Case Report

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Bone remodeling of the sinus floor observed 19 years after third molar transplantation to close a maxillary defect: a case report

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Abstract

Autologous tooth transplantation is the transplantation of an erupted, partially erupted, or unerupted tooth from one site to another in an individual. This is expected to maintain alveolar bone volume through physiological stimulation of the periodontal ligament (PDL). Tooth transplantation can be used for the closure of oroantral communication. As a simple, useful, and minimally invasive method, it should be considered a surgical option when a donor tooth is available in indicated cases. Herein, the authors report the case of a 20-year-old female patient whose left permanent maxillary first molar had to be extracted due to a longitudinal fracture and radicular cyst in the maxillary sinus floor. After the extraction, tooth 28 was exposed through an osteotomy and positioned in the gap. Nineteen years later, the autologous grafted tooth 28 could no longer be retained due to massive external resorption and was replaced by an implant. Human PDL stem cells can differentiate into bone-, fiber-, and cementum-forming cells and have the potential to build a PDL complex. Therefore, care must be taken to avoid damaging the PDL of the donor tooth during extraction. Autotransplanted teeth are expected to retain the alveolar bone volume. This case demonstrates the use of a transplanted tooth 28 for the treatment of a maxillary defect caused by the extraction of tooth 26 and removal of a radicular cyst. External resorption and regeneration of the bone of the maxillary sinus floor around the transplanted tooth occurred after 19 years.

Keywords: case report, external resorption, human periodontal ligament stem cells, maxillary defect, tooth transplantation

Introduction and importance

Autologous tooth transplantation is the repositioning of an erupted, partially erupted, or nonerupted autologous tooth from one site to another[1,2] when a tooth is missing or requires extraction due to tooth decay, periodontal disease, or other reasons[2].

The commonly transplanted teeth are premolars, canines, incisors, and third molars[3]. In traditional autogenous tooth transplantation, the third molar is commonly used to replace the first or second molar because of its similar size and shape[4].

HIGHLIGHTS

- Autotransplanted teeth can be expected to maintain the volume of alveolar bone.
- Human periodontal ligament stem cells can differentiate, for example, in bone-forming cells.
- Bone volume can be maintained by physiological stimulation of periodontal ligament.

Autotransplanted teeth are less likely to cause an immune rejection response and have the advantage of being integrated with the rest of the body because they remain vital. They can also maintain the volume of the alveolar bone or even regenerate it through physiological stimulation of the periodontal ligament (PDL)[5]. PDL-resident stem cells can differentiate into three cell types: fibroblasts, cementoblasts, and osteoblasts. Differentiated osteoblasts can induce regeneration of the surrounding alveolar bone, providing adequate support and leading to stable maintenance and functionality of the tooth. PDL plays an important role in bone remodeling owing to the long-term survival rate of autotransplanted teeth[3]. The PDL is one of the most important success factors for a transplanted tooth[6]. The connective tissues of the PDL of the donor tooth root and the bony wall of the recipient alveolus reattach within ~2 weeks of autotransplantation[7,8]. Healing can be achieved by cementitious healing of small damaged periodontal surfaces. Moreover, if the extent of damage is large, resorption of the root surface and replacement of dentin with bone occur, leading to the loss of the tooth root[3].

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Autologous tooth transplantation has some risks. Oral surgeons must have considerable knowledge, skill, and patience, and a careful surgical approach is essential for a successful outcome. Failure after the initial attempts is almost always due to surgical complications or difficulties in removing and preserving the graft from the donor site, which may be caused by the tooth being partially erupted or unerupted.

Extraction of the donor tooth results in complete rupture of the neurovascular bundle and periodontal fibers, which is dependent on the healing process of the pulp at the recipient site after surgery[9].

Long-term follow-up and monitoring must be performed after grafting to assess its success. Grafting often results in poor outcomes, with two major complications: tooth ankylosis and root resorption[10].

