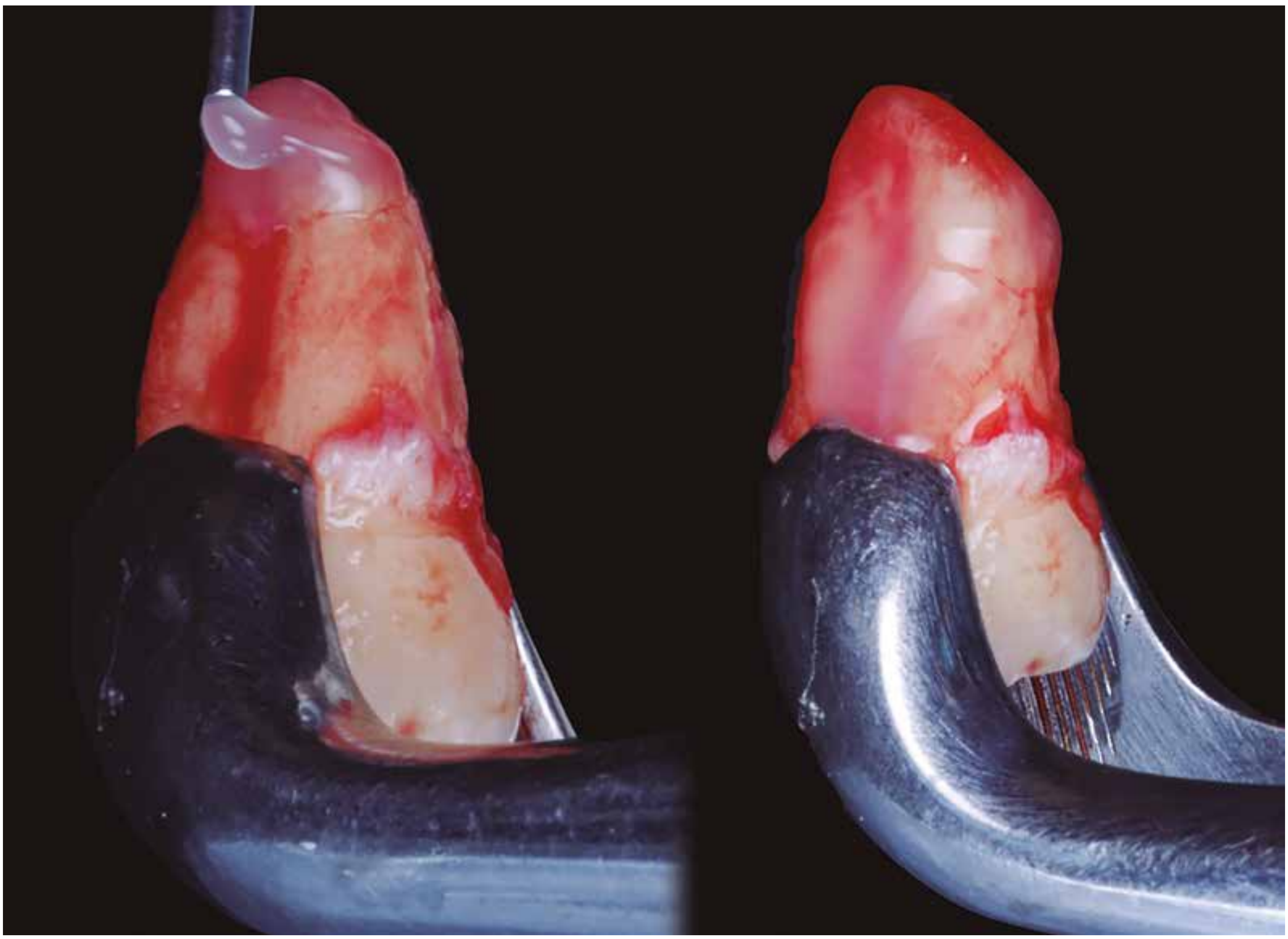

USE OF ENAMEL MATRIX PROTEINS IN AUTOTRANSPLANTATION THERAPY.

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SUMMARY

DENTAL AUTOLO¬TRANSPLANTS have demonstrated survival rates of over 90% with follow-ups of more than 20 years. The success of this treatment depends directly on the vitality of the periodontal ligament of the donor tooth and its consequent regenerative and reparative capacity. In recent years, the protocols for performing this therapy have been modified to improve its predictability. Thus, the ultimate goal is to decrease the extra-oral time of the donor tooth and increase or preserve the regenerative potential of the periodontal ligament (PL) to the maximum. In this clinical case, a digital workflow supported by three-dimensional (3D) technology and the coadjuvant use of proteins derived from the enamel matrix (EMD) is employed.

