Autotransplantation: a lost art worthy of revival in the era of implants

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While synthetic implants represent a significant contribution to the advancement of dental medicine, they are associated with high costs, potential complications, and time delays. With autotransplantation, the patient is both donor and recipient of a living tooth; in the ideal case, this procedure transfers a healthy, nonfunctional tooth to a functional position. The aim of this article is to review the literature surrounding autotransplantation and present a successful case with the hope of increasing awareness of this approach to tooth replacement. A 20-year-old patient presented with a maxillary right second molar showing poor prognosis for restoration, and the patient's financial difficulties rendered extraction the only treatment option. The patient's fully soft tissue–impacted maxillary right third molar was atraumatically extracted and transplanted as a replacement for the second molar. The autotransplantation technique was enhanced via use of bone allograft to adapt the distal portion of the socket to the transplant, immediately reestablishing a healthy bony anatomy. In addition to reviewing the biologic basis, high success rate, and advantages of tooth autotransplantation, this article introduces a naming convention for transplanted teeth.

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The history of tooth transplantation can be traced back to ancient Egypt, where pharaohs received forced allotransplantations from people they enslaved.[1,2] Despite the cruel origins of the concept of a living tooth transplant, the modernized autologous transplantation technique is among the more beneficent treatments performed in contemporary oral surgery. With autotransplantation, patients are their own donor and recipient; in the ideal case, this procedure transfers a healthy, nonfunctional tooth to a functional position.

The earliest detailed report on this technique in the modern scientific literature was by M. L. Hale in 1956.[3] These early attempts at autotransplantation carried success rates around 50%, likely due to a traumatic extraction technique.[1] Unfortunately, these early failures and a lack of widespread adoption of the technique, which in many cases requires extraction of an impacted tooth, have made autotransplantation a rare exception in dental treatment planning.[4] Much of the surveyed literature on the topic consists of studies from the Eastern hemisphere, with at least one study noting that the technique is rarely practiced outside Europe.[4] Further, it is likely that the cases in which the technique is most applicable—transplantation of a young, impacted third molar to a first or second molar site—present as acute extraction cases to general dentists, who as a group vary widely in their comfort extracting an impacted tooth and transplanting it.[5] Nevertheless, the autotransplantation procedure has a good scientific foundation, and more recent data point to its high success rates.[6]

Fundamentals of autotransplantation

Indications

There are several indications for which autotransplantation is a highly viable treatment option. The classic case is posttraumatic reimplantation. There is a long history of pediatric and adult posttraumatic tooth reimplantation after avulsion injuries.[7] While trauma to the pulpal tissues from the primary injury often leads to endodontic complications, the success rates are high, especially when endodontic therapy is performed.[7]

True autotransplantation, however, is typically indicated for cases in which a tooth is planned for extraction due to impaction or as part of orthodontic therapy.[6,8] In such cases, a healthy tooth that would otherwise be discarded is repurposed to fill an edentulous space created by extraction. The ideal case for routine adult transplantation is the replacement of a first or second molar with an unerupted third molar. These teeth, particularly if they retain an open apex, are especially well suited for transplantation.[1,2,6,8-12]

In pediatric populations, a premolar can be used as a transplant for an extracted anterior tooth when crowding lends itself to an extraction-mediated orthodontic treatment plan.[8] In many of these cases, the orthodontic treatment plan may follow the surgical plan rather than precede it, such as when the etiology for extraction is traumatic fracture.

Similarly, the final plan for transplantation in molars may be a quick decision made based on the instant success or failure of third molar extraction; for example, if a third molar is badly damaged during extraction, it may not be viable as a transplant candidate. Nevertheless, the possibility that the extracted tooth may not be viable is not sufficient reason to automatically exclude autotransplantation from the treatment options in favor of a titanium dental implant. It is not unreasonable to provide a patient with a flexible treatment plan of "possible autotransplantation" should the donor tooth appear viable postextraction. Timing is one of the critical factors in the autotransplantation procedure, which will be elucidated in detail below.

