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Treatment by Preplanned Virtual Autotransplantation of a Microdont Immature Third Molar to a Maxillary Central Incisor Socket Using a 3D Printed Tooth Replica: A Case Report

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ABSTRACT

An 18-year-old female patient presented to emergency dental clinic for avulsion of maxillary left central incisor (#21) in a car accident. In the presence of an immature left maxillary microdontic third molar (#28), a preplanned virtual autotransplantation using an implant planification software was chosen to replace #21. A guided osteotomy using a 3D printed thermoplastic replica was performed to reduce the extra-oral time to < 1 min. Indirect restorations with lithium disilicate veneers were made for both central incisors. After 4 years, the esthetic integration remained satisfactory. The case presented, involving the replacement of an avulsed #21 with an immature microdontic third molar #28, illustrates the possibilities of extending the indications for autotransplantation using virtually planned surgery.

1 | Background

It is always a challenge to restore missing teeth due to trauma, especially in patients who are still growing but even more so in the anterior area where esthetic outcomes are not easy to manage [1]. Conventional treatment options such as dentures, bonded bridges, or orthodontic closure are well documented but recently, one of the emerging option for traumatized central incisors is tooth autotransplantation [2].

The first case series of tooth autotransplantation in the anterior maxilla using immature premolars was reported by Slagsvold and Bjercke in 1974 [3]. Few years later, a long-term study including 370 premolars conducted by Andreasen et al. [4] found a good survival rate for both immature (95%) and mature teeth (98%) over a mean 5-year follow-up. Atraumatic extraction of the donor tooth, reduction of extra-alveolar period, quality of the preparation of the recipient site [5, 6], sufficient tooth length and incomplete root formation [4] are the criteria identified to improve success.

The traditional surgical technique uses the natural donor tooth to prepare the recipient site, which leads to an extended extra-oral time, increased donor tooth manipulations, and reduces the success rate [7]. More recently, preplanned virtual autotransplantation was reported to minimize such damage by using a three-dimensional surgical replica [8, 9]. This replica is provided by Cone Beam Computed Tomography (CBCT) data, exported into

Abbreviations: CBCT, Cone Beam Computed Tomography; DICOM, digital imaging and communications in medicine files; MTA, mineral trioxide aggregate; STL, standard triangle language.

a Digital Imaging and Communications in Medicine (DICOM) format and manipulated with a software to segment the donor tooth into an Stereo Lithography (STL) file. The donor tooth replica is then printed in resin using a 3D printer [10]. A higher survival rate was reported for this new strategy (92%) compared to traditional approach (84%) [11]. However, preplanned virtual autotransplantation was mostly reported for premolars, a procedure only relevant until the age of 12 years due to the apical closure [12]. The literature remains scarce for immature third molars, which are frequently available in patients between the age of 14.5 and 21.5 years and could therefore allow for later autotransplantations [12].

This case report aims to present a case of autotransplantation of an immature microdont third molar in place of a maxillary central incisor using a 3D replica of the donor teeth in a young adult patient.

2 | Case Presentation

This case report was prepared according to the PRICE 2020 Guidelines (Data S1; [13]).

Written informed consent was obtained from the patient when she registered at the clinic for future publication of the case report and any accompanying images.

An 18-year-old female patient with no medical condition was referred to emergency dental clinic following a car accident. After clinical and 3D analysis of the maxillary left central incisor (#21) with a localized low-dose CBCT (ProMax 3D; Planmeca, Helsinki, Finland), the diagnosis was established according to the International Association of Dental Traumatology (IADT) guidelines: [14] avulsion of #21 with buccal alveolar bone fracture and enamel fracture of the maxillary right central incisor (#11) (Figure 1a,b). Alveolar bone disinfection, collagen sponge apposition and sutures were performed to close the traumatized site.

The patient was seen 2 weeks later to review the initial healing following the accident and remove the sutures. After 4 weeks, the accident a clinical and whole mouth low-dose CBCT examination were performed which confirmed the complete loss of the buccal plate around #21 (Figure 2a) and allows us to consider autotransplantation as an option, considering that a left maxillary microdontic third molar (#28) was found. During an interdisciplinary team meeting, bonded dental bridge and implant treatment were contraindicated because of patient's heavy occlusal contacts in the anterior area and age respectively [15]. Autotransplantation of an existing immature (apical diameter estimated between 0.5 and 1 mm, stage 9 of the Nolla classification) left maxillary microdontic third molar (#28) was preferred. (Figure 2a,b) This would be followed by monitoring for possible revascularization. This patient gave her consent to the proposed treatment plan.

