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Management of Late Complications in Autotransplanted Teeth

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***Abstract**: Autogenous tooth transplantation, or autotransplantation (AT)—the surgical relocation of a donor tooth within the same individual. There are numerous indications for autotransplantation (AT). It serves as a therapeutic option in cases of tooth loss due to trauma, caries, periodontal disease, or endodontic issues, as well as in cases of impaction or agenesis. Contraindications may be absolute—precluding the procedure entirely—or relative, meaning the procedure may be performed after a certain period or once appropriate conditions have been established. The healing of periodontal wounds is generally considered a more complex process compared to the healing of epidermal wounds. Complications during healing include root resorption—which may manifest as inflammatory resorption or replacement resorption (leading to ankylosis)—pulp necrosis, impaired periodontal healing, etc. Therefore, precise surgical technique, atraumatic extraction, preservation of the integrity of the periodontal ligament (PDL), minimal extraoral time, and careful postoperative monitoring are essential to reduce the risk of root resorption and ensure the long-term success of the autotransplanted tooth. Recently mineral trioxide aggregate (MTA) has emerged as a reliable material due to its biocompatibility, good sealing property, and it encourages regeneration of peri-radicular tissues such as periodontal ligament bone and cementum. These favorable properties render MTA a suitable material for the management of tissues damage caused by external root resorption. The use of MTA via the root canal demonstrates positive clinical and radiographic signs, indicating both the cessation of the root resorption process and the repair of the associated bone defect.*

***Key Word**: Autotransplantation (AT), Periodonal ligament (PDL), External root resorption, Mineral Trioxide (MTA).*

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I. Introduction

Autogenous tooth transplantation, or autotransplantation (AT)—the surgical relocation of a donor tooth within the same individual—has been investigated for decades as an alternative to prosthetic treatment, particularly in adolescents and young patients [1].

The number of studies demonstrating that tooth autotransplantation serves as an alternative method for replacing missing teeth is steadily increasing. This procedure offers not only an immediate but also a permanent restoration of lost teeth [2].

In recent decades, the use of dental implants has become an exceptionally popular therapeutic option. Despite its significant potential, tooth autotransplantation has increasingly become an overlooked alternative. Dental implants have emerged as the predominant solution for replacing missing teeth, largely due to their high success rates and excellent stability. Nevertheless, autotransplantation remains an underutilized yet clinically valuable approach—especially for patients who are still growing, or in cases where dental implants are contraindicated. This biologically-based technique enables the management and resolution of edentulous spaces through the transplantation of a healthy tooth (most commonly a premolar, third molar, or canine), the replacement of teeth for which treatment is not feasible, or the repositioning of an impacted tooth into its proper location. Furthermore, it offers unique advantages such as natural proprioception, continued root growth and development, the possibility of orthodontic movement, and—most importantly—the preservation of the alveolar bone [3].

The concept of tooth autotransplantation dates back to ancient civilizations. Historical records from ancient Egypt reveal that slaves were frequently forced to donate their teeth for transplantation, primarily to serve the needs of the pharaohs. The practice of transplanting teeth between different individuals of the same species—known as allotransplantation—became a well-known and widely used procedure; however, over time, this trend was gradually abandoned due to numerous complications.

The concept of modern autotransplantation gained prominence in the mid-20th century. In 1954, M. L. Hale reported the first documented case, establishing the fundamental principles upon which the performance of this procedure is still based today. Subsequently, Dr. Jens Uwe Andreasen—a pioneer in the field—played a key role in advancing the technique; by meticulously documenting successful cases and publishing his research, he helped formalize clinical protocols and significantly improve the outcomes of this therapy [3].

1.1 Indications and contraindications

Several authors [3, 4, 5, 6] cite numerous indications for autotransplantation (AT) in their work, emphasizing that it serves as a therapeutic option in cases of tooth loss due to trauma, caries, periodontal disease, or endodontic issues, as well as in cases of impaction or agenesis. They highlight that, unlike implants, transplanted teeth retain a living periodontium; this provides the aforementioned advantages regarding the preservation of bone and soft tissue, as well as the potential for orthodontic or physiological tooth movement. Furthermore, one of the primary benefits of this procedure is that it can be performed on young, growing patients—a group in which the incidence of tooth loss due to trauma is relatively high.