The clinical case of a 17-year-old male patient with a non-restorable lower left first molar is presented. After meticulous virtual planning, tooth autotransplantation therapy was performed and replaced by the third molar of the same quadrant. The treatment was carried out following a completely digital workflow by obtaining a cone beam computed tomography (CBCT) scan, which was transformed into a Standard Tessellation Language (STL) file for exhaustive planning of the case. Then, using a 3D printer, a mandibular stereolithographic model was obtained along with a replica of the donor tooth and a guided surgery splint to perform the ostectomy in the recipient socket. Finally, after extraction, proteins derived from the enamel matrix were applied to the root surface of the autotransplanted tooth before placing it in its new position to increase regenerative potential and supplement those areas of the root surface where the PL could have been damaged. In this way, an improvement of the clinical and radiographic variables together with a decrease in the complications inherent to this procedure is sought.


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Follow-up is at 12 months where, once the pertinent restorative treatment has been carried out, and after evaluating clinical, aesthetic and radiographic parameters, the case has been successfully closed.

INTRODUCTION

TOOTH AUTOTRANSPLANTATION is a well-documented procedure supported by scientific evidence, with successful results described since 1950 (Apfel 1950). Studies show success rates of 93-100% with follow-up of over 20 years (Andreasen et al. 1990; Akhlef et al. 2018). The high incidence of biological complications associated with dental implants (Derks and Tomasi 2015; Rodrigo et al. 2018; Romandini et al. 2021), together with the existence of clinical situations in which implants may be inadvisable, such as patients in the process of dentoalveolar development (Bernard et al. 2004; Daftary et al. 2013), makes tooth autotransplantation a viable alternative to consider (Plakwicks et al. 2016).

The biological justification for this treatment is mainly based on the regenerative potential of the residual periodontal ligament of the donor tooth, capable of fomenting the regeneration of new periodontal tissues and maintaining the height of the marginal bone around the donor tooth in the recipient area (Tsukiboshi 2002). In recent years, modifications to the traditional autotransplantation procedure have been developed to make it more predictable and to increase the success rate. Among these modifications, we find the incorporation of digital planning, specifically three-dimensional (3D) technology, which allows us to choose the most appropriate donor tooth, plan its ideal position. and minimise extra-oral time.

The most common medium- and long-term complications of autotransplantations are inflammatory root resorption and ankylosis (Schwartz et al. 1985; Kvint et al. 2010). It has been shown that, in those areas in which the periodontal ligament (PL) has been damaged or eliminated during the surgical procedure, areas of root resorption and ankylosis frequently appear. These areas may extend to adjacent areas during the healing or self-repair process depending on their spread (Andreasen et al. 1981).

The coadjuvant use of proteins derived from the enamel matrix (EMD) has been proposed with the aim of stimulating the reparative potential of the PL and consequently: (1) improving clinical variables, (2) radiographic variables, and/or (3) reducing the complications inherent in this procedure. Although the scientific literature is scarce in this regard, there is evidence that these complications can be reduced in cases of replantation after dental avulsions in which EMD is applied (Barret et al. 2005).

Studies in a preclinical model have shown the presence of a higher percentage of PL on the root surface (Iqbal et al. 2001) and a lower rate of inflammatory root resorption (Lam et al. 2007) after the application of EMD in reimplanted teeth whose PL had been unintentionally damaged.

On the other hand, the only clinical evidence there is corresponds to the description of a case where the effects and benefits of applying EMD on the root surface of the donor tooth are described. One of these studies shows a successful outcome in an autotransplanted third molar (+EMD) after 29 years of follow-up (Kimura et al. 2021).

PRESENTATION OF THE CASE

A 17-YEAR-OLD MALE PATIENT, with no medical or family history of interest (ASA I), who comes to our service after an episode of dental tissue loss during chewing. The patient does not conserve the lost fragment.

As dental history of interest, the patient received root canal treatment of the lower first molar (36) two years before the initial evaluation. As a result of an advanced caries lesion.

Clinical examination revealed the presence of 32 erupted teeth and a probing depth of 9 mm on the mesial-vestibular surface of tooth 36 accompanied by bleeding on probing.

