

Review Article

Tooth auto-transplantation as an alternative treatment option: A literature review

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ABSTRACT

Rapidly evolving implantation and alveolar ridge reconstruction techniques created a new area in modern dentistry where tooth loss is no longer a problem. Endless variations of implant's length, diameter, surface, and design along with autogenous, alogenuous, aloplastic, or xenogenous bone substitutes made it possible to recreate physiological occlusion, esthetic and masticatory function. However, none of nowadays technologies in implant dentistry have the potential to adapt to a growth and development changes of a child's jaw. Therefore, patient's young age is a restriction for implantation and a particular challenge for a dentist willing to restore missing tooth. Thus, tooth auto-transplantation can be a good choice for treatment. The objective of this review is to underline the biologic principles required for successful auto-transplantation of teeth. Limits, indications, technique, and prognosis will be analyzed.

Key Words: Autologous, auto-transplantation, tooth transplantation

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INTRODUCTION

Dental auto-transplantation or autogenous transplantation is defined as the movement of one tooth from one position to another, within the same person.^[1,2] This could involve the transfer of impacted, embedded, or erupted teeth into extraction sites or into surgically prepared sockets.^[2] The procedure itself is not a new invention, and the earliest reports of tooth transplantation involve slaves in ancient Egypt who were forced to give their teeth to their pharaohs.^[3,4] Eventually, allotransplantation, transplantation of a tooth from one individual to another, was abandoned because of histocompatibility and replaced with auto-transplantation.^[3]

Although today dental implant is mostly desirable treatment method in case of lost teeth (because of its

predictable and long-term results), it cannot be applied to all patients due to young age or socio-economic reasons; therefore, tooth auto-transplantation could be considered as an alternative.

Indications

There are many reasons for tooth auto-transplantation, but most common indication is teeth to be extracted due to advanced caries destruction: In adolescents, the first permanent molars erupt early and are often heavily restored. When first molar is lost in young patient, it can result in abnormal occlusion because of tooth migration and due to uneven jaw growth. Thus, treatment of such patient should be aimed on maintenance of lost tooth space without alterations to growing jaw. When dental implants are placed in adolescent patients, they do not erupt along with adjacent teeth and result in infraocclusion with functional and esthetic problems.^[5] In this case, auto-transplantation is indicated: A tooth with incomplete rhizogeneses and maintained PDL remains ability of further growth and promotes alveolar bone development in the receptor area.^[6] Most frequently, a wisdom tooth is transferred to the site of a hopeless molar because of its late development compared to the other teeth.

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Another indication is maxillary incisors that are most frequently involved in trauma. In such case, avulsed tooth brought to dental office in a proper condition (during first 24 hours after trauma, in a suitable solution) could be replanted and splinted for a healing period. Even partially damaged tooth (cracked, chipped, or broken crown) could be saved applying endodontic and restorative treatment. Although when a tooth is lost completely (advanced cariotic destruction, trauma), it could be replaced with patients own tooth.^[7] Therefore, considering the stage of root development and the size of the crown of a donor tooth is chosen. Usually, mandibular first or second premolars are appropriate in mesiodistal dimension to replace lost central incisor, although later an adequate reconstruction of the crown with composite resin or artificial crown according to anatomy is needed. The posterior space that results from harvesting of the premolar could be closed by unilateral protraction of the posterior teeth with traditional or mini-implant anchorage mechanics.^[8]

One more indication for tooth auto-transplantation is congenital tooth absence. Tooth agenesis is mostly of unknown etiology. It was determined that about 90% children with agenesis misses 1 or 2 teeth, and only 3% of people with agenesis lack 2 or more teeth in the same quadrant.^[9] Most frequently, absent teeth are mandibular third molars, followed by mandibular second premolars, maxillary lateral incisors.^[10] The alternative treatment options to transplantation when missing mandibular second premolars usually include space closure in connection with routine orthodontic treatment involving extractions of 2 maxillary premolars (extraction can be planned for the correction of crowding or reduction of overjet^[11-14] or leaving the deciduous second molars for as long as possible.)^[15] Missing lateral incisor alternatively to transplantation can be treated by orthodontic space closure,^[16] conventional or resin-bonded bridges, or single-tooth implants.^[9]

