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CASE STUDY

Translational approach to tooth autotransplantation: A 27-year case study

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Abstract

Background: The aim of this case report was to present a translational approach to tooth autotransplantation using jiggling forces to enlarge the periodontal ligament (PDL) space before autotransplantation, with the goal of improving treatment success and long-term survival.

Methods: A 23-year-old patient, undergoing orthodontic therapy and with an unrestorable maxillary first molar, was proposed to have a healthy and fully-erupted maxillary third molar transplanted in the socket of the first molar. Jiggling forces were applied to the third molar to enlarge the PDL space and facilitate the preservation of PDL fibers on the root surfaces during the extraction.

Results: Jiggling forces induced hypermobility and widened PDL space of the third molar. The autotransplantation was successful and the patient was followed regularly over a 27-year period. At the 27-year visit, the patient showed optimal chewing function, oral plaque control, and absence of gingivitis. The transplanted molar exhibited periodontal health and absence of mobility. Probing depth of 5 mm and radiographic external root resorption was noted on a localized area of the transplanted tooth which had experienced traumatic and unintentional removal of PDL fibers during the extraction.

Conclusions: A translational approach was proposed by integrating knowledge from the fields of orthodontics, trauma from occlusion, and replantation. It validated the crucial importance of maintaining healthy PDL fibers on the root surface and demonstrated clinically the successful autotransplantation of a fully formed third molar into the socket of a first molar with a retention of 27 years.

KEYWORDS
orthodontics, periodontal ligament, root resorption, translational science, transplantation

Key points

Why is this case new information?

- This case provided evidence of successful autotransplantation of a molar with complete root formation. It reported the longest-term follow-up (27 years) present in the literature. Most importantly, it used a translational medicine approach to apply concepts from the fields of orthodontics and traumatic occlusion to improve the success of the autotransplantation procedure.

What are the keys to the successful management of this case?

- Jiggling forces induced tooth hypermobility and increased the PDL space of the tooth planned for autotransplantation. In turn, they facilitated the atrau-

matic extraction and preservation of the PDL fibers on the transplanted tooth, improving the success of the reattachment of periodontal fibers.

What are the primary limitations to success in this case?

- Traumatic extraction resulting in the unintended removal of PDL fibers from the tooth planned for autotransplantation, or intentional removal of PDL fibers with root planing are expected to decrease the success rate of the autotransplantation procedure. This is due to the lack of viable PDL cells necessary for reattachment.

INTRODUCTION

Tooth autotransplantation is a surgical procedure in which a healthy tooth is moved from one location in the oral cavity to another within the same individual.[1] It involves extracting a healthy tooth, usually a third molar or premolar, and transplanting it into a different site, such as a socket or a region with dental deficiencies.[1–3] Tooth autotransplantation, or other similar approaches such as replantation of the same tooth after traumatic avulsion, are especially utilized in young patients where implant placement would be contraindicated.[4,5]

The literature in this field demonstrates that the longevity of autotransplantation/replantation procedures is reduced over time with an unfavorable prognosis due to root resorption, tooth hypermobility, endodontic-periodontal infections, or ankylosis with loss of cementum, dentin, periodontal ligament, and bone substitution.[6,7] This occurs because the periodontal fibers may be irreversibly damaged during the extraction for autotransplantation, or dentists may intentionally remove the periodontal ligament with extraoral scaling and root planing procedures.[8] Additionally, the replantation may occur too long after the traumatic avulsion, causing the periodontal ligament (PDL) to lose vitality.[9] These clinical observations are supported by classical histological studies in the periodontal literature; animal studies by Lindhe et al.[10,11] have demonstrated that a replanted tooth, deprived of cementum and periodontal fibers, undergoes aggression from alveolar osteoclasts, leading to ankylosis and root resorption. On the other hand, in the same studies, regeneration of healthy periodontium was obtained when the PDL tissue and cells were maintained on the root surface of the explanted/replanted tooth, achieving successful outcomes in autotransplantation/replantation procedures.