At the dental level, we found the absence of the mesial-lingual and distal-lingual apex of the lower left first molar (36), exposure of the endodontic filling material and a composite resin fragment on the occlusal face of 36, corresponding to the direct filling it supported (Figure 1).

The radiographic examination (Figures 2 and 3) of the 4th sextant shows an extensive restoration of the clinical crown of tooth 36 corresponding to more than half of the area of the clinical crown, together with a treatment of four complete root canals, without the presence of any periapical radiolucency.

In the 3D reconstruction of the CBCT scan (Figure 4) a discontinuity of the vestibular cortical is seen in the mesial root of tooth 36. This image, together with the 9 mm probing in the area and the patient's medical history, leads us to a diagnosis of the corresponding tooth that is compatible with a vertical crown-root fracture. Due to the prognosis, extraction is planned.

Figure 1.
Initial clinical condition of the third quadrant. Occlusal view.

Figure 2.
Previous restoration of the affected tooth.

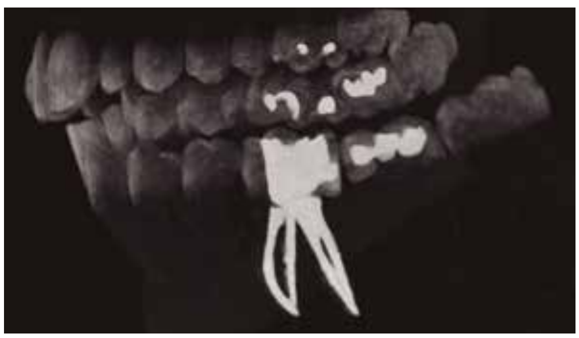

Figure 3.
Filling material completed in 4 canals. 3D reconstruction.

Figure 4.
Vestibular bone plate dehiscence in mesial root. 3D reconstruction.

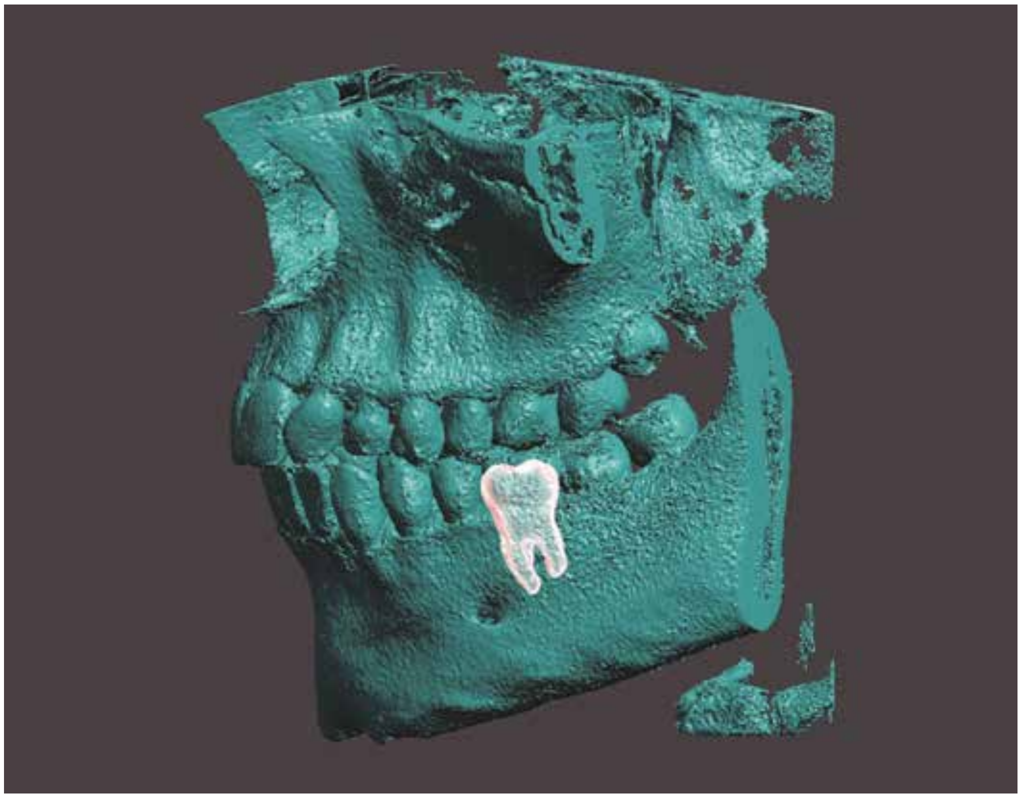

Figure 5.
Conversion of the DICOM file to STL.