Atypical tooth eruption can also be an indication for auto-transplantation. Ectopically positioned teeth are usually exposed surgically and then orthodontic treatment is applied. In cases of severe ectopic position of maxillary canines (ectopic canines present about 2% of population),^[15] correction of its position may present a challenge for traditional orthodontic mechanics. Therefore, auto-transplantation of canine into a more natural orientation could provide a simplified and faster treatment option.^[13]

Candidate criteria

Patient selection is very significant for the auto-transplantation success. Candidates must be in a good health, demonstrate excellent level of oral hygiene, and be amenable to regular dental care; otherwise successful outcome of auto-transplantation could be jeopardized. Patients must be able to follow post-operative instructions and be available for follow-up visits; co-operation and comprehension are important to ensure predictable results. Above all, the patients must have a suitable recipient site and donor tooth.^[17-23]

Recipient site criteria

The recipient site should be free from acute infection and chronic inflammation.^[23] Adequacy of bone support is crucial criteria for success. To ensure stabilization of the transplanted tooth and to avoid infection penetration from the mouth, there must be sufficient alveolar bone support in all dimensions with adequate attached keratinized tissue.

Before the auto-transplantation, thorough treatment planning should follow careful clinical and radiographic examination. If the mesiodistal recipient space is insufficient for the donor tooth, an orthodontic space generation prior to transplantation will be necessary. In cases of insufficient buccolingual bone width an autogenous bonegraft or green-stick fracture may be performed at the recipient site.^[19,20,24] The apico-coronal parameters of recipient site bone should be carefully examined from radiographs at the same time evaluating length of the tooth's root to be transplanted. If needed, additional preparation of recipient alveolus depth may be performed during auto-transplantation.

Donor tooth criteria

Teeth with open or closed apices may be considered as donors. However, the stage of root development of the transplant tooth is very important. Studies have evaluated the success of auto-transplantation looking at both development of the periodontal attachment and pulpal survival.^[8,19] Success rates are highest when the root development is one-half to two-thirds. Transplantation of a bud with roots formed less than one-half may be too traumatic and could compromise further root development. Surgical manipulation with full length roots and an open apex (such tooth would remain vital and should continue root development after transplantation) are still possible, but the increased length may cause encroachment on vital structures such as maxillary

sinus or the inferior alveolar nerve. If a tooth with a complete root formation is transplanted, it will generally require root canal therapy performed 2 weeks after transplantation.^[13] A tooth should be considered appropriate when its roots are sufficiently long to be preserved if no root development occurs after transplantation. Ideally, transplantation should be performed when a tooth is at its maximal length but still has the potential for pulp regeneration (apex opening >1 mm radiographically).^[5]

One of the factors contributing to successful auto-transplantation is vital intact periodontal ligament (PDL) fibers that play an important role in healing. Usually, the PDL fibers on the walls of the surrounding prepared sockets are absent. Therefore, it is desirable to extract a tooth with as much PDL attached to it as possible as it seems to be effective in preventing root resorption.^[24-27]

Timing

Immediate replantation of exarticulated teeth is known to have a good prognosis, while transplanted teeth to recipient beds prepared at the same time show a high prevalence of root resorption.^[23] Ideally, extraction of the tooth from recipient site should be performed on the same day when donor tooth is removed for transplantation. In cases when tooth from recipient site must be extracted earlier due to toothache or other reasons, transplantation should be scheduled within a month.^[20] The later donor tooth will be transplanted, the less support it will have as resorption of the bone would occur at the recipient site.