Other therapeutic options for tooth replacement include implants, fixed bridges, and removable dentures. These options may be preferred if the donor tooth is not available, or if the patient is not a suitable candidate for autologous tooth transplantation.

However, it should be noted that the above limitations may vary depending on the individual case and the surgeon's experience.

Clinical data on the defects and bone regeneration due to maxillary cysts are limited. However, the literature shows that tooth grafting is a minimally invasive method for closing the oroantral communication[11].

Periapical lesions of the jaws are most commonly of endodontic origin and are classified as either periapical granulomas or radicular cysts[12]. They arise as a result of inflammatory or developmental pathogenic causes associated with the epithelium of the tooth-forming apparatus[13].

The reported prevalence of radicular cysts within periapical lesions varies from 6 to 55%[14,15]. In the 2017 edition of the WHO classification of odontogenic lesions, radicular cysts were included in the inflammatory cyst group. The inflammatory cyst group is subclassified into radicular cysts (apical and periodontal cysts) and inflammatory collateral cysts (paradental and buccal bifurcation cysts)[16,17]. Radicular cysts are more frequently found in the maxilla[18], occurring almost 10 times more frequently than in the mandible[19] and most radicular cysts range in size from 5 to 15 mm. However, in the maxilla, the cysts may grow to greater than 15 mm[20].

Moreover, even though the principle of early marsupialization followed by enucleation after initial bone healing was proposed by Killey *et al.*[21], the management of large jaw cysts remains a challenge. Treatments vary from aggressive to minimally invasive procedures in an attempt to minimize the risk of recurrence. Marsupialization is indicated for large cysts in elderly, debilitated, or young patients[22].

Enucleation of jaw cysts – the so-called 'cystectomy' – and primary closure without the use of additional bone grafts remain 'state of the art', even in large defects with a diameter of greater than or equal to 3 cm. A safe mucoperiosteal flap on solid margins accompanied by perioperative antibiotic treatment provides physiological organization of the blood clot, aiding the transformation into regular fibered bone[23].

The purpose of this case report was to demonstrate the use of a transplanted tooth 28 for the treatment of a maxillary defect caused by the extraction of tooth 26 and removal of a radicular cyst. We present this case report in accordance with SCARE 2020 criteria[24].

Case presentation

We present the case of a 20-year-old Caucasian female patient who was referred (on 28 April 2003) to an oral and maxillofacial surgery clinic, with apical periodontitis and a radicular cyst in the region of tooth 26, buccally near the alveolar process. The radicular cyst originated from the endodontically treated tooth 26, in which apical radiolucency in the region of the mesial and distal root could be diagnosed as periapical osteitis using a radiograph (Fig. 1A).

After a detailed clinical and radiological examination, the patient was informed about various treatment options, including endodontic revision, apicoectomy of the buccal and palatal roots, and extraction with subsequent implant placement. The patient's genetic information was unremarkable, as was her psychological, family, and drug history, and she was a nonsmoker.

The patient decided to undergo an apicoectomy of the buccal roots. The treatments were performed by an oral and maxillofacial surgeon (Dr Andrew Grün) in Rottenburg, Germany. Intraoperatively, a pronounced bone defect with involvement of the maxillary sinus mucosa was observed. After root-tip resection and removal of the radicular cyst, the maxillary sinus was widely opened, and the maxillary sinus mucosa was damaged in this area (Fig. 1B). The patient was informed of the complications and was advised to undergo stabilization of the tooth with a new prosthetic restoration, which she refused. Six months later, longitudinal fracture of tooth 26 occurred, and it had to be extracted. The first consideration was replacing the extracted tooth with an implant.

After the extraction of tooth 26, augmentative procedures were necessary to place an implant. The maxillary sinus mucosa was damaged due to the removal of the radicular cyst; therefore, subantral sinus floor elevation was not possible. The patient was informed of the extraction and immediate visualization of the condition, which was followed by sinus elevation.