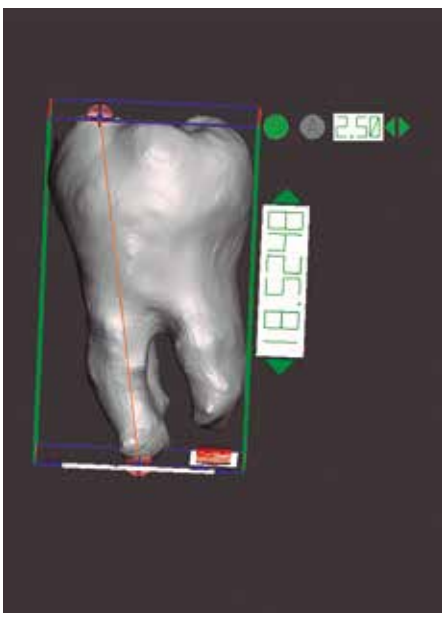

Figure 6.
Digital measurements of the donor tooth.

Treatment Plan

This is a young patient who is still growing , in whom we evaluate the different treatment options to replace the tooth which has a non-restorable prognosis:

1. Immediate or early implant. Together with a guided bone regeneration procedure, if necessary.
2. Alveolar preservation and subsequent restoration with a late implant (once the patient is finished growing).
3. Resection of the affected root and subsequent fixed prosthesis restoration.
4. Tooth-supported fixed prosthesis (using teeth 35-37 as pillars).
5. Space closure, orthodontics.
6. Adhesive and removable prosthesis until growth is complete.
7. Tooth autotransplantation.

To select the most appropriate therapeutic option, an exhaustive analysis of the case was carried out using digital tools. First, the files derived from the CBCT were obtained to perform the radiographic study. Second, these files were converted to STL format, which allowed for the superimposing of structures volumetrically and for the carrying out of a meticulous study of the case in the three reference planes. Additionally, this format (STL) allowed for the creation of a physical replica of the structures of interest through the use of a 3D printer.

In the 3D analysis (Figure 5) it was possible to see that:

- The conditions of root development, the length, and the dimensions of tooth 38 were suitable to be used as a donor tooth (Figure 6).
- The mesial-distal space of tooth 36 coincided more than 90% with the donor tooth on the coronal surface and was also compatible in the apical area (Figures 7 and 8).
- The morphology of the clinical crowns of teeth 36 and 38 was similar (Figure 9).
- The root length of the donor tooth (38) and the distance to the canal of the inferior dental nerve were adequate after the preparation of the new recipient socket (Figure 10).

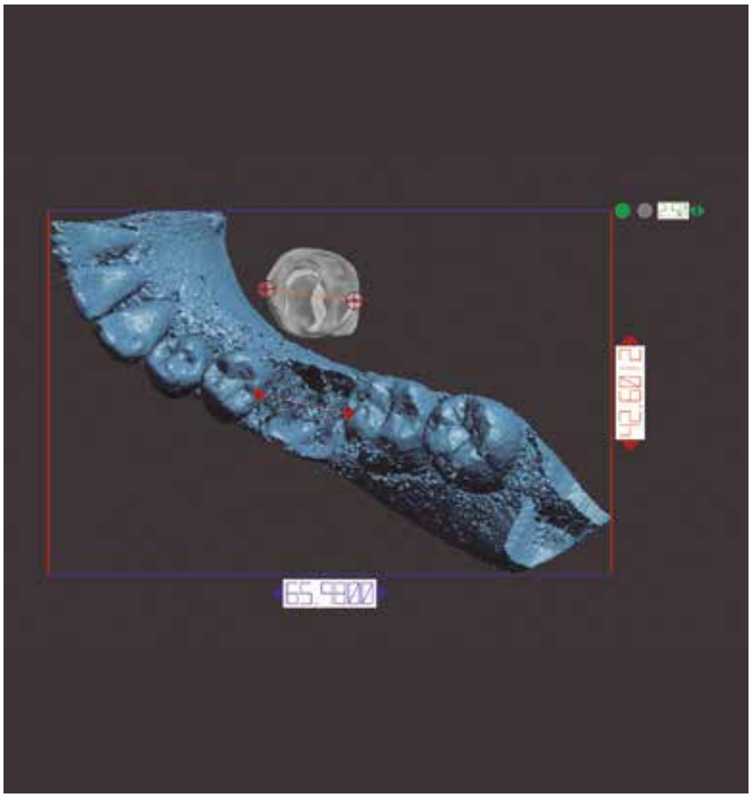

Figure 7.
Checking M-D space in recipient socket and occlusal face of the donor tooth. Occlusal image.