Biologic basis

It is important to review the biologic foundation for the autotransplantation procedure. The ultimate goals of autotransplantation are to achieve normal periodontal ligament (PDL) attachment of the transplant to the donor site and to maintain pulpal vitality—essentially, to recreate the natural tooth that existed before the transplant.

Reattachment of the PDL to the alveolar bone requires viable PDL cells. Studies examining reimplantation procedures for avulsions have recorded PDL cell survival times as great as 24 hours under controlled conditions.[7] It has been generally concluded that the postimplantation prognosis improves as the amount of time the tooth spends outside the body decreases. The PDL is likely to show deleterious effects after approximately 20 minutes of dry time outside the body in reimplantation cases.[7]

Though extensive explantation time is not advisable for the donor tooth, the existence of data supporting avulsed tooth reimplantation after as long as 1 hour out of the socket in routine clinical scenarios should be reassuring for the autotransplant surgeon.[7] Of course, reimplantation cases have a few advantages over autotransplantations, including a precisely shaped socket and a greater likelihood of possible PDL fibers present circumferentially on both sides of the tooth-socket interface. Therefore, much tighter time constraints are recommended for autotransplantation.

The ideal autotransplantation outcome includes a vital pulp and functional PDL; however, an endodontically treated pulp with a viable PDL or an ankylosed tooth that exhibits long-term stability may also be considered a success in certain cases.[10] The best donor tooth is one with an open apex. The biologic basis for this is similar to that of endodontic apexogenesis procedures, where bleeding from an open apex facilitates reestablishment of pulpal-systemic circulation via a regenerative process.[11,13]

Autotransplantation is a particularly powerful tool for use in pediatric populations. Even in cases where the transplant is only partially successful and a necrotic pulp or ankylosis develops, the ability of the tooth to maintain bone architecture for a future implant is valuable. In cases where a fully viable pulp and PDL are reestablished, the advantages over immobile titanium implants in a growing jaw are especially salient. Especially considering the improved prognosis of autotransplants with immature teeth, the case for consideration in a pediatric patient is all the more compelling.[6]

One of the primary benefits of autotransplantation is the perfect compatibility of the tissue. This procedure categorically avoids the risk of immune rejection or metal allergy. Furthermore, unlike titanium implants, the autotransplanted tooth establishes a true PDL, providing the patient with the benefits of proprioception and normal mobility in function as well as a more robust antibacterial tissue architecture in the arrangement of the soft tissue attachment fibers.

Fig 1. Preoperative view of the poorly restorable maxillary right second molar.

Outcomes

Since Hale's modern characterization of the technique in the 1950s, the autotransplantation procedure has been documented by numerous authors despite its lack of widespread use. A small but compelling number of studies have established a high efficacy rate. Slagsvold and Bjercke documented 34 cases with a 100% survival rate in 1974.[8] A study from 2013 by Cross et al showed a 96% success rate for autotransplantation, compared to 95% for implants and success rates no greater than 89% with other treatment options (eg, bridges and removable restorations).[1] In a 2018 systematic review, Rohof et al found a success rate of 96.6%, with an annual estimated survival rate of 98.2% and a 10-year survival rate of 96.3%.[6] Complications were relatively rare, with ankylosis (2.0%), root resorption (2.9%), and pulpal necrosis (3.3%) reported. Rohof et al also found that teeth with open apices had a 70% lower risk of posttransplantation extraction compared to mature teeth.[6] A 2019 study by Abela et al examined 366 autotransplants over 34 years and found a mean survival time of 19.31 years and a success rate of 89.9%.[14] In a 2018 systematic review of autotransplanted teeth, Akhlef et al found a survival rate of 96.7%.[9]

Case report

A healthy 20-year-old woman presented to the dental clinic for extraction of a symptomatic maxillary right second molar, which had a poor prognosis for restorability (Fig 1). The patient's financial situation also made endodontic and implant therapy untenable.

Radiographic evaluation revealed that the maxillary right third molar might become accessible on reflection of a mucoperiosteal flap as part of the planned extraction of the second molar (Fig 2). The patient was informed that if the third molar

Fig 2. Cropped panoramic radiograph revealing the maxillary third molar fully impacted beneath the soft tissue.