The #28 was first isolated from the CBCT and the DICOM file was read using an open-source software (Blue Sky Plan; Blue Sky Bio, Libertyville, IL, USA). The tooth was then segmented to extract only the tooth image and the 3D image obtained was converted into a STL file (Figure 2c). After which, the preparation of the receiver socket and the position of the donor tooth in the receiver socket was planned using the Blue Sky Plan software (Blue Sky Bio; Figure 2d–f).

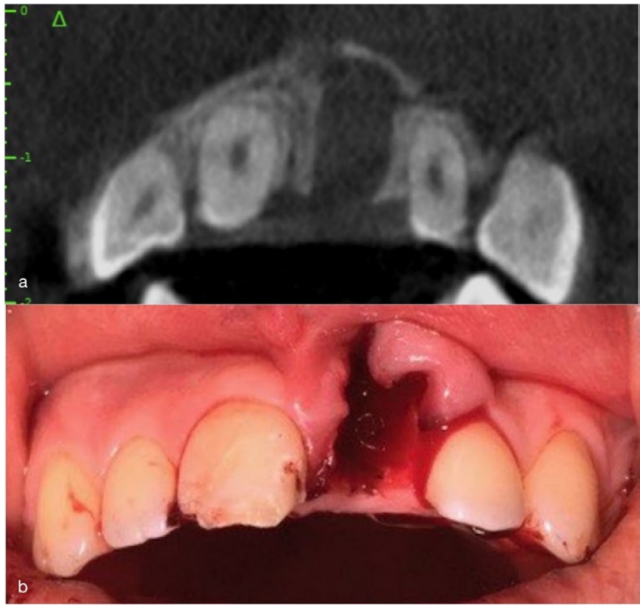

FIGURE 1 | Day of the accident. (a) CBCT showing the avulsion of 21 associated to an alveolar bone fracture, (b) clinical view showing soft and hard tissues traumas.

After analysis, the mesial side of the microdont was chosen to become the vestibular side of the new maxillary central incisor because this position was the best to minimize alveolar bone preparation during surgical transplantation and veneer preparation to achieve an aesthetic outcome; the tooth was placed infracluded to prevent any contacts that could compromise healing. The STL file of the microdont was used to print the tooth replica in a thermoplastic polymer material (Polyether ether ketone, PEEK).

Six weeks after the accident, surgery was performed under local anesthesia with articaine 4% and epinephrine 1:100000 (Septanest; Septodont, Saint-Maur des Fosses, France) for both donor and receiver sites. The tooth replica was disinfected in 0.12% chlorhexidine solution (Eludril; Pierre Fabre, Paris, France). An intrasulcular and mid-crestal incision was made from the mesial of the maxillary right central incisor (#11) to distal of the left lateral incisor (#22), and a full muco-periostal elevation was made without discharge. The receiver socket was prepared using the replica and a round bone bur until there was sufficient space to avoid compressing the donor tooth periodontal ligament. (Figure 3a) The donor tooth was extracted atraumatically to protect the periodontal ligament and the immature periapical cells. The donor tooth was placed into the recipient socket under digital pressure in under 1 min. The vestibular flap was repositioned coronally. The site was closed using monofilament sutures (Monocryl 5.0; Ethicon, New Jersey, USA) and the donor tooth was stabilized for 4 weeks using a 0.2 mm-diameter semirigid stainless steel wire (American Orthodontics, Wisconsin, USA). The retention of the transplant was a challenge because of the difference in dental anatomy between the transplant and #21. The choice of using an orthodontic standard bracket (GC Orthondics Europe, Breckerfeld, Germany; Figure 3b) made it possible to obtain a strong and clean enamel bonding close to the flap. This facilitated the reconstruction of the crown with