As an alternative to implant restoration, the patient was offered a transplant of tooth 28 in the region of tooth 26. Once the patient agreed, local anesthesia was administered buccally and palatally to tooth 28. With a triangular incision and formation of a periosteal flap, the osteotomy area could be extensively visualized.

Tooth 28 was exposed through gentle osteotomy without damaging the dental sac. After complete exposure of the impacted tooth, it was removed without pressure to prevent trauma to the yet-to-be-formed roots. Before retrieving tooth 28, the alveolar socket of tooth 26 was prepared so that the tooth could be transplanted immediately. The recipient site was prepared with round surgical drills at a low speed while being cooled with saline. Tooth 28 was placed in the alveolus of tooth 26 immediately after removal and without any pressure. The tooth was fixed with single-button sutures using MERSILENE 3/0 (Johnson & Johnson). The patient was educated on postoperative management, which included oral hygiene indications, rinsing with 0.12% chlorhexidine solution, a liquid and soft-food diet, antibiotic therapy, and the use of anti-inflammatory medications as needed. Likewise, the patient was informed that excessive masticatory load could result in the loss of the grafted tooth. Tooth 28 was optimally positioned in the gap (Fig. 1C). The transplantation and wound healing processes did not have any complications. The sutures were removed 7 days postoperatively. Tooth 28 was well-fixed and had grade 1 mobility.

