
Abstract:
This article describes one case of the successful autologous transplantation of two, immature and un-erupted third molars to a partially edentulous right maxillary posterior arch of a 13 year old female. The dental follicles of the right maxillary and mandibular 3rd molars were transplanted to the edentulous sites of teeth Nos. 2 ad 3. This resulted in the complete anatomical and functional development of the transplanted teeth and regeneration of the pre-treatment vertical bone loss that is typical following tooth extraction. This is supported by pre-treatment casts and 18 and 31 years of post-treatment casts, x rays and photos.

The results of this case suggest that autologous transplantation of teeth with minimal (3 mm) root development may have a successful life-time result. This procedure can be considered whenever teeth need to be replaced in younger individuals.

The patient’s pre-treatment and early post-treatment x rays were destroyed in an office flood and are not available. However, a panoramic x ray of a 13 year old child is presented to demonstrate the anatomy of 3rd molars at this stage of development (figure 3).

Key words: autologous, homologous, transplantation, antigenicity, embryological, follicle, follicular membrane.

History
The recognition of the importance of teeth dates back to man’s early beginning. Tooth transplantation and a variety of other dental procedures, including homologous transplantation of teeth (between unrelated persons), were discovered in ancient Egyptian mummies. (1, 3, 4). In addition, the implantation of materials and devices into jawbones dates back thousands of years to ancient cultures including Egyptians, Romans, Greeks, Mayans, Aztecs and Etruscans (3,2 6). During the 16th and 17th centuries there was a resurgence of interest in homologous tooth transplantation which reached a peak in popularity in the 18th century (22, 3). Dr. John Hunter, a Scottish surgeon (1728-1793), advanced the
state of knowledge of tooth transplantation by reporting that greater success of
homologous tooth transplantation would be achieved if the donor tooth was
freshly extracted, of the same size and shape as the recipient site and from
healthy donors. (15) This practice was abandoned because of long-term failures
we now recognize was most likely due to the immunological transplantation
rejection response (histocompatibility). In spite of this many of these
homologously transplanted teeth survived 6 to 8 years. In 1963 the author, in a
senior thesis (unpublished) at Harvard School of Dental Medicine), conducted a
study where mouse teeth were homologously transplanted subcutaneously
followed by homologous skin graft challenges. The study demonstrated that
mouse teeth are antigenic and immunologically competent to initiate a transplant
rejection response. Valente et.al. also reported on the role of immunology in
tooth transplantation (17), the inactivation of tooth antigenicity (17), and
transplantation immunity to a single subcutaneously implanted tooth in mice (16,
18 ). Schulman and Valente conducted animal studies and reported on the
histological observations on subcutaneous autologous and homologous tooth
implants (19). They also reported on a quantitative time study of allogenic tooth
transplantation immunity (21). Currently, the majority of proponents of
autologous tooth transplantation support the idea that teeth with at least one
third to three-fourths root formation (Kristerson, 1985) may have the highest rate
of success, ranging from 50% to 96% and surviving 10-20 years. The literature is
replete with articles related to the transplantation of canines, bicuspids and
molars. Regardless of the specific tooth to be transplanted, the surgical
principles, procedures and techniques apply similarly to all. There is general
agreement that teeth with apices greater than 1 mm have a greater chance of
survival than mature teeth with closed apices, which require endodontic
treatment within 2-4 weeks following transplantation.

Clinical Case
In 1964 a 13 year old white healthy female was brought to the office by her father
requesting the replacement of her maxillary right first and second molars (Nos. 2,
3). Her medical history was unremarkable but the dental history indicates a
degree of neglect. Oral examination revealed the presence of caries, significant
plaque, damaged upper central incisors, narrow pre-maxilla, Class II Division I
molar relationship, 100% vertical over-bite and horizontal over-jet of 8-9 mm.
Oral hygiene was fair and there was no evidence of periodontitis. Teeth Nos. 2
and 3 were missing. The edentulous ridge was well developed with
approximately 2-3 mm of post extraction vertical bone resorption and no significant amount of horizontal (width) bone loss. (Figure 1 and 2).

(Figure 1)

Periapical X rays of the edentulous ridge revealed good bone healing of the extraction sockets. X rays of the right maxillary and mandibular third molar areas revealed the presence of dental follicles (dental sac) of teeth Nos. 1 and 32. They had fully formed crowns and approximately 2-3 mm of the root formation. The patient’s pre-treatment x rays were destroyed in an office flood and consequently are not available. However, a panoramic x ray of a typical 13 -14 year old child is presented to demonstrate the Typical size, shape, anatomy and location in the bone of third molars at this stage of development. (Figure 3).

(Figure 2).

(Figure 3)
After considering all possible options transplanting teeth Nos. 1 and 32, still in embryological stage of development, was considered be the only long-term treatment option available. The benefits and risks of the procedure were presented to the patient’s father, who gave his permission to proceed with the treatment.