Translational medicine is an interdisciplinary field that aims to bridge the gap between scientific discoveries and their application in clinical practice by the translation of basic research findings into practical solutions.[12,13] In the context of tooth transplantation, the principles of translational medicine can be utilized to incorporate knowledge from various fields of study. By adopting a translational approach, what is known about trauma from occlusion and jiggling forces can be applied to expand the PDL space of the tooth intended for replantation. Histologic results showed that jiggling-induced trauma was followed by transient alterations such as a widening of the PDL space and increased vascularity.[14–16] Clinically, teeth showed increased mobility and radiographic widening of PDL space. In a tooth with healthy periodontium, elimination of the jiggling forces was followed by reversal of histologic and radiographic changes, without signs of pocketing or histological apical migration of junctional epithelium.[14–16] These studies clearly demonstrated a cause-effect relationship between reversible periodontal changes, such as ligament widening and increased dental mobility, and forces induced by orthodontic appliances or trauma from occlusion.

On the basis of this knowledge, Prato et al.[13] reported a clinical case where a translational medicine approach was applied to transplant a fully erupted periodontally healthy third molar in the socket of a non-restorable maxillary first molar. Jiggling forces were used to increase tooth mobility and to enlarge the periodontal ligament before tooth replantation thus favoring the atraumatic extraction and preserving the integrity and vitality of the periodontal ligament during the procedures. The treatment was successful and the patient retained the transplanted tooth for 20 years in health, comfort, and function. The aim of this current case report is to present a longer-term follow-up outcome (27 years) of the same patient, reporting on the sustainability of this approach as well as the risk of complications over time.

MATERIALS AND METHODS

The case preparation and treatment were extensively reported in the previous publication by Prato et al.[13] In summary, in 1996, a 23-year-old woman sought orthodontic treatment for a Class I malocclusion, and periodontal treatment for the extraction of her unrestorable maxillary left first molar in the private practice setting (Florence, Italy). In the same quadrant, a healthy fully erupted third molar was present (Figure 1). The plan discussed with the patient was to transplant the third molar into the empty socket of the first molar. All patient's questions were adequately answered, the patient accepted the therapy and provided verbal consent for the treatment. Throughout the orthodontic treatment, intermaxillary elastics were used to

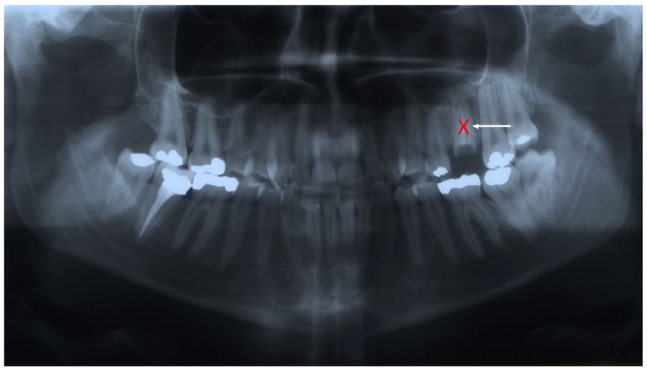

FIGURE 1 Panoramic radiograph of a 23-year-old patient. The red cross highlights the upper left first molar, scheduled for extraction due to large caries and unrestorable root. The white arrow reminds us of the autotransplantation of the upper left third molar into the socket of the first molar.

FIGURE 2 Extraoral view of the maxillary left third molar right after the extraction. The periodontal ligament is preserved entirely on the root surface except for a localized area on the distobuccal site (white arrows), which shows the root is deprived of the periodontal ligament.

apply jiggling forces to the periodontally healthy maxillary left third molar. The direction of the elastics was altered daily, and the mobility of the maxillary third molar was monitored weekly. As a result of this controlled orthodontic tooth movement, the tooth became hypermobile. After a 2-month orthodontic treatment, the healthy maxillary left third molar was deemed suitable for transplantation. The process involved removing the archwire and making buccal and palatal incisions on the residual part of the crown of the first molar under local anesthesia. The roots of the first molar were extracted after a conservative buccal flap.[*,†,‡] A minimal alveoloplasty was performed by removing the interradicular bone to adjust the socket for the fused root morphology of the third molar. Exploiting the enlarged periodontal space, a deep syndesmotomy[§] was carried out, almost reaching the apex of the third molar while preserving the ligament attached to the root surface. The third molar, with enlarged PDL, was gently extracted and immediately transplanted into the empty socket of the first molar, avoiding mechanical root instrumentation. As soon as the third molar was extracted, it was quickly examined by the operator wearing 4x magnification loupes before being placed in the surgical socket. It was found that a thin, white-red, transparent membrane with small hemorrhagic areas covered the root surfaces all around, up to the cemento-enamel junction. Only a small area on the distal root appeared glossy because deprived of PDL fibers (Figure 2). After implantation (Figure 3), the buccal flap was repositioned and sutured.[**] No systemic antibiotic therapy was prescribed. The tooth was splinted for six months, and endodontic treatment was done three days after the surgery.