Timing is critical when assessing root formation stage suitable for auto-transplantation; therefore, age of the patient must be considered when planning this type of operation. Pulp regeneration can be expected in immature (developing) teeth but not in mature teeth.^[28-31] It is established that formation of the root continues after tooth emerges in the mouth for about 2-3 years [Table 1]. Mostly, the right stage of root

development occurs between the ages 9 and 12 years. Most traumatic injuries to anterior teeth seem to occur at the same period, making auto-transplantation a good option for these patients.^[5,17-19] Yet, wisdom tooth that is best for replacement of failed molars is better to be transplanted in elder patients. Finally, indicated age groups shouldn't be followed strictly in case of possible deviations in teeth maturation, and every possible candidate for transplantation should be examined by radiographic evaluation.

Success

Abulcassis documented the first dental surgical interventions of such kind in 1050, but the first surgery with details of tooth bud transplantation was recorded only in 1564, performed by a French dentist Ambroise Pare. In 1965, M.L. Hale described a transplantation technique for molars, and the major principles of his technique are still followed today.^[1,2,4] The literature reports excellent success rates following the appropriate transplantation protocol: Cohen^[24] found 98-99% survival rates over 5 years and 80-87% over 10 years with transplanted anterior teeth with closed apices. Lundberg and Isaksson^[18] had success in 94% and 84% of cases for open and closed apices, respectively, in 278 auto-transplanted teeth over 5 years. Josefsson^[33] had 4-year success rates of 92% and 82%, respectively, for premolars with incomplete and complete root formation. Andreasen^[11,12] found 95% and 98% long-term survival rates for incomplete and complete root formation of 370 transplanted premolars observed over 13 years. Kugelberg^[17] achieved success rates of 96% and 82% for 45 teeth with incomplete and complete root formation transplanted into the upper incisor region over 4 years. Nethander^[25,27] found 5-year success rates of over 90% for 68 mature teeth transplanted with a 2-stage technique. Most extensively tooth auto-transplantation has been studied in a long-term review of cases had a

Table 1: Permanent teeth development chart^[32]

Tooth position	Central incisor	Lateral incisor	Canine	First premolar	Second premolar	First molar	Second molar	Third molar
Maxillary (upper) teeth								
When tooth emerges	7-8	8-9	11-12	10-11	10-12	6-7	12-13	17-21
Root completed	10	11	13-15	12-13	12-14	9-10	14-16	18-25
Mandibular (lower) teeth								
When tooth emerges	6-7	7-8	9-10	10-12	11-12	6-7	11-13	17-21
Root completed	9	10	12-14	12-13	13-14	9-10	14-15	18-25

Table 2: Successful healing factors associated with auto-transplantation of teeth^[34]

Categories	Influencing factors for prognosis
Patient-related factors	Better results in younger patients A patient free of major systemic and metabolic problems or specific habits (e.g., smoking) Good oral hygiene and a co-operative attitude
Donor tooth-related factors	Periodontal ligament (PDL) The presence of intact and vital PDL attached to the root surface Preservation of vital PDL when the tooth is outside the mouth using physiologic salt water or milk or preservation liquids and as short a surgery time as possible Enhanced healing of the gingival tissue by placing a 1 mm band of PDL fibers on the root above the crest of bone A major factor in the formation of alveolar bone A chance of inadequate PDL development as an effective attachment with an impacted tooth (non-functioning tooth) Healing of dental pulp The preservation of Hertwig's epithelial root sheath Healing of the dental pulp occurs until Moorees tooth development stage 5 When the diameter of the apical foramina is >1 mm, there is more than an 87% chance the dental pulp will heal Continuation of root development Ideal timing of transplantation is when development of the donor tooth roots is 3/4 to 4/5 complete Gingival adaptation Tight flap adaptation prevents bacterial invasion into the recipient socket Root morphology Teeth with a single, cone-shaped root without concavity around the cervical area are most favorable
Recipient site-related factors	Bone width and height should be adequate to receive the donor tooth Better healing can be expected if the PDL tissue is still attached Transplantation should be performed on the day of transplantation or within 1 month after extraction
Clinical factors	Surgery should be performed by a clinician with experience in such areas as donor tooth extraction, preparation of the recipient site, and tissue management

follow-up range of 17 to 41 years.^[9,19] The success rate was over 90%, which is similar to that of dental implant-supported restorations.