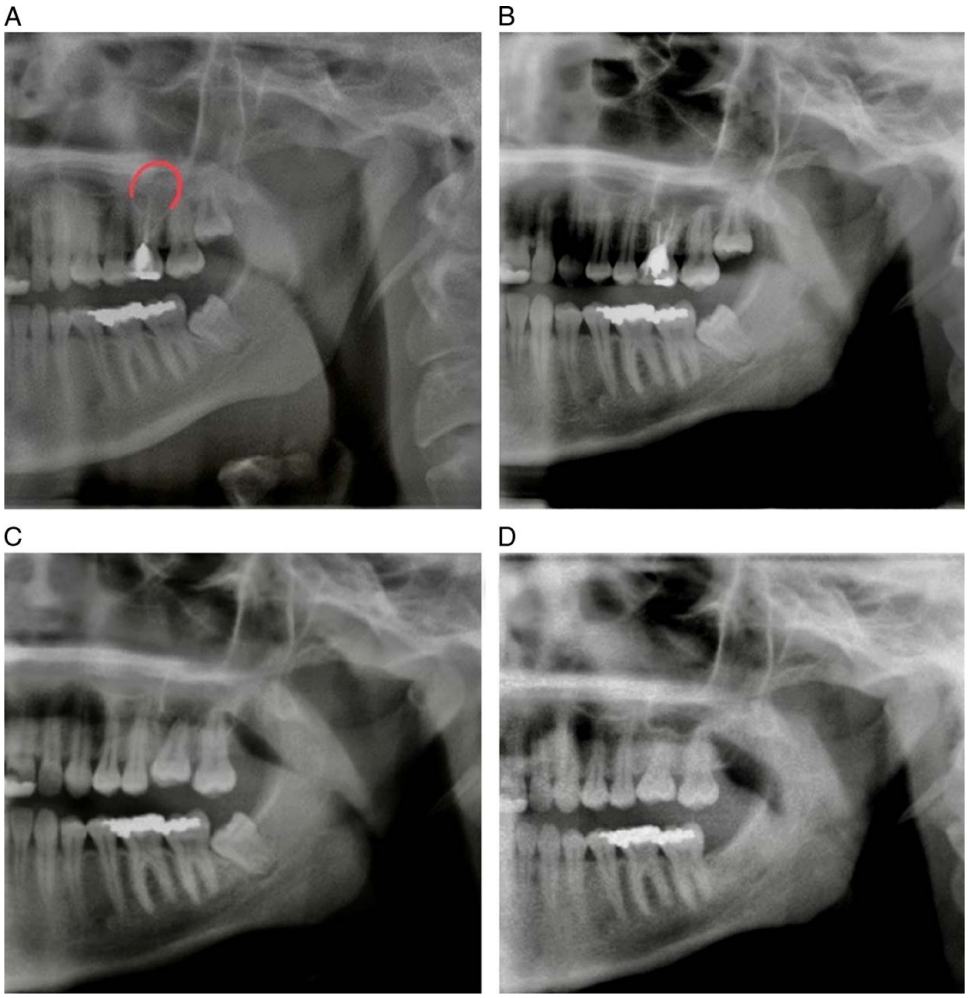

Figure 1. (A) Panoramic radiograph (OPG): parodontis apicalis + radicular cyst tooth 26. (B) OPG: tooth 26 after root-tip resection. (C) OPG: tooth 28 was transplanted in region 26. (D) OPG: recall after 1 year.

A re-evaluation was performed at 1, 3, 6, 9, and 12 months postoperatively to clinically assess mobility, percussion sensitivity, and probing depth. Radiographically, signs of inflammation, bone resorption, or periodontal space disappearance were evaluated. No abnormalities were identified.

The grafted tooth was only slightly involved in masticatory function. Later, as optimal stability developed, the tooth was fully loaded (Figs 1D, 4A). Clinical examination revealed a functional tooth with the necessary occlusal contact points. A periapical gap was also present, indicating that the tooth had been optimally integrated with the Sharpey's fibers in the bone and was fully functional. Fortunately, the bone surrounding the alveolar process had also regenerated in all areas (Fig. 2A).

Interestingly, bone also developed in the maxillary sinus region. During follow-ups by the treating dentist after 13 (Figs 2B, 3A, B) and 14 years postoperatively (Fig. 3A, B), the tooth remained unremarkable. Upon inspection by the treating dentist after 17 years postoperatively, the tooth was inconspicuous, and the patient's masticatory function was normal (Fig. 2C).

Nevertheless, after 19 years, the tooth could no longer be preserved due to a massive external resorption, and extraction was performed without any complications. The extracted tooth root was normally developed, and a typical periapical pink tissue with Sharpey's fibers was visible (Fig. 4B). The surgical removal of the tooth without any complications preserved all of the surrounding bone, allowing the surgeon to place an implant in the extraction socket without sinus floor augmentation (Straumann BLX, implant diameter 6.5 mm WB and length 12 mm SLActive, Roxolid) (Fig. 4C). To stabilize the buccal bone wall, only the buccal area of the implant was augmented using a bovine bone substitute material with a grain size of 0 mm (Geistlich, Bio Oss) (Fig. 4D). No complications occurred intraoperatively or postoperatively (Fig. 2D). After successful osseointegration, uncovery was planned at 6 months postoperatively. An implant crown was placed on the prosthetic restoration to restore masticatory function. The patient reported an improvement in her general well-being.

Clinical discussion

Once healed, successfully autotransplanted teeth have the potential to completely integrate and interact with the recipient