Fig 3. Occlusal view immediately after transplantation of the third molar.

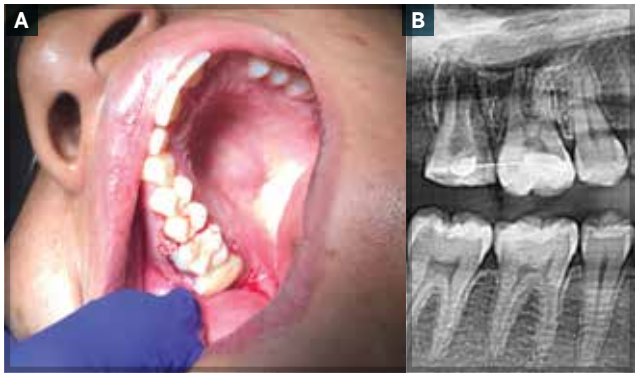

Fig 4. Views after reduction of the occlusion and splinting of the transplanted tooth. A. Intraoral view. B. Cropped panoramic radiograph.

extraction were completed, the tooth might prove a viable autotransplantation candidate. The risks of the procedure were reviewed, including the potential for loss of the transplanted tooth, and the patient agreed to the procedures.

After profound local anesthesia was achieved, a full-thickness mucoperiosteal flap was reflected, and the maxillary right second molar was extracted atraumatically. The third molar was likewise atraumatically extracted and placed immediately in the extraction socket of the second molar. The socket could not satisfactorily accommodate the transplant; therefore, the transplant tooth was briefly placed in room temperature sterile saline. A high-speed surgical handpiece was used to make adjustments exclusively to the distal aspect of the extraction socket wall. The transplant was tried in again and fit satisfactorily (Fig 3). The total time for adjustment and try-in was less than 30 seconds, with the transplant either in a bleeding socket or in a saline container at all times.

When the tooth was satisfactorily positioned with the aid of the distal wall adjustments, cadaveric 1:1 mineralized/demineralized cortical bone graft material hydrated in sterile saline was added to the distal aspect of the extraction socket to fill any irregular or unused distal socket space behind the transplant. No graft material was placed on the mesial, buccal, or lingual walls of the socket, which had transplant-to-socket contact. Any minimal shortcomings in exact adaptation were filled by blood. Primary closure distal to the transplant was achieved with resorbable sutures.

The metallic portion of a trimmed, sterile endodontic hand file was bonded to the buccal surface of the maxillary right first molar and the transplanted tooth with flowable composite resin after the application of 35% phosphoric acid gel for 30 seconds and a bonding agent. After the semirigid splint was applied, occlusal adjustments were performed to remove the tooth from occlusion (Fig 4). The patient was given standard postextraction postoperative instructions for home care and recommendations for over-the-counter pain medication. In addition, the patient was prescribed 500 mg of oral amoxicillin 3 times a day for 7 days and 0.12% chlorhexidine gluconate mouthrinse twice a day for 2 weeks, beginning 48 hours postoperatively.

During a 1-month follow-up visit, the patient reported no significant postoperative pain immediately following the procedure and no discomfort at the time of evaluation. The patient reported feeling completely normal and did not have a particular awareness of the transplant in the mouth. Clinical examination revealed no appreciable mobility of the tooth, and a radiograph suggested reestablishment of the PDL and bony architecture (Fig 5). An appointment was scheduled for removal of the splint and other unrelated operative treatment, including restoration of the disto-occlusal surface of the maxillary right first molar. Due to scheduling issues, this follow-up took place approximately 2 months after the transplantation date.

At the 2-month follow-up appointment, the patient reiterated that she perceived the transplanted tooth as completely natural and unremarkable in her mouth. The splint was removed, and photographs and a radiograph of the site were obtained (Fig 6). The transplanted tooth responded normally to palpation and percussion, was immobile (ie, exhibited normal physiologic response to mobility evaluation), and was deemed vital. In response to electric pulp testing, the first molar registered as 34 and the transplanted tooth as 39, confirming its vitality. The gingival tissue around the transplant was appropriately vascularized and had a healthy appearance. The patient was reminded of the need for placement of a crown to create a well-designed occlusal and embrasure geometry.