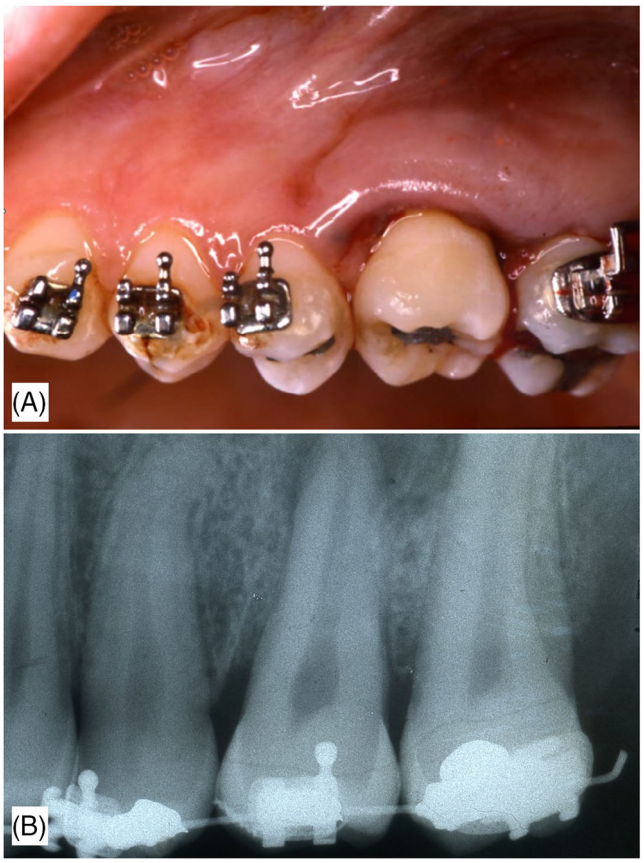

FIGURE 3 Postoperative clinical (A) and radiographic (B) evaluations after autotransplantation.

RESULTS

The patient underwent regular check-ups every 6 months for professional assessments. During this period, at the 1-year, 10-year, and 20-year, the transplanted molar exhibited perfect stability in the dental arch and showed physiological mobility (Figures 4 and 5). The molar was surrounded

[*] Bard Parker 15C Surgical Blade. Henry Schein. Mellville, NY, USA
[†] Buser Periosteal Elevator. Hu-Friedy. Chicago, IL, USA
[‡] 17 Forceps, Hu-Friedy. Chicago, IL, USA
[§] Bard Parker 15C Surgical Blade. Henry Schein. Mellville, NY, USA
[**] 5-0 Caprosyn Suture. Medtronic. Minneapolis, MN, USA