Contraindications may be absolute—precluding the procedure entirely—or relative, meaning the procedure may be performed after a certain period or once appropriate conditions have been established. Depending on their nature and location, contraindications can be classified into the following categories [7, 8]: Local contraindications related to the recipient site; contraindications related to the patient's health and compliance; and contraindications related to the donor teeth.

II. Periodontal wound healing

The healing of periodontal wounds is generally considered a more complex process compared to the healing of epidermal wounds. As previously mentioned, the periodontium comprises cementum, a functionally oriented periodontal ligament (PDL), alveolar bone, and the gingiva. The integrated interaction and interconnection of these four tissues constitute a highly complex structural and functional entity.

2.1. Possible outcomes for periodontal ligament healing

• ***Regeneration.*** The ideal scenario involves the formation of a vital periodontal ligament (PDL) on the root surface. In this case, complete healing can occur, resulting in the maintenance of a vital and functional PDL. Atraumatic tooth extraction is crucial for preserving the viability of the PDL and the cementum. The cementum forms a protective layer covering the root, to which a new PDL can attach. Without it, the root is at risk of resorption by osteoclasts derived from the bone.

• ***Replacement resorption / ankylosis***. If the area of necrosis involving the cementum and PDL is too extensive, healing will occur via bone replacement, characterized by direct contact between the root surface and the adjacent alveolar bone.

• ***Infection-related resorption (also known as inflammatory resorption)***. This type of resorption occurs when there is a concurrent infected root canal and damage to the adjacent cementum, allowing for direct communication—via the dentinal tubules—to the periodontal ligament space. Inflammatory products from the root canal trigger an inflammatory response on the root surface, promoting further resorption of the periodontal ligament and cementum. Unlike replacement resorption, inflammatory resorption can be halted by the timely initiation of root canal therapy and the removal of the infected pulp. It progresses much more rapidly than replacement resorption; therefore, careful monitoring is required for early identification and treatment.

2.2. Possible outcomes during pulp healing.

• ***Revascularization and obliteration of the pulp canal***. The pulp of any transplanted tooth may undergo ischemic damage and become necrotic. However, in teeth with an open apex, the pulp canal space can be revascularized through the ingrowth of capillary vessels via the apex. This revascularization progresses at a rate of 0.5 to 1 mm per day. Following revascularization, calcification of the pulp canal space occurs, manifesting radiographically as progressive obliteration of the pulp canal. It should be noted that the tooth still contains vital pulp tissue and typically yields a positive result on vitality testing.

• ***Pulp necrosis***. Pulp healing cannot be expected if the apical opening of the donor tooth is less than 1 mm in diameter; a tooth with a closed apex will most likely require endodontic therapy. This fact does not constitute a

contraindication for the transplantation of teeth with closed apices, although many clinicians avoid this procedure, as scientific evidence associates it with poorer outcomes. Pulp necrosis in an immature tooth presents an endodontic challenge. Historically, apexification was performed using calcium hydroxide; however, it has been shown that this leads to a weakened root with an increased risk of fracture. An alternative is to use Mineral Trioxide Aggregate (MTA) or other calcium silicate cements to form an apical plug (MAP).

III. Complications

The survival and prognosis of autotransplanted teeth are similar to those of dental implants. However, it must be emphasized that certain complications can compromise the clinical outcome of these teeth. Such complications include root resorption—which may manifest as inflammatory resorption or replacement resorption (leading to ankylosis)—pulp necrosis, impaired periodontal healing, etc. [4, 5, 6].

3.1. Root resorption in autotransplanted teeth.

Damage to the periodontal ligament (PDL) can compromise the success of tooth autotransplantation by triggering external root resorption—a destructive process involving the activity of clastic cells. This leads to the loss of root structure, ultimately threatening the stability and longevity of the transplanted tooth. Under normal conditions, the PDL serves as a vital barrier, preventing direct contact between the root and osteoclasts (the cells responsible for the resorption of mineralized tissues). Once this barrier is damaged, the underlying dentin becomes exposed, initiating a cascade of biological reactions that result in tissue degradation. Mechanical trauma during tooth explantation, excessive orthodontic forces, or improper handling of a donor tooth can compromise this structure.

3.1.1. Types of external root resorption: associated with autotransplantation and its pathophysiology.

External root resorption is a pathological process that can compromise the outcome. Although several types of external root resorption are classified, only three are relevant to dental autotransplantation based on their etiology, clinical behavior, and histological characteristics: surface resorption, inflammatory resorption, and replacement resorption (ankylosis) [3, 8, 9, 10, 11].