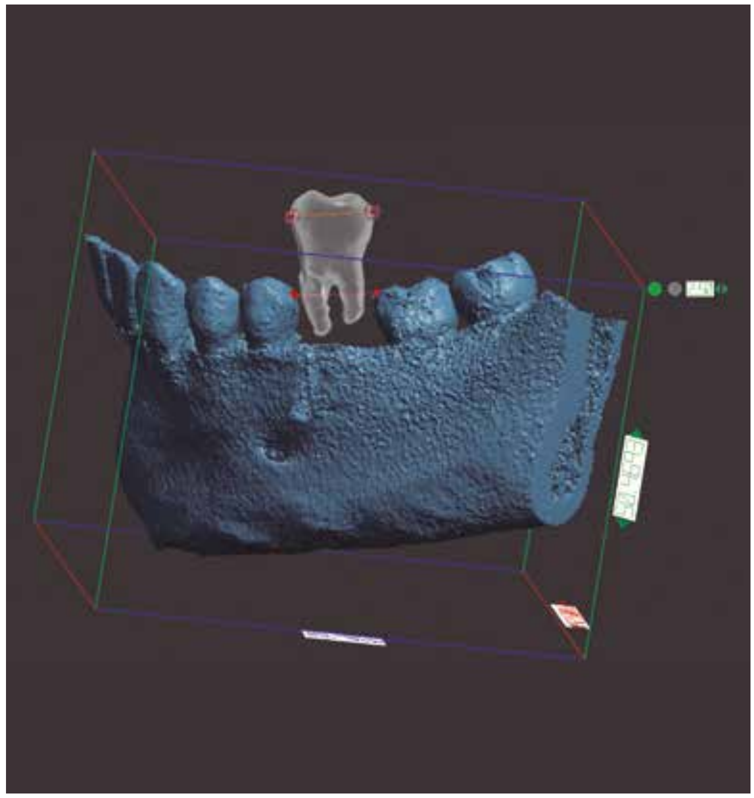

Figure 8.
Checking M-D space in recipient socket and occlusal face of the donor tooth. Vestibular image.

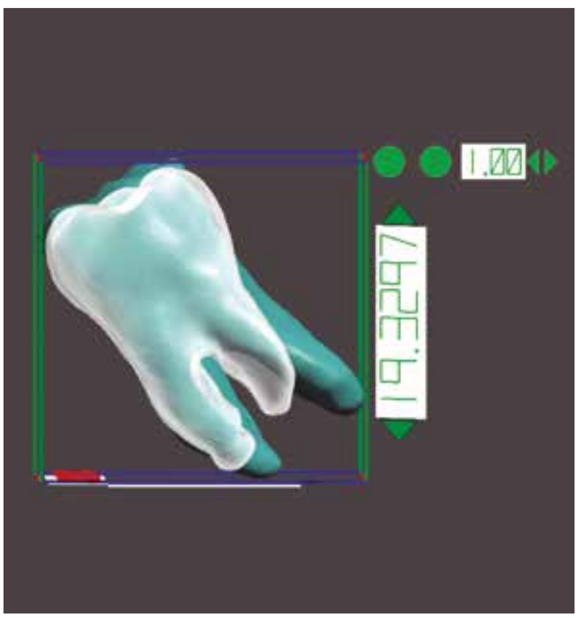

Figure 9.
Three-dimensional overlay of STL files of donor and recipient teeth.