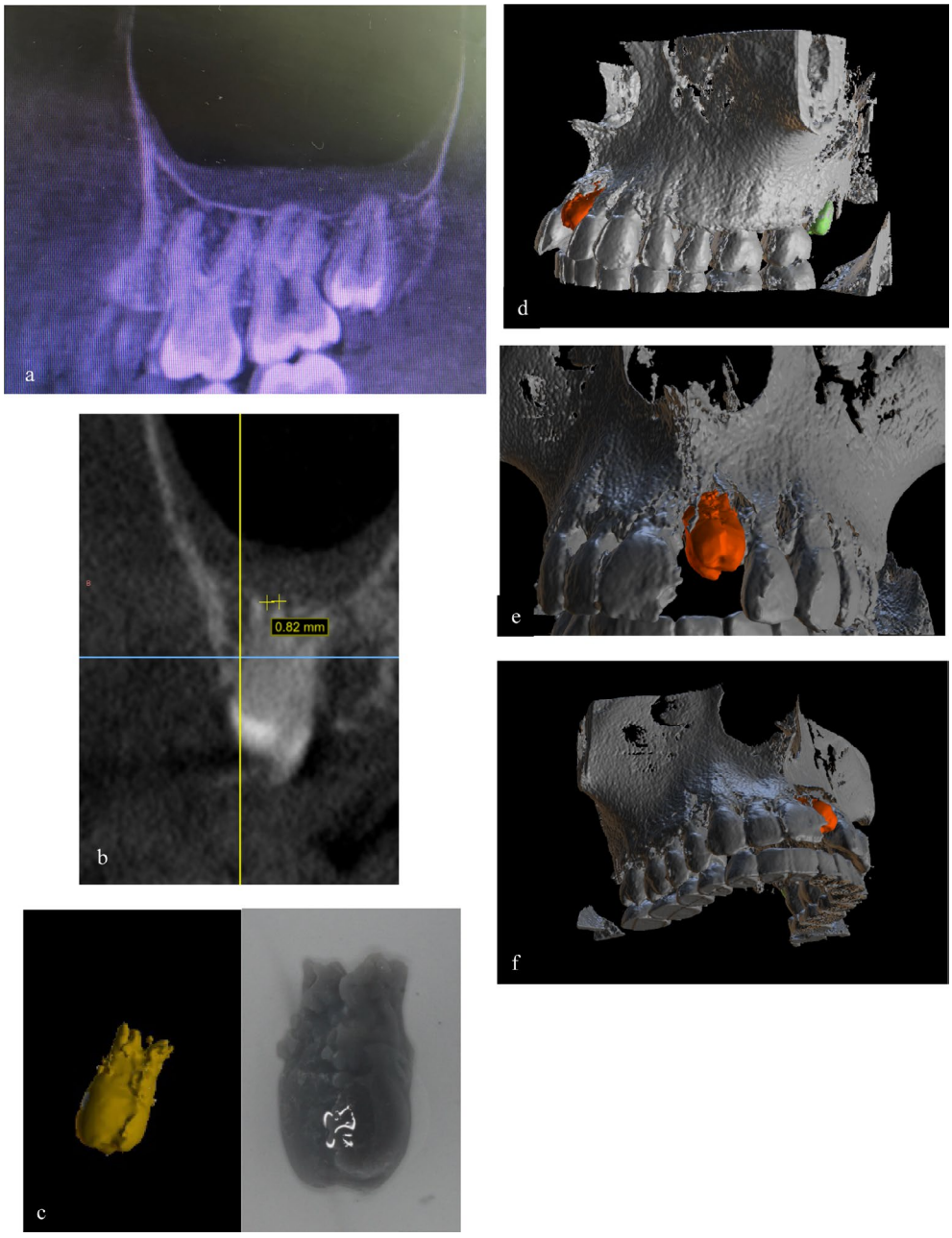

FIGURE 2 | Surgical planning and printed replica. (a) CBCT showing the 28 microdontia, (b) estimated apex opening of tooth #28 (0.82 mm), (c) segmentation of tooth #28 using BlueSkyPlan open software and transplant replica (PEEK) used to prepare tooth #21 socket, (d) ideal placement of the transplant found using BlueSkyPlan. (e) frontal zoomed view of the transplant position planned, (f) lateral view of the transplant position planned.

a Temporary composite resin restorations (Tetric EvoCeram; Ivoclar, Schaan, Liechtenstein) to give an acceptable aesthetic appearance. The post-operative prescription was: 7 days of amoxicillin (2 g/day), 3 days of prednisolone (60 mg/day), 4 days of acetaminophen, and chlorhexidine 0.2% rinse (2 times/day). Endodontic treatment of the #28 was not immediately indicated in the case reported.

