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Case series

AUTOTRANSPLANTATION OF THIRD MOLARS WITH OR WITHOUT IMMATURE ROOTS: A CASE SERIES WITH 3-YEAR FOLLOW-UP

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PURPOSE. To evaluate the outcome of autotransplantation with third molars with or without complete root formation to replace irrecoverable teeth.

MATERIALS AND METHODS. This study was designed as a case series. Unrecoverable teeth were extracted atraumatically. Third molars were extracted and positioned in the recipient site. Transplanted teeth were fixed with x-shaped sutures suspended above the occlusal surface or were splinted to the adjacent teeth and removed from occlusion. Teeth with immature roots were not endodontically treated to allow apex formation, whereas teeth with completely formed roots were endodontically treated three weeks later. Outcome measures were tooth loss and complications. Vitality tests were also performed on non-endodontically treated teeth. All patients were followed-up for three years after tooth transplant.

RESULTS. Fifteen patients received 17 autotransplanted teeth, 10 with completely and seven with incompletely formed roots. Three years afterwards, no patient had dropped out. Only one transplanted tooth, with a mature root, failed, specifically after three months with compromised periodontal healing. No complications, including infection, inflammation or root resorption, were observed. However, ankylosis was radiographically visible in four mature teeth with completely formed roots at transplant. All teeth transplanted with immature roots maintained their vitality.

CONCLUSIONS. Within the limitations of the present case series, autotransplantation, in particular of third molars with immature roots, could be a valid alternative to other therapies in selected patients.

CONFLICT OF INTEREST STATEMENT
This study was not supported by any company, and there are no conflicts of interest to declare.

INTRODUCTION

Rehabilitation with excellent functional and aesthetic results represents the goal of treatment for partial and total edentulism[1]. In recent years, fixed prostheses and dental implants have been used to restore lost teeth, with a high success rate[2]. However, there are some clinical conditions where implant supported restorations are not accepted by the patients, are not financially viable, or not indicated in growing jaws. In these cases, tooth transplantation, a surgical procedure in which an unerupted or already erupted donor tooth is transfer-

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red from its original position into a post-extraction socket as a recipient site, may be an effective option[3-6].

The first tooth autotransplant in history was recorded by Abulcasis (936-1013)[7] in ancient Egypt. Ambroise Paré, a French dentist, was the first to describe in detail the transplantation of tooth buds in 1564[7,8]. The famous transplant researcher John Hunter reported a successful tooth transplant in a London gentleman in 1772[9], but the first case series, involving autotransplantation of immature premolars in the anterior maxilla, was published in the American Journal of Orthodontics by Slagsvold and Bjercke[10] in 1974. These authors observed a 100% success rate for the transplantation of 34 premolars between May 1959 and January 1970, with a follow up of three years.

According to Azzolina[11] dental transplant options are as follows:

- autotransplants, or autologous transplants, performed from one site to another in the same individual;
- isotransplants, also known as isologous transplants, performed between members of the same species who have the same genetic make-up (homozygous twins);
- allogeneic transplants, or homo-transplantation, performed between members of the same species with different genetic make-up;
- xenotransplants, performed between members of different animal species.

Currently, however, due to blood-borne diseases and thanks to the immunological discovery of histocompatibility antigens, dental transplants should only be performed within the same subject[12].

In comparison to other treatment modalities, such as dental implants or fixed prostheses, tooth autotransplantation has a number of advantages. The procedure is particularly suitable for children and young adults, whose maxillofacial growth has not yet been completed[13]. In fact, due to the presence of the periodontal ligament, the transplanted tooth can promote alveolar bone growth during the eruption process. In addition, if orthodontic treatment is required, transplanted teeth can be moved to the ideal position[13,14].

However, a number of variables affecting the procedure's outcome must be taken into consideration, including the surgeons' skill and knowledge, patient selection, the presence of local inflammation, endodontic treatments, and the presence of periodontal ligament at both the donor and recipient sites[15,16]. Nowadays, autotransplantation represents a valid therapeutic choice, with the most common indications[17] being replacement of teeth missing due to agenesis, particularly premolars and lateral incisors[18]; traumatic avulsion[19]; root fractures[20] or large intractable carious lesions[21].

This case series aimed to evaluate the outcome of dental autotransplantation in patients with irrecoverable teeth who rejected other therapies such as a dental implants or prosthetic solutions, or young patients not suitable for implant therapy. This study was reported according to the STROBE guidelines (https://www.strobe-statement.org/checklists/).