The autotransplantation was deemed a success in this case, resulting in a vital and periodontally stable transplanted tooth. The patient was extremely pleased with the procedure and the results throughout the process.

Discussion

Several deliberate procedural strategies were followed in this case to help improve the prognosis of the transplant. An important part of the operative plan was that the procedure was performed with deliberate but purposeful haste; the transplant spent virtually no time outside of the body. Studies are supportive of a goal time of less than 1 minute outside the body for autotransplanted teeth.[4] This goal serves the objective of not providing the PDL (or pulp) cells the opportunity to become necrotic.

Fig 5. Follow-up radiograph at 1 month showing reestablishment of the periodontal ligament.

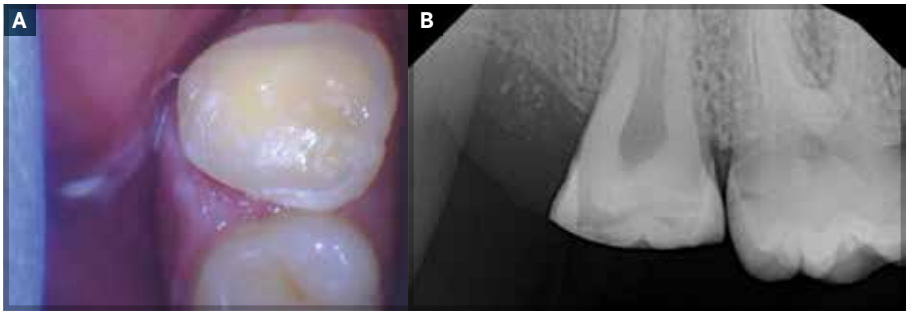

Fig 6. Appearance after removal of the splint at the 2-month follow-up examination. A. The soft tissues are healed and the tooth is vital. B. The radiograph verifies the health of the periodontal ligament.

Furthermore, to the extent possible, the transplant was handled by the crown, minimizing unneeded trauma to the cells lining the roots. As in reimplantation protocols, there was no instrumentation of any kind of the transplant root surface.

As part of the strategy to preserve any residual PDL cells, the extraction socket was not curetted along the lateral walls. With the reestablishment of a healthy PDL looming so large in the success of the procedure, the decision was made to prioritize the PDL above other factors. Due to the preservation of the majority of the extraction socket architecture, the transplanted tooth was given the opportunity to re-form a functional PDL with the benefit of cells from both the transplant and the extraction socket. While a slightly more idealized position could have been achieved with a more aggressive osteotomy, it would have come at the cost of socket PDL cells and resulted in additional time outside the body for the transplant tooth while the bone was contoured.

In pursuit of the goal of preserving maximum health of the PDL, the tooth was splinted with a semirigid splint and taken out of occlusion, a commonly practiced clinical technique for allowing periodontal ligament healing.[7] Other reports have described the use of suture-only splints; however, the widespread history of successful use of semirigid splints in reimplantation, as well as in healing of PDLs traumatized by occlusal or periodontal disease, led the surgeon to choose the semirigid splint as a scientifically grounded, logical approach in this case.[4]

While not all authors have reported removing the tooth from occlusion to the extent that was performed in the present case, there is a strong rationale for doing so. Indeed, there is a long history of endodontic practitioners removing a tooth from occlusion after root canal therapy as well as a similar history of periodontists promoting a healing phase by removing from occlusion any mobile teeth with PDLs traumatized by malocclusion.[15,16] In the present case, where the socket architecture was maximally preserved and the position of the tooth was not completely dictated by the surgeon, the transplant did not have ideal occlusion and required more aggressive reduction than would have been preferred. However, it was hypothesized that the overall prognosis would be improved if the tooth were allowed to heal free from occlusal forces until an indirect occlusal restoration could be designed to restore a perfect occlusal scheme.