DISCUSSION

The factors that lead to success have been extensively investigated, and it is well documented how extracted teeth gain complete function and good esthetics when replantation happens on ideal conditions [Table 2].

It was determined that the most significant contributor is the continued vitality of the periodontal membrane. When the periodontal ligament is traumatized during transplantation, external root resorption and ankylosis is often noted;^[35-37] root resorption is the most common cause of failure of the transplant. More specifically, the causes of tooth loss following auto-transplantation from most common to least common are: Inflammatory resorption, replacement resorption (ankylosis), marginal periodontitis, apical periodontitis, caries, and trauma. Atraumatic extraction of the donor tooth and immediate transfer to the recipient site to minimize the risk of injury to the PDL can decrease the incidence of most prevalent inflammatory (that becomes evident in 3 to 4 weeks) and replacement (becomes evident after 3 to

4 months) resorption.^[36-38] Therefore, the biological principles for auto-transplantation success that are understood and described in the literature along with the correct indications may lead to a successful alternative treatment with a very good prognosis.

However, as implant technology has taken great achievements in recent years of predictability in success rates and esthetic results, comparison between auto-transplantation and implantation as treatment options is inevitable. From the patient's perspective, auto-transplantation preserves the dentition using a natural tooth rather than a mechanical prosthesis,^[5] from the doctor's perspective, it is beneficial in many points. Transplantation is a biological procedure in which teeth, especially in a germ phase, have the potential capacity to induce alveolar bone growth;^[26,39-41] therefore, it can be applied in patients before puberty growth is finished. Several clinical studies performed rigid protocol in order to have clinically success results. Usually, the patient should then be seen at weekly intervals for one month if there are no complications. After one month, the patient should be seen every 6-8 months for 2-3 years. During this period, the tooth should be clinical and radiographically evaluated for the onset of pulpal breakdown seen as intrapulpal calcification, periapical radiolucency, or root resorption.^[42,43]

Osteointegrated implants will not grow with the changing patients jaw and result in infraocclusion. The open apex of the transplanted tooth with intact Hertwig epithelial root sheath allows healing and regeneration of the pulpal tissue and thus saving subsequent root canal treatment.^[41,43,44,45] Immediate transplantation with extraction at the recipient site is a procedure that provides significant time saving compared to implants. Healing is rapid, and function is regained almost immediately.^[46-48] Transplanted tooth with its PDL has osteoinducing properties that results in bone regeneration of the bony defects around transplants without graft materials, thus significantly reducing time and cost compared to implants.^[5] Transplanted tooth have potential for good esthetical results, since it allows the formation of a normal interdental papilla, the natural emergence profile, and natural crown form is maintained. Moreover, a subsequent orthodontic treatment and the position adjustment after surgery may be possible.^[23,43,45,47]

Anyway, today osteointegrated implants are the therapeutic alternative of choice when replacing a lost tooth, but transplantation and implantation techniques are similar in difficulty and so is the high prognosis supported by scientific evidence (more than 95% implants survival at 10 years^[42,43,49] and a transplant success rate over 90% at 17 to 41 years long-term studies.^[9,19,44,50]

CONCLUSION

Tooth auto-transplantation can be considered as an alternative approach in oral rehabilitation for some clinical situations (especially in young patients). It induces bone formation, and re-establishment of a normal alveolar process permits tooth movement to distant or opposite sides of dental arch or even to opposite jaw. In case of a failure, an intact area still remains possibility of implantation. However, beside its relatively low cost compared to the traditional methods of rehabilitation (such as osteointegrated implants) and high success rates, it requires careful case selection, professional skill, and patient and parent collaboration. Although auto-transplantation has not been confirmed as a traditional means of replacing a missing tooth, the procedure needs more consideration and future clinical studies in order to obtain predictable long-term results. Several research highlight how auto-transplantation of teeth can be considered as successful as endosseous dental implant

positioning.^[24,43,50,51] This treatment option may also be valued as a temporary measure in young patient because of replacing missing teeth in order to keep ridge volume of bone for at least 5 next years.^[50-55]

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