the end of treatment, normal gingival tissues and papillae will surround all teeth. Even when PLVs are needed in young patients, such restorations can be made shortly after the surgical and orthodontic treatment. Only a minimal amount of enamel is removed during preparation and there is little risk of
pulp damage. This is important because the majority of patients presenting with missing incisors due to trauma or agenesis are children and adolescents. If treatment is postponed or spaces are opened, young patients have to wait until completion of facial growth before receiving their final restoration. During the interim period, which may last several years, the patient will have to wear either a removable or fixed resin-bonded temporary prosthesis.

Evidence-based clinical practice for the management of missing anterior teeth should be established from data on the functional and esthetic clinical result of various treatment modalities, as well as costs in the long-term. No such data are currently available. One of the reasons may be the difficulties in collecting samples of sufficient size for follow-up and analysis. The frequency of missing maxillary lateral incisors is about 1%, and the incidence of dental injuries is <2% annually, of which only 3–4% may be considered to be severe. Optimal results also require integrated interdisciplinary teamwork, which further complicates the collection of research data.

Even if solid comparative research data for the different replacement methods so far are not available, our experience indicates that orthodontic space closure and transplantation of teeth can produce treatment results that are almost indistinguishable from an intact dentition. The goal should be that patients who have received treatment for missing teeth will have treatment results that are indistinguishable from normal appearance. A prerequisite is that the therapy is based on a complete diagnosis, that the indications for the selected approach are present, and that attention to detail throughout treatment is exercised by all involved in the treatment.

References


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