The transplantation procedure in the present case was also supplemented by the use of bone allograft. The rationale for the use of graft material was to repair the unused socket space posterior to the interseptal-distal osteotomy. This provided a matrix for the bone to re-form and reestablish a healthy bony architecture circumferentially around the crown to avoid reintroducing the transplant to a site with preexisting bone loss.

It is worth reiterating that the autotransplantation procedure can be performed not only successfully but also quickly by a skilled surgeon. It is a valuable tool with several advantages over the placement of titanium implants, including the ability to place a natural tooth with a visible crown quickly and immediately postextraction. Another advantage is the ability to splint the transplant to a natural abutment and thereby minimize the risk that instability would jeopardize osseointegration of the implanted tooth. In contrast, instability is often a concern with a fully or partially loaded crown in same-day titanium implant protocols in which success relies on immobility of the implant, which is mediated solely by the quality of bone-to-implant contact.[17,18] Other advantages include the restoration of natural clinical mobility and proprioception as well as the lower cost to the patient.

As natural solutions gain in popularity and the pendulum swings back and forth between implant- and endodontic-mediated dental solutions, autotransplantation may find its way into favor, particularly for pediatric and young adult populations. As future clinicians and investigators delve further into the possibilities offered by autotransplantation, and possibly even transplantation of laboratory-grown teeth, a few areas for future exploration are offered for thought and study. For example, the ubiquity of bone grafting material among would-be dental transplant surgeons is likely to coincide with increased use of platelet-rich fibrin (PRF). Certainly, there is good reason to suggest that PRF would provide an invaluable tool in autotransplantation, particularly when the recipient site is an osteotomized and healed alveolar ridge.[19]

The possibility of providing additional resources for preventing ankylosis and pulpal necrosis are certainly intriguing. Some authors have used PRF as a root canal filling material to reestablish tooth vitality.[13] Future research might examine the use of PRF and even possible pretransplantation apicoectomy to alleviate the minor canal restriction and establish a bleeding pathway for vascular connection even in mature autotransplanted teeth. Since the goal is to maintain a vital PDL (more than a vital pulp), the rationale is to prevent pulpal

necrosis by-products from entering the regenerating PDL space as well as to avoid the cost of root canal treatment.

From a practical standpoint, it may be necessary for clinicians to note transplanted teeth in dental records. The American Dental Association has a naming convention for supernumerary teeth.[20] For permanent teeth, the tooth number of the nearest adjacent permanent tooth is increased by 50; for primary teeth, the letter *S* is added after the letter of the adjacent primary tooth. However, to the author's knowledge, no such protocol exists for autotransplanted teeth. Therefore, the author suggests the implementation of a system for naming autotransplanted teeth in which they are designated by the tooth number of the recipient site followed by a letter *X* and the source tooth number, which are enclosed in brackets. For example, tooth 1 transplanted into a tooth 2 site would be designated *tooth 2 [X1]*. This system uses the letter *X*, which often denotes a former position and has the advantage of using a letter outside the *A* to *T* primary tooth identifiers to prevent misidentification. In addition, enclosing the additional information in brackets will help to alleviate confusion for providers who are unfamiliar with transplantation.

Conclusion

Autotransplantation of teeth is a viable alternative to dental implant placement, particularly in cases where implants are not financially possible or recommended, such as in pediatric populations. Autotransplantation can retain tooth vitality as well as establish a functional PDL, providing benefits that include normal clinical mobility and proprioception. Minimizing explantation time is critical to the success of the procedure; with proper planning and a decisive surgical technique, a tooth can be transplanted in a matter of seconds. Possible complications of autotransplantation include pulpal necrosis, ankylosis, and resorption.

This technique has a high success rate that has been reported in case reports and systematic reviews. It has a variety of procedural variants, including the one discussed in the present case, which included very limited explantation time, minimal contouring of the extraction socket, and placement of allogeneic bone graft material in selected areas. The documentation of successful clinical cases is important so that consensus protocols can be established. To further support that goal, a new naming convention for autotransplanted teeth is suggested.