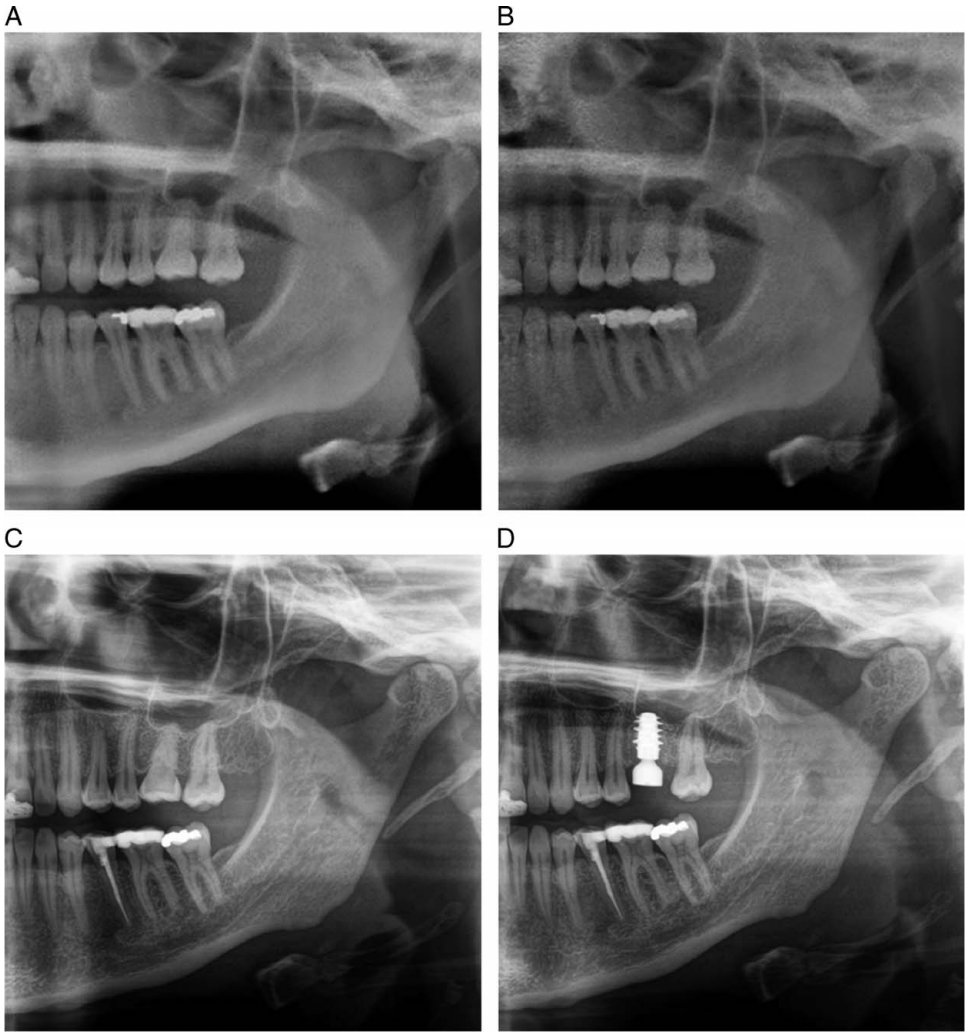

Figure 2. (A) Panoramic radiograph (OPG): recall after 4.5 years. (B) OPG: recall after 8 years. (C) OPG: recall after 17 years. (D) OPG: osseointegrated implant region 26.

site. This is mainly due to the numerous stem cells found in the PDL. Human periodontal ligament stem cells (hPDLSCs) can differentiate into bone-, fiber-, and cementum-forming cells. These have the potential to regenerate the periodontium and build a bone-PDL-cementum complex[25]. hPDLSCs and other oral stem cells have also been identified as promising therapeutic agents for the reconstruction of bone and tissue defects[8].

Further, care must be taken not to damage the PDL of the donor tooth, and the tooth must be extracted as slowly and atraumatically as possible[26]. Successfully autotransplanted teeth