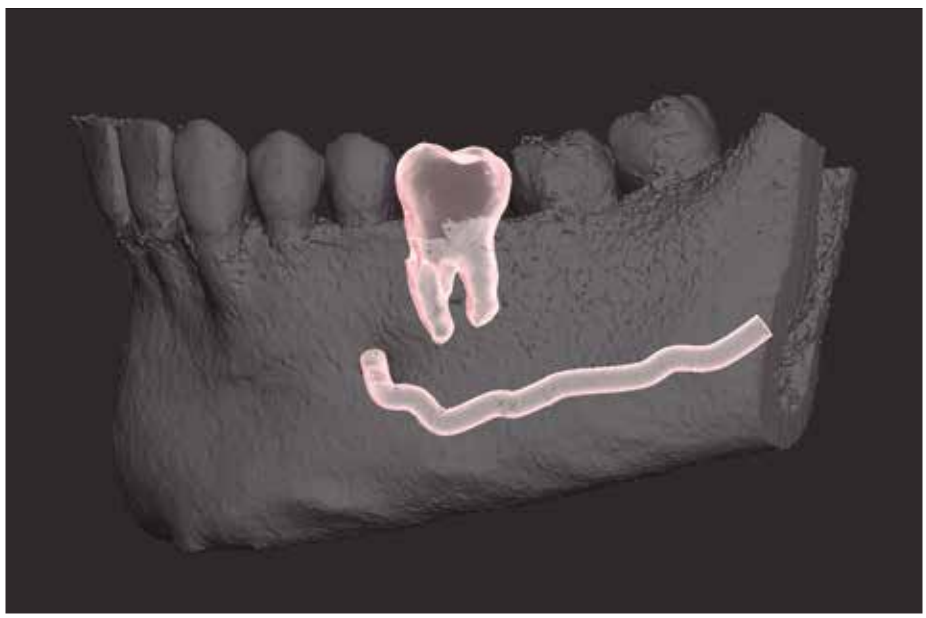

Figure 10.
Relationship of the donor tooth in new position with respect to the inferior dental nerve.

Figure 11.
Interradicular septum detail after virtual extraction. Stereolithographic model. Occlusal view.

Figure 12.
3D reconstruction of the patient’s basal condition. Segmented tooth. Stereolithographic model. Vestibular view.

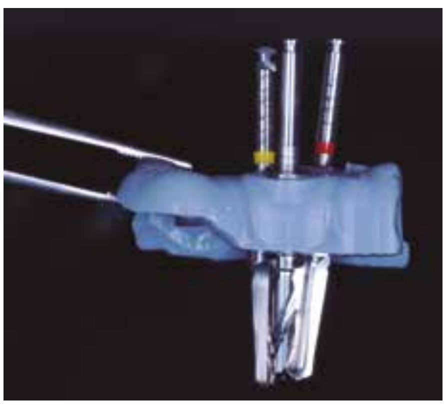

Figure 13.
Guided surgery splint for implants with burs in position. The area of planned ostectomy is shown.

Figure 14.
Example of a guided surgery splint for implants with burs in position after having performed the ostectomy in the alveolus.

To complete the diagnosis, a replica of the donor tooth was printed to confirm the precise creation of the recipient socket and a stereolithographic model of the half mandible was printed with tooth 36 extracted virtually (Figure 11). This made it possible to ensure the precise adaptation of both structures, to simulate the surgery, and to explain the treatment to the patient in a simple and visual way (Figure 12).

Objectives of treatment

The objective of the treatment was to recover the lost function of the tooth in a predictable and definitive way, reducing morbidity and the number of procedures for this developing patient, with a favourable long-term prognosis. To do this, an autotransplantation of tooth 38 was performed at the site of tooth 36 and EMD was used as a coadjuvant.

Figure 15.
Comparison of the donor tooth after its extraction and the 3D replica printed.

Figure 16.
Example of the application of enamel-derived proteins (Emdogain®) on the surface of a donor tooth.

Treatment sequence

1. Preoperative antibiotic prescription.
2. Reduction of intra-oral bacterial load by using 0.12% chlorhexidine + 0.05% cetylpyridinium chloride rinses (Perio-Aid Treatment®).
3. Local anaesthesia in the 4th sextant.
4. Extraction of 36 by odontosection in order to prevent damage to adjacent tissues and to completely preserve the cortical bone.
5. Minimally invasive ostectomy of the recipient socket by using a guided surgical splint (Figure 13) to fit the donor tooth. During planning, a space was left that was necessary for the formation of a clot around the entire surface of the tooth that did not traumatise the periodontal ligament when in contact with the walls of the alveolus (Figure 14).
6. Verification of the correct fit of the 3D donor tooth replica in the new socket.
7. Careful extraction of the donor tooth for maximum preservation of the periodontal ligament. To do this, the insertion of the elevator apically is avoided to avert contact with the root area. Likewise, the forceps should only make contact with the coronal surface while performing slow and controlled movements. There is a large similarity between the 3D printed replica and the donor tooth (Figure 15).
8. Immediately after extraction, EMD (Emdogain®, 0.15 ml) is applied to the root surface of the donor tooth, without prior root conditioning (Figure 16).
9. Placement of the donor tooth in the recipient socket in its digitally planned position (infraocclusion) maintaining EMD on the root surface, after a minimum extra-oral time corresponding only to the application of the gel to the root.