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References

1. Cross D, El-Angbawi A, McLaughlin P, et al. Developments in autotransplantation of teeth. *Surgeon*. 2013;11(1):49-55.
2. Nimčenko T, Omerca G, Varinauskas V, et al. Tooth autotransplantation as an alternative treatment option: a literature review. *Dent Res J(Isfahan)*. 2013;10(1):1-6.
3. Hale ML. Autogenous transplants. *Oral Surg Oral Med Oral Pathol*. 1956;9(1):76-83.
4. Ong D, Itskovich Y, Dance G. Autotransplantation: a viable treatment option for adolescent patients with significantly compromised teeth. *Aust Dent J*. 2016;61(4):396-407.
5. Cottrell DA, Reebye UN, Blyer SM, Hunter MJ, Mehta N. Referral patterns of general dental practitioners for oral surgical procedures. *J Oral Maxillofac Surg*. 2007;65(4):686-690.
6. Rohof ECM, Kerdijk W, Jansma J, Livas C, Ren Y. Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis. *Clin Oral Investig.* 2018;22(4):1613-1624.
7. Goswami M, Chaitra T, Chaudhary S, Manuja N, Sinha A. Strategies for periodontal ligament cell viability: an overview. *J Conserv Dent*. 2011;14:(3):215-220.
8. Slagsvold O, Bjercke B. Autotransplantation of premolars with partly formed roots. A radiographic study of root growth. *Am J Orthod*. 1974;66(4):355-366.
9. Akhlef Y, Schwartz O, Andreasen JO, Jensen SS. Autotransplantation of teeth to the anterior maxilla: a systematic review of survival and success, aesthetic presentation and patient-reported outcome. *Dent Traumatol*. 2018;34(1):20-27.
10. Murtadha L, Kwok J. Do autotransplanted teeth require elective root canal therapy? A long-term follow-up case series. *J Oral Maxillofac Surg*. 2017;75(9):1817-1826.
11. Simon S, Smith AJ. Regenerative endodontics. *Br Dent J*. 2014;216(6):E13. doi:10.1038/sj.bdj.2014.243
12. Chugh A, Aggarwal R, Chugh VK, Wadhwa P, Kohli M. Autogenous tooth transplantation as a treatment option. *Int J Clin Pediatr Dent*. 2012;5(1):87-92.
13. Prasad J, de Ataide IN, Chalakkal P, Likhyani LK. Comparison between the outcomes of two platelet-rich concentrates on apexogenesis in young permanent incisors requiring endodontic retreatment. *Contemp Clin Dent*. 2018;9(Suppl 1):S156-S159.
14. Abela S, Murtadha L, Bister D, Andiappan M, Kwok J. Survival probability of dental autotransplantation of 366 teeth over 34 years within a hospital setting in the United Kingdom. *Eur J Orthod*. 2019;41(5):551-556.
15. Rosenberg PA, Babick PJ, Schertzer L, Leung A. The effect of occlusal reduction on pain after endodontic instrumentation. *J Endod*. 1998;24(7):492-496.
16. Burgett FG. Trauma from occlusion. Periodontal concerns. *Dent Clin North Am.* 1995;39(2):301-311.
17. Koh RU, Rudek I, Wang HL. Immediate implant placement: positives and negatives. *Implant Dent*. 2010;19(2):98-108.
18. Al-Sabbagh M, Eldomiaty W, Khabbaz Y. Can osseointegration be achieved without primary stability? *Dent Clin North Am*. 2019;63(3):461-473.
19. Miron RJ, Moraschini V, Fujioka-Kobayashi M, et al. Use of platelet-rich fibrin for the treatment of periodontal intrabony defects: a systematic review and meta-analysis. *Clin Oral Investig*. 2021;25(5):2461-2478.
20. American Dental Association. Current policies. Adopted 1954-1920. 2021. Accessed June 21, 2022. https://www.ada.org/-/media/project/ada-organization/ada/ada-org/files/resources/research/oral-health-topics/ada_current_policies_2020.pdf