**Procedure**

Prior to surgery, periapical x rays of the immature 3rd molars (No. 1 and 32), embedded in the alveolar bone, measurements were made of the mesial-distal widths and depth of the teeth in the bone. These measurements were used to determine the size and shape of the slightly oversized osteotomies to be prepared at the reception sites.

The first step was to map out the exact location and sizes of the two proposed recipient osteotomy sites on the edentulous area of the maxillary study model. A right mandibular alveolar nerve block was performed using lidocaine 2% with 1 to 100,000 epinephrine (Xylocaine, Astrazeneca LP). A full thickness crestal incision was made from the distal of tooth No. 31 through the retro-molar pad. Using sharp dissection the gingiva was reflected to expose the ridge. Hand and rotary instruments were used to carefully remove enough bone from around No. 32, the immature 3rd molar, to permit mobilization and elevation from its crypt. The tooth was left it the crypt until the recipient sites was prepared.

The next step was to expose tooth No.1. Lidocaine was infiltrated into the buccal and palatal areas of the maxillary right posterior arch. A full thickness crestal incision was made from the distal of tooth No. 4 to the tuberosity. A buccal vertical releasing incision was made just distal to No. 4 to facilitate the reflection of a muco-gingival flap. Using the same procedure as for tooth No. 32, the dental follicle was exposed and left in the crypt.

The next step was to transfer the location of the proposed osteotomies from the model to the edentulous ridge, formerly occupied by teeth Nos. 2 and 3. Using a No. 8 round bur, two slightly over-sized osteotomies were prepared so that the follicles would not be compressed between the bony walls of the socket. The depth of the osteotomies was dictated by the depth of the two 3rd molars in their crypts. The osteotomies were examined for blood clots and to be certain that the floor of the sinus had not been perforated.
The next step was to carefully remove tooth No. 32 from the bony crypt along with as much of the follicular membrane as possible. Once out of the crypt the follicle was properly oriented, root pointed upward, and immediately transplanted into the recipient site of tooth No. 3. Using the same procedure the follicle of tooth No.1 was elevated out of the crypt, properly oriented, root pointed upward, and transplanted to tooth No. 2 site. Every effort was made to be gentle with the handling of the teeth, being especially careful to avoid damaging Hertwigs Root Sheath. Bleeding was minimal. Primary closure was achieved at both donor and recipient sites with interrupted 3-0 silk sutures. Post-op medications included Penicillin VK 250 mg. q. i. d. and Tylenol Codeine 30 mg 1 q4h. Post-op recommendations included interrupted cold packs to the right side of the face, soft diet and gentle brushing near the surgical site. There were no post-op complications or complaints and the sutures were removed 10 days later. The patient never returned for further post-op visits because the family moved to New Hampshire, a neighboring state.

Results

In 1981, eighteen years post-op and now 31 years of age, the patient, travelling through Massachusetts, decided to stop by my office to show me the results of the transplant surgery years earlier. Examination of the surgical site revealed two fully developed and erupted teeth (formerly Nos. 1 and 32) in sites formerly occupied by Nos. 2 and 3. into full and stable occlusion with contacts between each other and tooth No. 4. In addition the fully submerged transplants stimulated the osteocytes to vertically regenerate the alveolar bone that was lost following the extractions. (Figure 4 and 5).
The gingiva around the transplanted teeth was healthy, with pale healthy color, normal texture and having the same width of attached gingival as teeth Nos. 4 and 5. (Figures 6).
The occlusal surfaces of both teeth had been restored with amalgam restorations. In 1994, 31 years post-op, a periapical x-ray (figure 7) of the transplanted teeth, revealed the crown and roots to be fully developed. The length of the roots was determined by the position of the floor of the maxillary sinus, which had already begun to expand inferiorly as a result of the missing teeth. The mesial root of No. 3 (originally NO. 1) was curved distally and in very close proximity to the floor of the sinus. The distal root was straight and a little shorter. The root canal was clearly visible in the mesial root and less so in the distal root. The lamina dura was not as clearly defined as it was or teeth Nos. 4 and 5 but the periodontal ligament space was evident. Tooth No 2 (formerly No.1) was longer and most likely due to the size and shape of the maxillary sinus. The lamina dura was not clearly defined but the periodontal space surrounding the root was visible. The surrounding alveolar bone appeared to be well developed and with similar density and trabecular pattern as the neighboring bicuspids. Sounding the teeth for ankyloses was negative. All tissues, hard and soft, revealed no significant changes from 1981. (Figure 7).