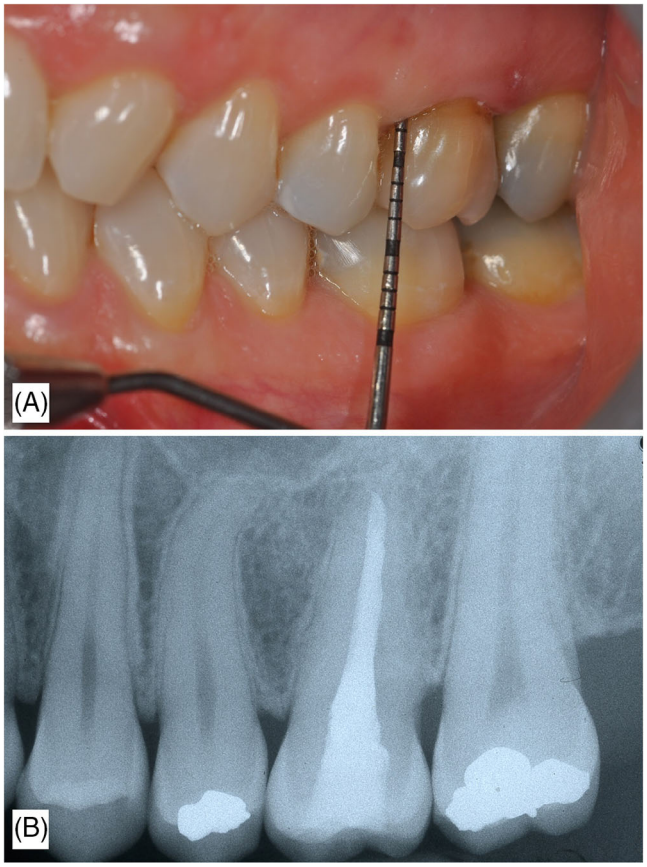

FIGURE 4 Clinical (A) and radiographic (B) evaluations 10 years after autotransplantation.

by healthy periodontal tissues, and the periapical X-ray revealed well-maintained crestal bone and a normal periodontal space. However, at the 10-year follow-up, a small area of external root resorption was detected on the cervical third of the distal root in the same area where the PDL fibers were absent after surgery. The patient was informed about this radiographic finding and expressed a desire to monitor the resorptive lesion during periodic periodontal examinations. The progression of the dental lesion was slow between the 10 and 20 years of follow-up, but much faster between 20 and 27 years (Figures 4–6).

The patient continued to receive periodic professional oral hygiene care and did not report any painful or chewing functionality issues. The patient underwent endodontic treatment of the second molar in the same quadrant in 2020, 24 years after the autotransplantation.

At the 27-year follow-up visit, the patient exhibited excellent oral hygiene, no signs of gingivitis, an 8% full-mouth plaque score (FMPS), a 1% full-mouth bleeding score (FMBS), and an optimal masticatory function. The replanted molar remained perfectly stable and probing depths ranged between 1 and 2 mm, except for a localized distal site with a probing depth of 5 mm with clinical exploration of a subgingival cavitated space (Figure 6). The patient reported no discomfort nor tenderness during probing of distal site.

A periapical radiograph of the replanted tooth revealed the well-maintained physiological level of crestal bone and a normal periodontal space on the mesial root. The radiographic examination also highlighted the presence of ankylosis and root resorption for the cervical third of the distal root, in the same zone where the PDL was not detectable immediately after the tooth extraction. The resorptive lesion reached a severe extent, involving a wide surface of the root and a minor surface of the crown, with penetration until the root canal therapy was performed 27 years prior. The patient, who is now 50 years old, was informed about the severe progression of the resorptive lesion and was proposed to replace the affected tooth with a dental implant. However, she ultimately decided to monitor the status of the transplanted molar and to postpone implant therapy.

DISCUSSION

Tooth autotransplantation is a surgical intervention where a healthy tooth is transplanted from one site of the oral cavity to another within the same individual. Despite the clinical usefulness of this approach, the extended viability of transplantation procedures diminishes over time, primarily due to an unfavorable prognosis resulting from processes such as root resorption or ankylosis.[1–3,6,7] Classical literature in the field of periodontics has clarified that the key factor facilitating the regeneration of the periodontium and preventing ankylosis or bone substitution is the PDL tissue and cells on the root surface of the transplanted tooth.[10,11] In simpler terms, the presence of intact cementum and fibers on the root surface plays a pivotal role in achieving successful outcomes in the context of transplantation procedures.

On the basis of this knowledge, Prato et al.[13] adopted an approach of translational medicine to preserve the PDL fibers of a fully erupted periodontally healthy third molar planned to be transplanted in the socket of a non-restorable maxillary first molar. The authors, drawing from the experimental studies by Svanberg and Lindhe on the effects of experimental jiggling forces on periodontally healthy teeth,[14–16] applied jiggling forces to the third molar, leading to the enlargement of the periodontal space and increased tooth mobility. This approach allowed for a carefully controlled and atraumatic extraction of the tooth, facilitating the retention of the PDL fibers on the roots; only a localized area of the distal root was found to be devoid of PDL fibers. The treatment was successful and the patient retained the transplanted tooth for 27 years in health, comfort, and function, as shown in the present report. This methodological approach to autotransplantation also provided a validation of the studies by Karring and colleagues[10,11] with the onset of ankylosis and external root resorption in the same site