A standardized follow up protocol was performed at 4, 7, 9, and 23 weeks after the surgery. Then, every 6 months for 2 years and every year after 2 years, the outcomes for the autotransplantation (clinical findings, radiological findings and patient-related outcomes) were evaluated following Barber's et al. protocol [16]. The first clinical follow-up occurred 9 weeks after accident (4 weeks post-autotransplantation); gingival healing was completed, there was a persistence of tooth vitality and the patient did not report any pain or discomfort. The sutures were removed. The tooth presented a Miller Class 2 mobility and therefore it was decided to retain stabilization for 3 more weeks.

At the 12th week follow-up (7 weeks post-autotransplantation), the transplant had physiologic (Miller Class 1) mobility. However, the tooth had a grey discoloration, and the vitality test was negative. The surrounding gingival was also hyperplastic because the patient was afraid to brush this tooth (Figure 4a). To verify bone healing and the autotransplant position, a low-dose

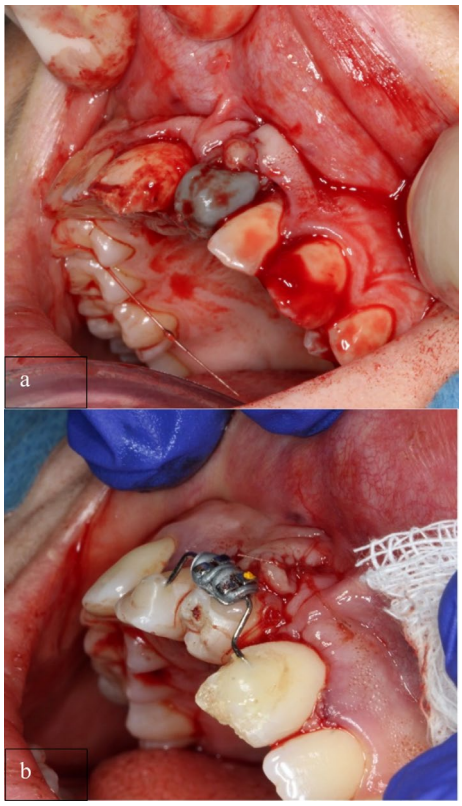

FIGURE 3 | Autotransplant placement on the day of surgery. (a) Intraoperative adjustment of the 28 tooth replica in the socket of 21, (b) tooth stabilized with bracket and passive wires.

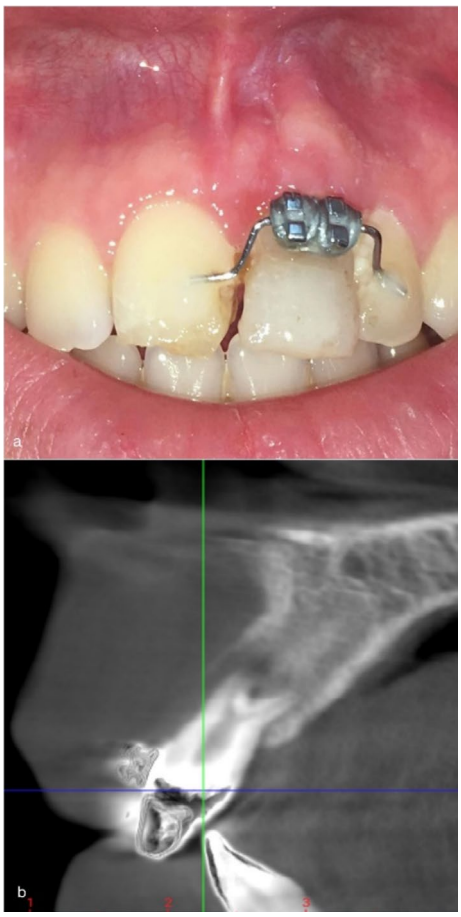

FIGURE 4 | Follow-up 12 weeks after the accident. (a) clinical view, (b) CBCT.

CBCT was performed (Figure 4b). In view of the septic risk it was decided to root treat the autotransplant. The stabilization was removed and the endodontic treatment was performed 2 weeks later under microscope; the root canal was obturated with a calcium silicate-based cement Bioroot (Septodont, Saint-Maur-des-Fossés, France). Views from the radiological follow up by retoalveolar are summarized in Figure 5.

Seven months after accident, the tooth was totally asymptomatic with no periapical lesions; gingival tissue level and thickness were satisfactory. For better aesthetic outcome and considering enamel fracture of the maxillary right central incisor (#11), both central maxillary incisors were restored with ceramic veneers. After a period of temporization with composite veneers, an aesthetic try-in was performed for patient validation and the final veneers were bonded. (Figure 6a).