(Figure 7)

Discussion
Treatment plan: The decision to transplant the immature molars at that age was preceded by a thorough evaluation of all positive and negative factors of treatment options available, which included: doing nothing, placing endossious blade implants, unilateral sub-periosteal implants, fixed bridge or removable free-end partial denture. None of these options would work for the following reasons:
1. Since alveolar ridge growth and maintenance are dependent on the presence of teeth, doing nothing would result in continued ridge resorption and pneumatization of the maxillary sinus. Furthermore, super-eruption of unopposed mandibular teeth would reduce or obliterate the inter-arch space; thereby, eliminating any possibility of future reconstruction of the edentulous ridge.
2. Endosseous implants should not be placed in a growing child: they would not stimulate bone growth and remain in hypo-occlusion. 3. A partial denture, subjected to the occlusal forces of mastication, bruxism and para-functional activity, would accelerate and increase the typical vertical and horizontal ridge resorption that follows tooth extraction. Furthermore, due to the patient’s age and stage of physical development, frequent replacement of partial dentures would be impractical. 4. Delaying treatment would allow additional donor root formation and the potential closure of the apices. This would prevent the revascularization of the pulp and necessitate endodontic treatment be completed within two-four weeks.

Follicle: The role of the follicular membrane is indispensable for the formation of a tooth because it contains the genetic material required for the formation of the periodontal ligament, cementum and alveolar bone. Transplanting the follicular membrane with the tooth may further promote tooth development. At the “crown stage” of development the dental papilla (future pulp) is protected by Hertwig’s Epithelial Root Sheath, which is also responsible for the development of the size and shape of the root. The surrounding bone and follicle are the source for the vascularization of the pulp. The periodontal ligament cells closet to the root’s outer dentine layer lays down cementum on the root after the crown has entered the oral cavity and towards the completion of the root growth (25). And lastly the thick follicular membrane fills the space between the crown and alveolar bone and facilitates atraumatic removal of the teeth. (22) The principles for transplanting undeveloped 3rd molars also apply to bicuspids and canines. (6, 7, 9,10).

Surgical considerations: A donor tooth with considerable root development is at greater risk of being traumatize during the surgical removal procedure due to the
compressive, torque and shear forces required. The periodontal ligament and cementum could be damaged or stripped off the root leading to inflammatory resorption, replacement resorption or ankyloses. The tooth may fail to vascularize, leading to aseptic necrosis. (23). However, if root replacement resorption occurs the ridge would be preserved and be amenable to dental implantation at a later date. Leaving a transplanted tooth exposed to the oral environment increases the potential for infection, trauma, excessive movement, displacement or ankylosis.

Success: In spite of the high success rates reported auto-transplantation has not yet reached the point where it is included as an option when teeth need to be replaced. (2, 5-10). There is no definitive consensus regarding the transplant procedure that produces the best results. The definition of success as it relates to autologous tooth transplantation requires clarification. Some clinician’s criteria for success may be based solely on whether or not the transplant is clinically functioning despite the fact that abnormalities may exist, including internal or external root resorption, replacement resorption, inflammatory resorption (ankylosis), calcified canals or periodontal infection. Transplanted teeth may function for some time even though a pathological process is on-going but is not obvious. Slight external resorption (either inflammatory or replacement resorption) is not radiographically detectable early on. Inflammatory resorption may be seen in 3-4 weeks whereas replacement resorption may take 3-4 months to 1 year to be detected (25).

Some authors report successful autologous transplantation of teeth with considerable root formation and no follicular membrane (14). Others have reported successful transplantation of teeth with considerable root formation and only remnants of follicular membrane (15). Some authors reported 5 year success rate of about 50% (1) while others reported survival of 10-20 years (22) without reference to the presence or absence of follicular remnants on the transplants.

The author’s definition of a successful autologous tooth transplant is one that has survived 20 years or more with normal anatomy (size and shape), lamina dura, periodontal ligament space, pulp chamber, well defined root canals, periodontal healing, sufficient alveolar bone support, physiological mobility and absence of periodontal disease.
Historical value: This case was done over 50 years ago when the principles and techniques of tooth transplantation had not yet been developed. Many of the principles and procedures used in this case are still applicable today.

Conclusion
1. Autologous transplantation of teeth during embryological stage of development may increase the chances of lifetime survival.

2. Transplanting the follicular membrane along with the tooth may increase the chance of successful lifetime result.

3. Surgical removal of a tooth follicle during the “crown stage” may be less traumatic than the removal of a tooth with advanced root formation.

4. Autologous tooth transplantation is a viable option for the long term replacement of missing teeth.

References
7. Andreasen JO, Paulsen HU, Yuz, Bayer T, Schwartz O. A long-term study of 370 Autotransplanted premolars. Part II Tooth survival and pulp healing to
13. Dr. Jerry Gordon The best dental implant may be your own tooth! http://www.dentalcommfortzone.com/archive/BestDental Implant.html pg.
14. Tooth bud transplant by William Gibson Neuromancer at Technovelgy.com
Company. Chapter 14, Page 446-454.

26. Dental Implant Chicago: Evolution of dental implants:

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