Surface resorption. Surface resorption is the most common and least serious form. It is a self-limiting, reversible process that typically resolves without intervention. This condition is usually caused by minor external trauma, resulting in slight injury to the outer layer of cementoblasts. Consequently, small surface irregularities or shallow depressions—often smaller than 0.1 mm—develop on the root surface; these are generally not detectable on radiographs. Such lesions are typically caused by irritation of the PDL and cementum, which exposes the underlying dentin. The exposed dentin activates phagocytic cells, which remove the damaged tissue over a period of 2 to 3 weeks. Subsequently, regenerative cells from the adjacent PDL tissues populate the area, promoting the repair of the cementum and the reattachment of the PDL fibers. This regenerative capacity underscores the importance of maintaining PDL vitality during the handling of teeth for transplantation.

Inflammatory root resorption. Inflammatory root resorption is an aggressive, destructive process that typically follows severe damage to the periodontal ligament (PDL) or a pulpal infection. When the root surface becomes exposed and inflamed, multinucleated clastic cells begin to break down the cementum and dentin. Following an injury, inflammatory mediators—such as interleukin-1 (IL-1), tumor necrosis factor-alpha (TNF-α), prostaglandins, and matrix metalloproteinases (MMPs)—are released at the site. These molecules recruit osteoclast precursors, promoting their differentiation into active osteoclasts that attach to the root and resorb the hard tissues. If the inflammation persists or is exacerbated by microbial contamination—which can occur due to poor aseptic technique or infection during transplantation—the resorptive process accelerates. Bacterial infiltration intensifies the release of cytokines, thereby increasing osteoclastic activity and the extent of root damage. Common predisposing factors include a prolonged extraoral period, dehydration of the PDL cells, and infection of the recipient alveolus. When bacterial contamination occurs and the diameter of the root apex is less than 1 mm, there is a high risk of inflammatory resorption. Necrotic debris stimulates odontoclasts, resulting in progressive dentin resorption. This condition may arise within one month following autotransplantation; it must be managed through endodontic procedures to eliminate the inflammatory stimulus (i.e., the infected pulp tissue) that is driving the infection. Careful handling of the periodontal ligament (PDL), an extraoral time of less than one minute, and an immature root apex (an open apex with a width of 1 mm) are essential for avoiding post-transplantation complications.

Replacement resorption (ankylosis-related resorption). Replacement resorption, also known as ankylosis-related resorption, occurs when a transplanted tooth fuses directly to the alveolar bone, bypassing the normal regeneration of the periodontal ligament (PDL). In this condition, bone is deposited directly onto the root surface, gradually replacing the tooth root with bone tissue. Over time, this fusion results in the loss of

physiological mobility and often manifests as aesthetic and functional complications, particularly in growing patients. This irreversible condition typically stems from extensive damage to the PDL, excessive pressure during stabilization, or inadequate functional mobility that hinders natural remodeling. Ankylosis is especially problematic in young patients, where continued skeletal growth can lead to infraocclusion and uneven alignment.

Diagnosing ankylosed teeth often presents a challenge for clinicians and requires special attention. High-quality radiographs and a careful clinical examination are essential for detecting signs of ankylosis. On radiographs, the primary focus is on identifying signs of fusion between the tooth root and the surrounding bone. In healthy teeth, the *lamina dura* appears as a well-defined, hyperdense, radiopaque line, which clinically corresponds to the cortical bone of the alveolar socket. The periodontal ligament (PDL)—located between the root cementum and the *lamina dura*—appears as a well-defined, hypodense, radiolucent line. In cases of ankylosis—where the PDL is absent—it becomes difficult to distinguish between these two radiographic lines; instead, a zone is observed where the alveolar bone has fused with the cementum and dentin.

Radiographic signs should always be interpreted within the clinical context and in conjunction with clinical findings (Figure 7). The status of the tooth is evaluated over the course of several consecutive examinations. Signs of ankylosis typically become apparent between the third and sixth month. Key clinical indicators of ankylosis include the sound elicited upon percussion, tooth mobility, and the tooth's position relative to the adjacent dentition. Specifically, an ankylosed tooth produces a "sharp, high-pitched, metallic" sound upon percussion, lacks physiological mobility, and becomes positioned in infraocclusion relative to the occlusal surfaces of the other teeth. The incidence of ankylosis in transplanted teeth has been examined in various studies, with reported rates varying significantly—ranging from as low as 4.8% to as high as 40%. However, this largely depends on the specific sample studied and the factors that influenced the healing process, whether positively or negatively.