Figure 17.
Tooth in infraocclusion after surgical procedure. Patient in maximum intercuspidation.

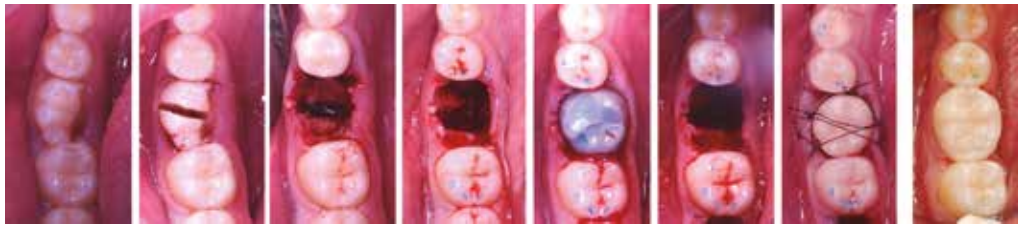

Figure 18.
Complete surgical procedure, from initial to final condition described step by step. Occlusal view.

10. Adaptation of the soft tissue margins to the tooth by suturing, seeking closure on the first try that avoids the migration of epithelial cells through the groove and thus favours the repopulation of the clot with cells from the periodontal ligament.
11. Stabilisation of the autotransplanted tooth by suturing (horizontal external cross mattress) to promote physiological mobility and avoid possible ankylosis of the tooth.
12. Occlusal fit verification to corroborate the final position of the tooth as digitally planned. This way, interference or excessive contact that exert a detrimental effect during healing are avoided (Figure 17).
13. Radiography test, instructions for a proper medication regimen and plaque control (Figure 18). Antibiotics are prescribed for 7 days (750 mg of amoxicillin every 8 hours) and 600 mg of ibuprofen every 8 hours for 5 days as an analgesic and anti-inflammatory treatment. Mechanical plaque control is suspended in the autotransplantation area until the sutures are removed and is replaced by mouthwash rinses of 0.12% chlorhexidine and 0.05% cetylpyridinium chloride (Perio-Aid Treatment®) and is resumed after two weeks with a surgical brush. We also recommend a soft food diet for two weeks.

Results

At 2 weeks, at the time of suture removal, a clinical examination is carried out, in which there are no signs of inflammation, infection or increased mobility of the autotransplanted tooth (Bauss et al. 2005; Almpani et al. 2015).

The radiological examination showed that healing was favourable and that there is no sign compatible with pathology.

In molars with completed root development and closed apices (Moorrees et al. 1963), the chance of revascularisation is minimal (Andreasen et al. 1990). In this case, root canal treatment was carried out after 2 weeks, following suture removal. It has been shown in the literature that performing root canal treatment prior to surgery or during the first 14 days after surgery reduces the risk of root resorption of the autotransplanted tooth (Chung et al. 2014; Jang et al. 2016).

Radiographically, (Figure 19) osseodensification can be observed over time corresponding to favourable bone healing. At 12 months, an image compatible with stability and bone health is seen without observing images compatible with ankylosis or inflammatory root resorption.

In this case, the restorative treatment of the autotransplanted tooth was carried out by means of a direct composite resin restoration to provide the tooth with proper occlusion and contact points, resulting in appropriate function and aesthetics (Figure 20).

In the final clinical examination, a maintaining of the volume of soft and hard tissues is observed, along with preservation of the initial keratinised gum and probing depths compatible with periodontal health (Figures 21 and 22).

Figure 19.
Radiographic evolution (immediate postoperative, pre- and post-root canal treatment, follow-up 12 months).

Figure 20.
Clinical condition at 12 months from the autotransplanted tooth (vestibular, occlusal, and lingual views).

Figure 21.
Clinical evolution after the surgical procedure for 12 months.