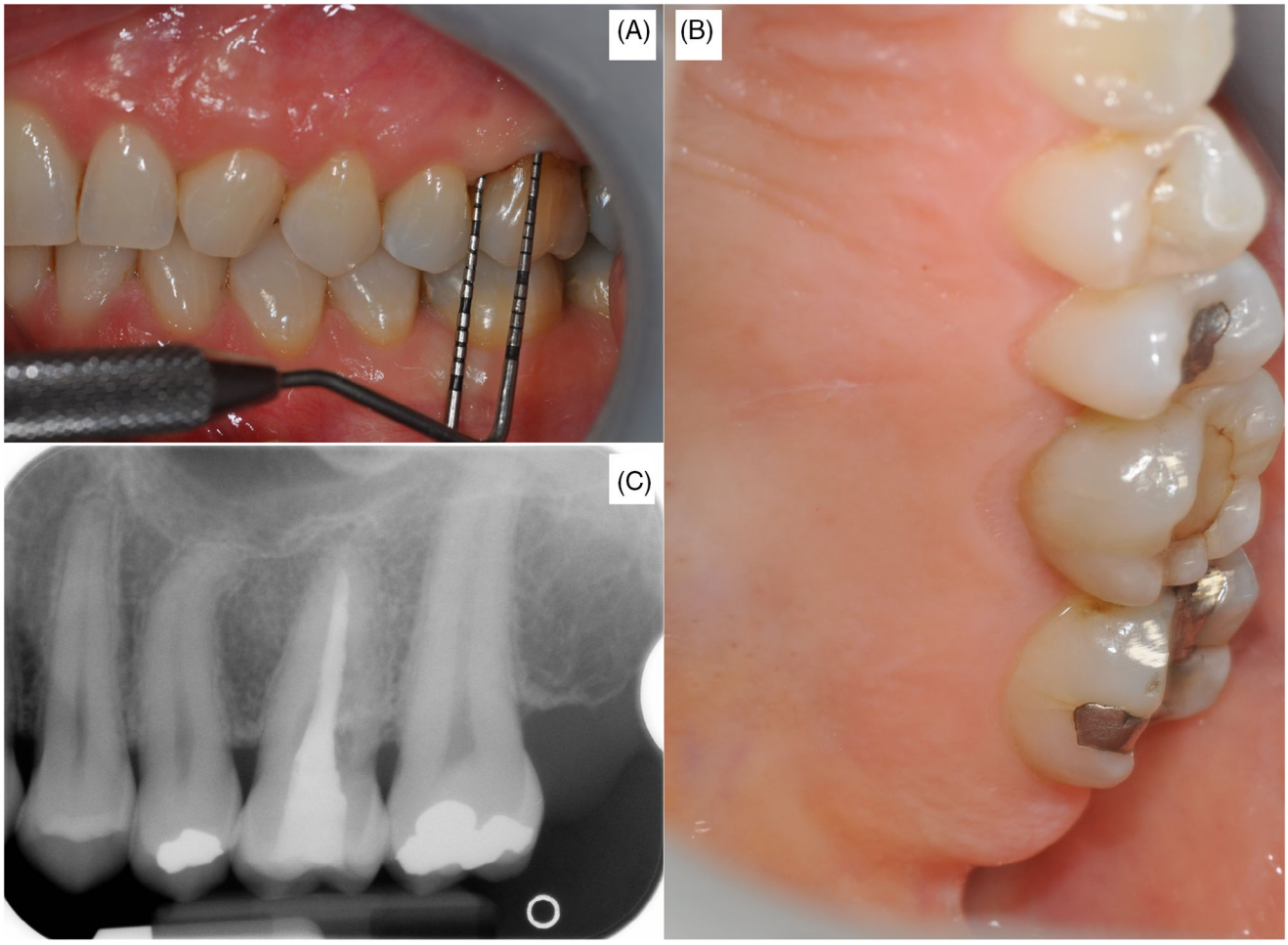

FIGURE 5 Clinical (A, B) and radiographic (C) evaluations 20 years after autotransplantation. Buccal (A) and palatal (B) views showed that the tooth is perfectly aligned in the arch. A periapical radiograph (C) showed that the crestal bone is within a physiological distance from the CEJ and that the periodontal ligament has a physiological space. A localized area of external root resorption was noted at the distal surface of the implanted tooth, in the same site where the periodontal ligament was not preserved after the extraction.

where the PDL fibers were not preserved immediately after the tooth extraction.