3.2. Clinical consequences.

All three forms of resorption present unique clinical challenges following tooth autotransplantation. While surface resorption typically resolves without intervention, inflammatory and replacement resorption can significantly compromise the prognosis. Inflammatory root resorption may be driven by contamination of the pulp tissue. Without timely intervention—which often necessitates endodontic treatment and infection control—this form of resorption can lead to substantial structural loss and, ultimately, the failure of the tooth. Therefore, precise surgical technique, atraumatic extraction, preservation of the integrity of the periodontal ligament (PDL), minimal extraoral time, and careful postoperative monitoring are essential to reduce the risk of root resorption and ensure the long-term success of the autotransplanted tooth.

3.3. Factors contributing to root resorption.

There are numerous factors that influence root resorption during tooth autotransplantation. Proper management of these factors can improve the success of the procedure.

- *Extraoral time*. Prolonged exposure leads to the death of PDL cells, increasing the risk of resorption. Immediate transplantation, or storing the tooth in HBSS or physiological saline during the operation, protects the PDL and reduces this risk.
- *Trauma during explantation*. The use of excessive force or improper techniques can damage the PDL and cementum, compromising the root and increasing the risk of resorption. Gentle, atraumatic extraction helps protect these structures.
- *Condition of the recipient site.* Infections, a lack of bony support, or poor preparation of the alveolus (socket) cause inflammation, increasing the risk of resorption. Maintaining aseptic conditions, properly shaping the alveolus, and ensuring an adequate volume of bone help prevent this.
- ***Stability at the recipient site***. Strong, rigid stabilization prevents the reattachment of the PDL, while excessive mobility delays healing, increasing the risk of ankylosis or resorption. Appropriate stabilization ensures successful transplantation [3, 8, 10, 11].

IV. The role of MTA in managing external root resorption in autotransplanted teeth

Recently mineral trioxide aggregate (MTA) has emerged as a reliable material due to its biocompatibility, good sealing property, and it encourages regeneration of peri-radicular tissues such as periodontal ligament bone and cementum. These favorable properties render MTA a suitable material for the management of tissues damage caused by external root resorption. The orthograde filling of the entire root canal system with MTA is the logical progression in the evolutionary application of this material [12, 13, 14].

When the pathway of communication is opened between the root canal and the periodontium it must be sealed with materials that preserves bacterial leakage, this material should be biocompatible and should favor regeneration of supporting structure [15].

Development of new bioactive material such as MTA makes possible other therapeutic approaches including the obturation of root canal space in complex cases of pathologic root resorption [16].

The major constituents are tricalcium silicate (3CaO.SiO2), dicalcium silicate (2CaO.SiO2), tricalcium aluminate (3CaO.Al2 O3), tetracalcium ironaluminate (4CaO.Al2 O3 .Fe2 O3) and dehydrated calcium sulphate (CaO.SO.2H2 O).21,22 MTA has been shown to provide a long term release of calcium ions and can maintain a high pH for longer periods.14 The present case shows arrest of root resorption after placement of MTA. Because of wider dentinal tubules in the present case, the alkaline pH of MTA may have deactivated the infl ammatory process and retarded the odontoclastic activity. Recently Bogern and Kuttler15 have advocated MTA obturation in complex and challenging endodontic conditions [17].

One of the characteristics of bioactive material is its ability to form an apatite like layer on its surface when it comes in contact with physiologic fluids in vivo or with stimulated body fluid in vitro, is MTA a bioactive material that is mainly composed of tricalcium and silicate. Investigation has shown that it can conduct and induct hard tissue formation; studies have illustrated the release of various ions from MTA [18].