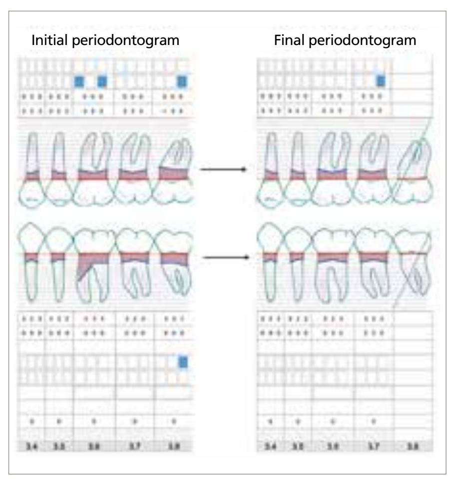

Figure 22.
Initial and final periodontogram (12 months) of the 4th sextant.

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DISCUSSION

IN THIS ARTICLE we have attempted to approach autotransplantation therapy from a biological focus in which the behaviour of the periodontal tissues is a priority. To understand the healing associated with the tooth autotransplantation procedure, it is necessary to know the embryological development of the tooth and the anatomy of the different periodontal tissues. This way, we can understand the biological plausibility that exists behind the application of EMD to the root of the autotransplanted tooth to improve its prognosis.

Histological evidence from experimental articles shows how, by removing part of the periodontal ligament from the donor tooth and reimplanting it, denuded root surfaces undergo a process of root resorption or ankylosis, which may extend to adjacent surfaces where the periodontal ligament was intact (Andreasen et al. 1981). The greatest evidence that, as long as the periodontal ligament of a tooth is preserved, it can be transplanted, is provided by the classic studies of the Nyman et al. (1980) group, who performed tooth extraction, scraping of the root surface, and replantation under different conditions. It was shown that achieving reinsertion and periodontal regeneration only occurred in those teeth that were not scraped and that maintained the periodontal ligament; while on denuded root surfaces, apical migration of epithelial cells prevented reinsertion, connective tissue cells had no regenerative capacity, and colonisation by alveolar bone cells could lead to ankylosis and root resorption (Karring et al. 1980). These findings support the biological plausibility of the use of EMD as a coadjuvant in tooth autotransplantations.

Although new digital protocols (Lucas-Taulé et al. 2021) considerably minimise trauma to the donor tooth and its periodontal ligament, it is inherent in manipulation and extraction that the root surface of the tooth can be damaged. Applying enamel matrix proteins on these damaged surfaces could initiate a regeneration process typical of developing teeth. Thanks to its biological capacity to increase the attraction, differentiation, and proliferation of cementoblasts and fibroblasts, it could favour the insertion of new periodontal ligament fibres into the cementum, minimising the possibility of biological complications of the autotransplanted tooth.

The scientific evidence available to prove this hypothesis is currently limited. There are animal studies (Iqbal et al. 2001; Lam et al. 2007) showing the efficacy of EMD in improving the healing of autotransplanted teeth and reducing the incidence of root resorption in an in vitro model. However, in another study in a similar model (Guzmán-Martínez et al. 2009) it did not find that the application of EMD was able to prevent root resorption in reimplanted teeth. Thus, systematic reviews of the literature conclude that the available evidence is scarce and unclear regarding the effectiveness of EMD in improving healing and reducing complications of dental replantation (Wiegand and Attin 2008; Mohamed et al. 2019).

As clinicians and researchers, it is our job to create hypotheses that generate new research. This is the way to keep science constantly evolving in our field, with the ultimate goal of improving our treatments to make them more predictable and to minimise possible complications, always seeking the benefit of the patient.

For this reason, our research group presents this clinical case, which belongs to a series of prospective cases in which the effect of EMD used as a coadjuvant in autotransplantation therapy is clinically evaluated, for the first time, under a controlled design in the scientific literature.

CONCLUSION

AFTER PRESENTING THIS CLINICAL CASE, it can be concluded that tooth autotransplantation performed using a completely digital protocol and with the coadjuvant use of EMD can be a satisfactory treatment for replacing non-restorable teeth.

CLINICAL RELEVANCE

THE INCORPORATION OF THE DIGITAL WORKFLOW using three-dimensional technology in this treatment has facilitated its execution and significantly improved its success rate.

In this way, virtual planning provides the following advantages: choosing the most appropriate donor tooth, reducing the extra-oral time of the donor tooth, and the possibility of avoiding trauma to the cells of the periodontal ligament, which entails the repetitive insertion of the donor tooth into the new recipient socket for adaptation.

The good clinical and radiographic results obtained regarding the healing of the periodontal ligament, bone crest, and soft tissues support the hypothesis that the incorporation of EMD to this procedure could improve its success rate and reduce biological complications. Randomised trials with long-term follow-up are needed to test this hypothesis.

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