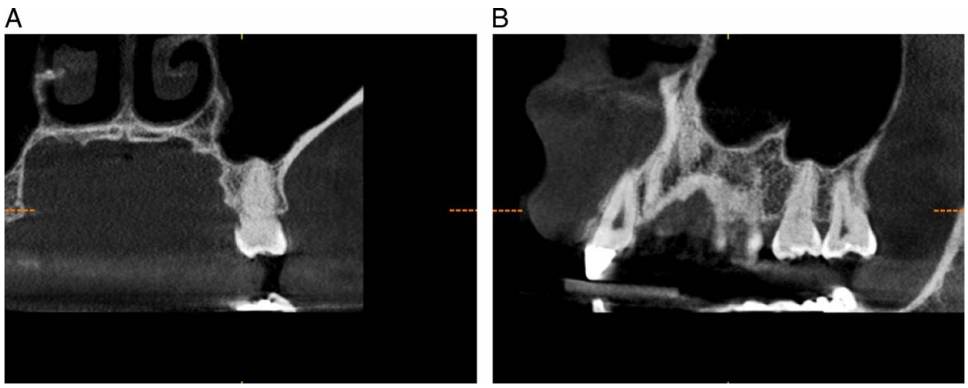

Figure 3. (A) Cone beam computed tomography: recall after 15 years (sagittal view). (B) Cone beam computed tomography: recall after 15 years (vestibular view).

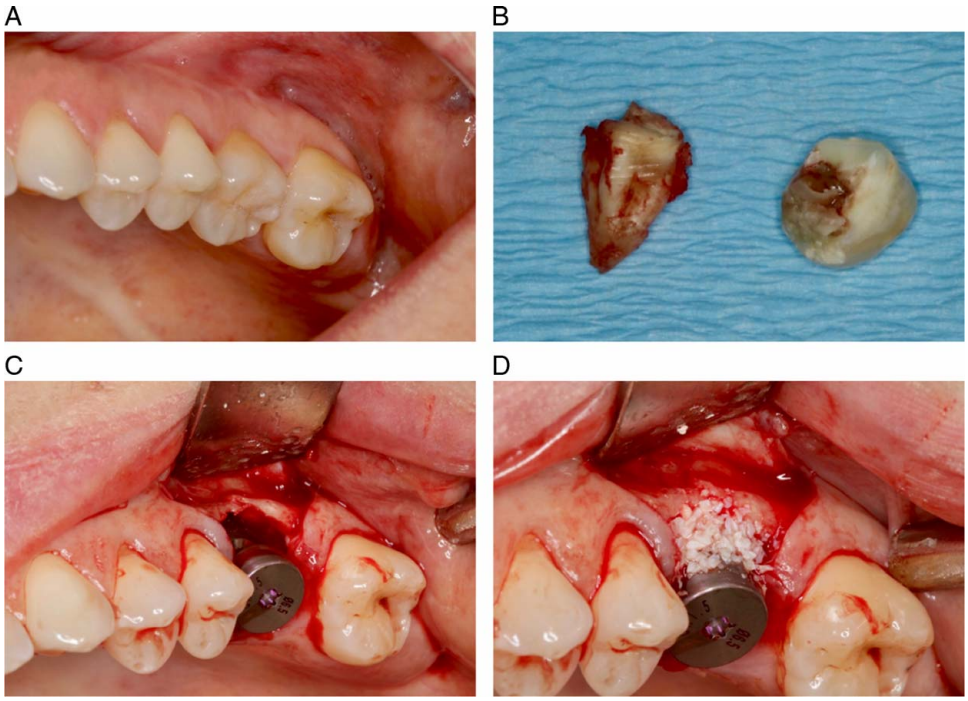

Figure 4. (A) Clinical photo after 1 year of transplantation of tooth 28 in region 26. (B) Transplanted tooth 28 after final extraction. (C) Clinical situation after implantation region 26. (D) Buccal area with augmentation region 26.

can maintain the alveolar bone volume at the recipient site. Differentiated hPDLSCs such as fibroblasts, cementoblasts, or osteoblasts induce bone remodeling[3]. They also stimulate the alveolar bone surrounding the tooth transplant, providing adequate support and leading to stable preservation and functionality of the tooth. In terms of the long-term survival rate of autotransplanted teeth, the PDL plays an important role in bone remodeling[5].

Pohl *et al.*[27] demonstrated that when a dental material is used, the transmitter substances contained in it can provide an inductive component of bone formation and induce the conversion of mesenchymal stem cells to osteoblasts, indicating osteoinduction.

The third molar, as a replacement for the first or second molar, is the most common variant of autologous tooth transplantation and is suitable because both teeth are of similar size and shape. Such autologous tooth grafts usually require multidisciplinary treatment, including endodontics, prosthodontics, and orthodontics[28].