MATERIALS AND METHODS

Patients were selected and treated at two private centres in Sardinia (Italy) from December 2018 to January 2020. Two experienced clinicians (C.Ad, C.Az) performed all surgical procedures, while a single clinician performed all endodontic treatments (C.Ad). All patients gave their informed written consent to the treatment. Any patient aged 15 years or older, able to understand and sign informed consent, with one or more irrecoverable teeth and with unerupted or erupted third molars available for dental reimplantation were treated. Patients were not included if any of the following exclusion criteria applied: American Society of Anesthesiolo-

gist (ASA) class III or IV; pregnancy or nursing; alcohol or drug abuse; heavy smoking (more than 10 cigarettes per day); radiation therapy to the head or neck region within five years; or untreated periodontitis.

Surgical protocol

Patients' medical history, photographs, preoperative panoramic radiographs and cone-beam computed tomography scans (CBCT) were obtained for the initial screening (**FIG. 1**). Patients received 2 g amoxicillin with clavulanic acid (Augmentin, GlaxoSmithKline, London, UK) two hours before surgery and 1 g twice daily for one week thereafter. In the event of penicillin allergy, 600 mg clindamycin was administered two hours before surgery, and 300 mg four times a day for one week afterwards. Patients were instructed to rinse with 0.2% chlorhexidine solution (Curasept, Curaden Healthcare, Saronno, Italy) for one minute before surgery.

Procedures were performed under local anaesthesia (Septanest with adrenaline, 1/100000, Septodont, Mataró, Spain). Extraction of the compromised teeth was performed atraumatically, with root separation and subsequent alveolar curettage using a Lukas curette (Henry Schein Krugg, Buccinasco, Italy). The vestibular wall and alveolar process were kept as undamaged as possible, in accordance with Aoyama[22], who emphasized the importance of the alveolar process and the buccal–lingual space, because in the absence of these, ridge resorption could occur with transplantation failure. After extraction, the recipient socket was washed with physiological solution, then the recipient site was prepared by removing the inter-radicular septum using a straight handpiece and ball bur (Komet Italy, Milan, Italy). After the donor tooth was extracted atraumatically, taking care not to injure the periodontal ligament, using a straight lever (Hu-friedy Italy, Milan, Italy) (**FIG. 2**), the tooth extraction was completed using extraction forceps (Henry Schein Krugg) in contact only with the tooth crown (**FIGS. 3, 4**). Once extracted, the donor tooth was placed into the recipient socket. Third molars with immature roots were fixed using an x-shaped suture suspended above the occlusal surface (**FIGS. 5, 6**) whereas those with mature roots were splinted directly using a flexible orthodontic wire. All transplanted teeth were occlusally adjusted to prevent occlusal contact with the opposing dentition.

Postoperatively, 80 mg of ketoprofen (Oki, Dompé, Milan, Italy), as needed, was prescribed. Patients were instructed to rinse with 0.2% chlorhexidine (Curasept) three times per day for

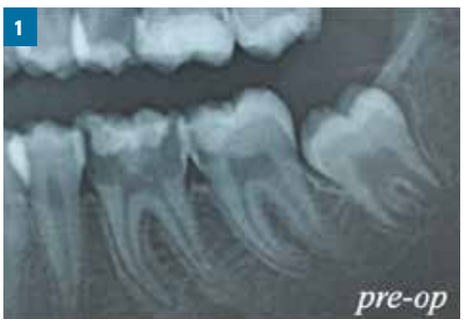

FIG. 1: *Preoperative radiographs showing unrecoverable tooth 36 and unerupted tooth 38 with incomplete root formation*

FIG. 2: *Extraction site of the unrecoverable tooth*

FIGS. 3, 4: *Donor tooth extracted using extraction forceps*

FIGS. 5, 6: *Donor tooth fixed in recipient site with an x-shaped suture*

FIG. 7: *Post-operative x-ray*

two weeks, and to eat only soft food for 30 days. The sutures were removed between 7 and 10 days after surgery, while the flexible orthodontic wire splints were removed 2 weeks later. Three weeks later, in accordance with Asgary[23] and Tsukiboshi[24], orthograde root canal therapy was performed under rubber dam on teeth with completely formed roots. If the donor teeth had immature apices, the endodontic therapy was not performed to allow root maturation (**FIG. 7**). All patients were followed-up for at least three years after autotransplantation. Post-operative and post-endodontic clinical and radiographic follow-ups were performed (**FIGS. 8-11**). Hygiene maintenance, occlusal control and pulp vitality testing were scheduled every 6 months.