The present case report offers the opportunity for reflection on multiple aspects of periodontal science.

1. Transferring scientific discoveries into practical solutions for applicable medical treatments is crucial in modern medicine. Hypotheses formulated in classical studies and then validated in human studies can serve as the basis for clinical guidelines aimed at enhancing the efficacy of therapies in routine practice or at predicting whether a treatment will work well or be unsuccessful. The presented case reviewed the cognitive steps used to apply a translational-medicine approach to periodontal clinical practice.
2. Hypotheses formulated in classical studies and then validated in the present case report can serve as the basis for clinical guidelines. A pertinent example would be to avoid the deliberate removal of PDL fibers through extraoral scaling from a tooth planned for autotransplantation/reimplantation.
3. Discussions can be raised on the therapeutic choice of tooth transplantation as an alternative to a dental implant.
   - First, the patient received treatment 27 years ago when implant-related technology was rapidly advancing but not as advanced as it is today. Considering these factors and the patient's age, which was 23 at the time of treatment, the decision was made in favor of the autotransplantation procedure.
   - For the treated patient, tooth autotransplantation offered several advantages, including the preservation of the natural dentition, allowing for maintaining optimal skeletal growth and spontaneous tooth migration. On the other hand, placing a dental implant might have interfered with natural growth patterns and mesio-occlusal tooth migration. Such interference could have resulted in long-term complications such as infra-occluded implant crowns or