In our case, remarkable functionality, stability, and optimal contact points were achieved without any conservative, orthodontic, or prosthetic treatment in the first month after transplantation. Moreover, in addition to bone augmentation and tooth replacement, autologous teeth also serve as a space maintainer. Thus, in the 21-year-old patient described herein, the adjacent teeth did not displace or shift to the region of the missing teeth.

To achieve a high success rate in autologous tooth transplantation, in addition to preserving the PDL, care must be taken to ensure patient selection with good oral hygiene and an infection-free recipient site[29]. In addition, many other factors of the tooth to be transplanted play an important role, such as the stage of root development, morphology of the tooth, selected surgical procedure, extraoral time, shape of the recipient socket, vascularity of the recipient bed, and vitality of the PDL cells[30].

If these factors are not considered, several complications may occur. The most common complications are root related, such as root ankylosis or resorption, while others involve pulp tissue, such as necrosis[31]. These complications seem to be related to the stage of root maturation and its ability to revascularize[32,33].

Therefore, it is recommended to use immature teeth from late stage 2 (half-root formation) to stage 4 (three-quarters to less than the complete root) of root development[32]. In addition, for the proper growth of the alveolar ridge, the vitality of the tooth must be maintained as much as possible to avoid ankylosis or root resorption[34].

A recent follow-up of autotransplanted mature teeth with a closed apex revealed a mean survival period of 11.9 ± 1.9 years (range: 9–15 years). The overall success rate at the time of the latest recall visit was 80%, and the survival rate was 95% in the analyzed cases[35].

In contrast to the present case, Park and colleagues described a case of autografting with simultaneous sinus floor elevation. To our knowledge, our case is the first to demonstrate remodeling of the maxillary sinus floor with the help of an autologously transplanted tooth, allowing the placement of an implant 19 years later without a sinus lift[36]. Furthermore, the fact that autologous transplanted teeth show external resorption after 19 years is unique.

Tooth resorption is either a physiological or pathological process that occurs internally (pulp related) or externally (periodontium related). According to the glossary of the American Association of Endodontists, resorption is defined as a physiological or pathological process that results in the loss of dentin, cementum, or bone[37]. In contrast to deciduous teeth, resorption

rarely occurs in permanent teeth unless it is caused by a pathological process. Pathological resorption occurs after traumatic injuries, orthodontic tooth movement, or chronic infections of the pulp or periodontal structures[38].

External resorption begins at the outer or cervical surface of the tooth and continues inwards[39]. The diagnosis and treatment of resorption are challenging for dentists. Due to its insidious pathology, resorption can progress far before its discovery. If left untreated, resorption can lead to the premature loss of affected teeth[40].

Conclusion

This case report demonstrates that the bone of the maxillary sinus floor around a transplanted third molar regenerates after 19 years and that the transplanted tooth shows external resorption only after 19 years. Even in adult patients, tooth transplantation of a mature third molar for closure of the oroantral communication is a simple and excellent method because the transplanted tooth not only closes the communication to the maxillary sinus but also helps restore masticatory function at the recipient site.

Ethical approval

This study was approved by the ethical committee of Commission for the Federal Province of Lower Austria at the seat of the Office of the Lower Austrian Provincial Government with approval number (GS1-EK-4/314-2015).

Consent

The patient received a thorough explanation of this report and gave her oral and written informed consent to be included in this report as well as for the publication of this case, anonymous data, and pictures. A copy of the written consent is available for review on request.

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Author contribution

P.G. and F.P.-M.: study concept and design, writing the paper. P.B., B.S., U.D., A.-S.G.: data collection, analysis, and discussion of data. D.T.: final approval of the version to be published.

Conflicts of interest disclosure

The authors declare that there is no conflict of interest.

Research registration unique identifying number (UIN)

Not applicable.

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