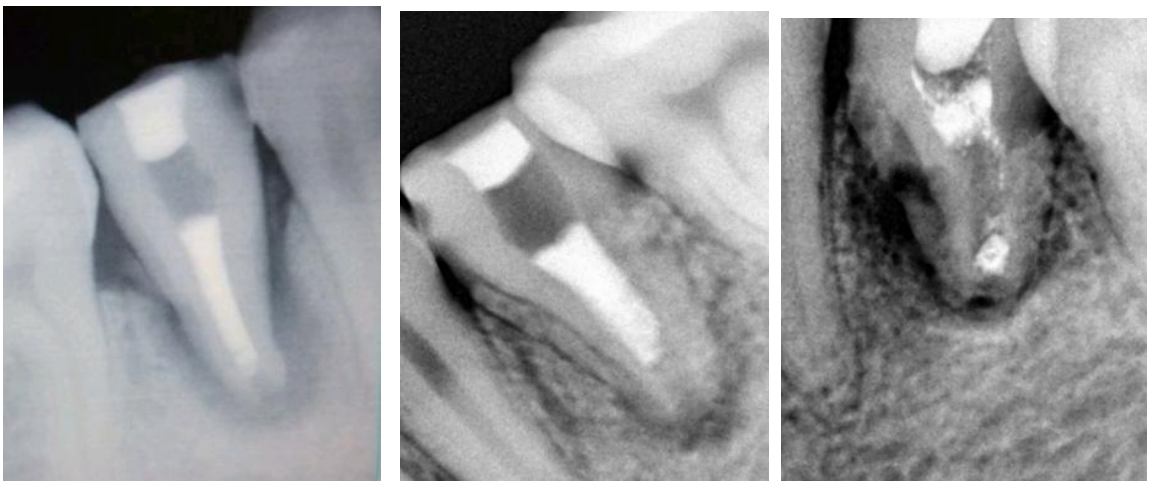


Figure 1. Case report. Tooth autotransplantation in a 20-year-old female patient. First view – status two weeks post-autotransplantation (noticeable bone defect following the procedure). Endodontic treatment and root canal filling with calcium hydroxide. Second view – status 3 months post-autotransplantation (noticeable bone formation, but also resorption of the root canal filling material). Third view – status 1 year post-autotransplantation (noticeable external root resorption and bone resorption, accompanied by clinical symptoms: luxation, pain, redness, and edema).

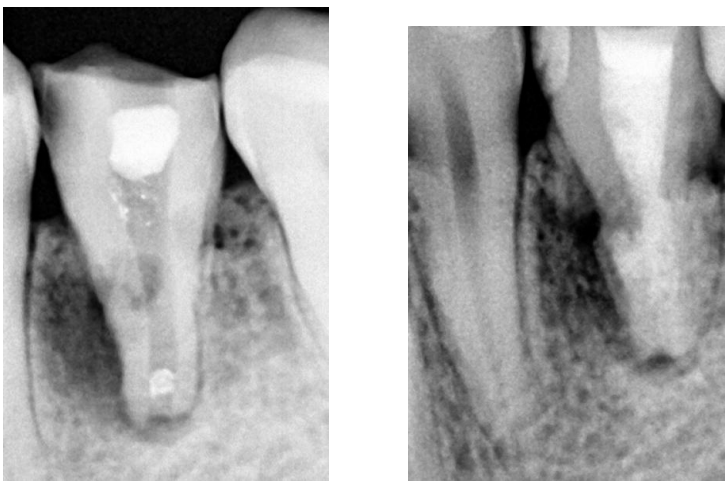


Figure 2. Treatment of external inflammatory root resorption and bone resorption using intracanal MTA. First image – status 20 months after the initial treatment (notable external root resorption and bone resorption, along with inadequate root canal filling). Second image – status 3 months after intracanal filling with MTA (showing periodontal tissue healing and the cessation of root and bone resorption, with a complete absence of symptoms).

V. Conclusion

It can be concluded that the survival of periodontal ligament (PDL) cells is of exceptional importance for the success of this intervention and the long-term survival of the transplanted tooth—factors which, in turn, depend on successful wound healing. Consequently, the greater the number of cells that remain viable and undamaged during the transplantation process, the more rapidly reattachment and the formation of a new PDL will occur.

Furthermore, it can be concluded that among all late postoperative complications associated with autotransplanted teeth, only inflammatory external root resorption is clinically significant—manifesting through symptoms and patient discomfort—and typically leads to the eventual loss of the tooth.

The process of external inflammatory root resorption can be halted if timely and appropriate therapeutic intervention is applied.

The use of MTA via the root canal demonstrates positive clinical and radiographic signs, indicating both the cessation of the root resorption process and the repair of the associated bone defect.

Further, more extensive studies are required to provide statistical validation of these positive trends in the management of complications following tooth autotransplantation.

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