FIG. 8: *Radiographic follow-up one month after autotransplant*

FIG. 9: *Radiograph one year after autotransplant*

FIG. 10: *Radiograph two years after autotransplant: roots are developing*

FIG. 11: *Radiograph three years after autotransplant: root formation has been completed*

Outcome measures

The following outcome measures were recorded by the treating dentists.

- Failure of autotransplanted teeth, namely compromised periodontal ligament healing leading to major tooth mobility and, ultimately, tooth loss.
- Complications, such as ankylosis, infection, inflammation and root resorption were clinically and radiographically assessed. Ankylosis was assessed clinically, through percussion of the tooth producing a dull sound, and radiographically, where partial or complete loss of the radiolucent space surrounding the root and/or a replacement of the root substance by bony structures was evident. Infection and inflammation were also assessed clinically, as subjective pain and pain after tooth percussion, and radiographically, evincing loss of dental substance or periapical lesion. Root resorption was evaluated only radiographically as the loss of dental substance. Periodontal healing was deemed compromised upon observing major tooth mobility.
- Lack of pulp vitality in autotransplanted teeth. Teeth were subjected to sensory stimuli, including pressing a cotton-wool ball, previously cooled with iced spray, onto the tooth for two seconds, and the response assessed. This test was performed six months after autotransplantation and every year thereafter.

RESULTS

Fifteen patients (eight males and seven females) of mean age 30 years (range 17-55) received one or more autotransplanted teeth with completely or incompletely formed roots. Fourteen procedures were performed in mandibles and three in maxillae. Nine right lower third molars, three left lower third molars and five right upper third molars were used as donor teeth to replace 11 lower first molars, three lower second molars and three upper second molars.

Three years after autotransplant, no patient had dropped out. Only one transplanted tooth with mature roots failed, after three months of follow-up, as consequence of compromised periodontal ligament healing. Seven teeth with immature roots were transplanted, did not receive endodontic therapy, and successfully maintained their vitality. No complication such as infection, inflammation or root resorption was observed. Ankylosis was, however, observed on peri-apical radiographs at four teeth transplanted with completely formed roots (**FIGS. 12, 13**).

FIG. 12: *Radiograph after endodontic treatment of an autotransplanted mature third molar*

FIG. 13: *Radiograph one year after of the same teeth: ankylosis (arrows) is visible*

DISCUSSION

The results of this case series reveal a high success rate for autotransplanted third molars, especially those with immature roots at the time of transplant, which were also able to maintain their vitality. Historically the exchange of teeth between people has been practiced for thousands of years. A success rate of 82% was reported by Tsukiboshi for 250 cases monitored over six years[25]. Similarly, Mejàre[26] reported high success rates for mature teeth, specifically a survival rate of 81.4% after four years of follow-up in 50 third molars with completely developed roots. Lundberg and Isaksson[27] reported success rates of 94% for 204 autotransplanted teeth with incomplete roots and 84% for 74 teeth with completely formed roots.

The success of autotransplantation greatly depends on the patient selection process. Candidates must be in good health, exhibit excellent oral hygiene, and be receptive to routine dental care. In order for autotransplantation to be successful, patients must, above all, have a suitable donor tooth and recipient site[28] without acute infection or chronic inflammation. Adequate bone support is also a key success factor, and another important parameter is the maturation stage of the roots of teeth to be transplanted[29]. Rohof[30], in a systematic review, claimed a high success rate for autotransplanted teeth with incompletely formed roots (> 95%), with a low rate of complications (< 5%), while Wen-Chen Chung[31], in their systematic review, noted a 90.5% survival rate for autotransplanted teeth with completely formed roots.

According to some authors[3-32], in order to maintain the vitality of Hertwig's epithelial sheath and preserve the periodontal ligament, it is essential to reduce the extra-alveolar time of the donor tooth to as little as possible, and atraumatic extraction should be performed to minimize the risk of complications or failures. Nonetheless, autotransplantation is not free of complications, and the most frequently reported are: pulpal necrosis, failed or compromised periodontal healing[33], root resorption and ankylosis[34,35]. The results of our case series are similar to those reported by other authors, namely Lundberg and Isaksson[27], Wen-Chen Chung[31] and Rohof[30]. The main limitations of the present case series are the low number of patients treated and the lack of independent assessment. It is our opinion that the procedures described in this study could be easily applied by general dental practitioners after a reasonable learning curve.

CONCLUSIONS

Within the limitations of the present clinical case series, autotransplantation of third molars could be a valid alternative to other therapies for replacing missing molars in selected patients.

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