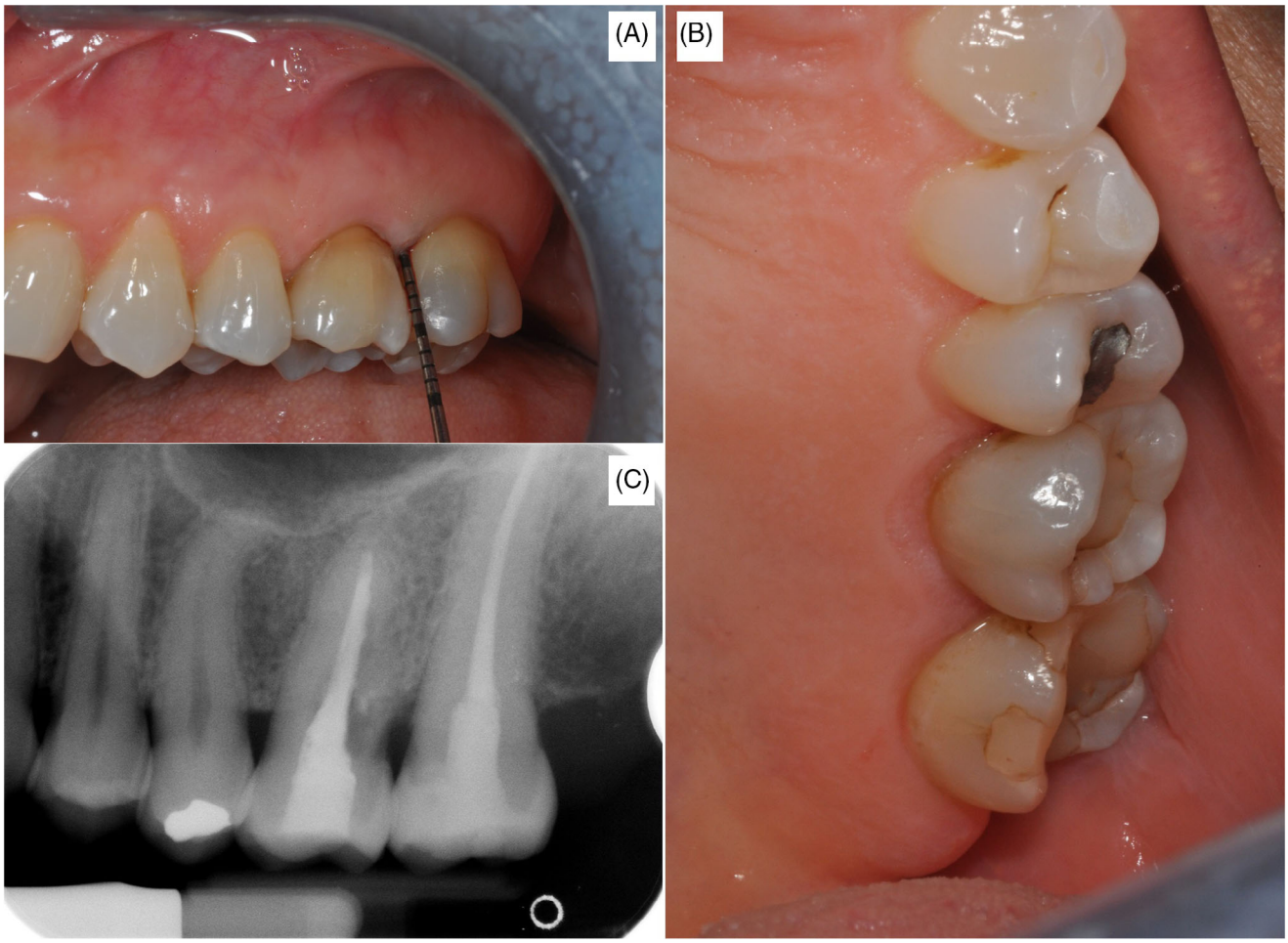

FIGURE 6 Clinical (A, B) and radiographic (C) evaluations 27 years after autotransplantation. Buccal (A) and palatal (B) views showed that the tooth is perfectly aligned in the arch. A periapical radiograph (C) revealed well-maintained bone height and periodontal space on the mesial site. The radiographic examination also noted the presence of an extended surface of external root resorption at the cervical third of the distal site of the root, penetrating until the endodontic space filled with gutta-percha.

unesthetic apical displacement of the gingival margin around the implant rather than adjacent dentition.

- In terms of economic analysis, the transplantation procedure proved to be more cost-effective compared to implant placement. The patient was already undergoing orthodontic therapy and the application of elastics for jiggling forces did not account for any increase in cost. Both the carried first molar and the third molar were already scheduled for extraction. The only additional cost for the patient was for the root canal therapy on the replanted tooth. Since the replanted tooth did not have any carious lesions, the endodontic access was reduced in size and was restored with a filling, eliminating the need for a crown. The transplanted tooth was maintained for 27 years without the need for retreatment, and the patient's cost during the follow-up was contained to the supportive periodontal care (SPC).

  On the other hand the implant therapy, in addition to the extractions and orthodontics that were already planned for the patient, would have added the cost for the ridge preservation at the site of the first molar, implant placement with or without sinus lift, implant crown, and possible maintenance due to long-term mechanical or biological complications in addition to SPC.
- An implant placed 27 years ago could have had a worse prognosis, with a more complex and unpredictable retreatment. Root pathologies such as root resorption/substitution are less destructive on local bone anatomy than peri-implant pathologies, such as peri-implantitis, and require a less demolition treatment. In addition, the patient remains eligible for a dental implant in the near future if the transplanted tooth, which was maintained for 27 years, is definitively lost.

It has to be acknowledged that the pre-existing orthodontic plan made a strong contribution to the decision to opt for tooth autotransplantation over implant

placement. In everyday practice, when orthodontics is not of interest to the patient and in the absence of retrospective information regarding the long-term health of the autotransplanted tooth, opting for a dental implant could be a more predictable alternative.

The results of the presented case study should be interpreted with caution due to its limited external generalizability. While a single case report can illustrate the validity of a biological principle, conclusive data are still lacking because of the scarcity of trials with more sophisticated methodologies. Designing randomized clinical trials for a topic like orthodontically-facilitated tooth autotransplantation is challenging due to the considerable heterogeneity and individual variations in each case scenario. Nevertheless, it would be desirable for future researchers in this field to design prospective studies or assemble follow-up data from cases, which could then be published as case series studies.

CONCLUSIONS

A translational medicine approach was applied to tooth autotransplantation procedures. This case report validated in a human model the findings of classical animal histological studies on the role of jiggling forces on healthy periodontium focusing on the crucial importance of maintaining healthy PDL fibers on the root surface. This example also involves the avoidance of deliberate removal of PDL fibers from a tooth designated for autotransplantation/replantation through extraoral scaling.

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