At 24 months follow-up, the aesthetic results and patient-related outcomes were satisfactory (Figure 6b,c). After 4 years, they remained fine with no periapical infection, root resorption or ankylosis which can allow us to consider this treatment as a success (Figures 5d and 6d–g) (Table 1).

3 | Discussion

Considering the loss of a central incisor, two other conventional options had been discussed: a single retained resin-bonded dental bridge which is now consider as a viable minimally invasive and low-cost option with a 91.4% (95% CI: 86.7%–94.4%) success rate after 5 years or an implant-supported crown. The first option was not retained because of debonding complications which occurred in 15% (95% CI: 10.9%–20.6%) of the resin-bonded bridge after 5 years [17]. These complications are increased in cases of heavy occlusion and therefore not indicated in our patient. Implant-supported crown cannot be considered from a biological perspective because it would not have followed vertical growth of the jaws in a young adult patient. The presence of an immature maxillary microdontic third molar made it possible to propose autotransplantation to replace #21. Furthermore, the osteogenic properties of a transplant allow for alveolar bone regeneration, making it easier to place an implant in the future, if required [18]. Existing literature refers to the use of premolars in this type of situation; in 2022, Sicilia-Pasos et al. published a meta-analysis of autotransplanted immature premolars and found that the survival rate at 5 years was 95.9% and at 10 years 96.9% [19] but there exists very few published cases of autotransplantation of other teeth [20]. In this case report, the premolars were not considered due to her well-aligned dentition, and using a premolar donor tooth would result her requiring additional orthodontic treatment for space closure.

Performing an autotransplantation of a microdont third molar into a central incisor can be considered as a challenge for periodontal (soft tissue color and texture, presence of papilla, facial mucosal level) and aesthetic (color, form, texture, translucency) integration of the transplanted tooth. To achieve this challenge,

FIGURE 5 | Radiological follow-up of the transplant by retro alveolar (since the day of endodontic treatment using a calcium silicate-based cement). (a) Intraoral radiograph before microdont immature tooth endodontic therapy, (b) immediately after, (c) 1 year after, (d) 4 years after showing healthy periapical conditions and absence of ankylosis.

the planning of the surgery and the production of a 3D printed tooth replica reduces manipulation and extra-alveolar time of the donor tooth. Ankylosis and root resorption were reported as the main reasons for failure of autotransplantation of premolars, but this was not found during follow-up in our case [9]. Regarding pulp management, we did not perform an endodontic treatment on the day of the surgery as recommended by Andreasen et al. [21]. Based on the results of the study reported by Laureys et al. [22] an apical diameter of <1 mm may be sufficient to ensure pulpal revascularization and the growth of new vital tissue. In the case presented the apical diameter was estimated to be between 0.5 and 1 mm for this immature tooth (stage 9 of the Nolla classification) [23] which was compatible with pulpal revascularization (Figure 2b). However, the endodontic treatment was performed at 6 weeks following pulp necrosis. The necrosis of the pulp in the present case confirms the importance of root development for the success of pulp revascularization [4, 5, 19]; it is also of note that Denys et al. reported that the best time to perform autotransplantation was at two-thirds to three-quarters of the final root length (stage 8 of the Nolla classification) to maximize the chances of regenerative processes [24]. It should be noted that in the case of autotransplantation of mature teeth associated with more frequent complications than for immature teeth [25].

In the case presented, we chose to use a 3D printed tooth replica to improve the chances of successful autotransplantation. Han et al. reported a significant extra-oral time reduction [20] and

FIGURE 6 | Clinical follow-up at 7, 21, 24 months and 4 years after accident. (a) Patient smile immediately after veneers bonding at 7 months after accident, (b, c) clinical follow-up and probing at 2 mm around 21 at 24 months after accident, (d) clinical follow-up at 4 years in vestibular, (e) palatal, (f, g) final smile view.

a higher success rate (95.5%–100%) than conventional surgery (80%–91.1%) by preserving the Hertwig epithelial root sheath cells and periodontal ligament [7]. This explains why the survival rate remains over 80% for digitally planned surgery while it drops below 60% for the conventional surgery [9].

Considering tooth replica positioning, several authors recommend the use of a printed surgical template to reposition the donor tooth [8, 9]. After analysis of the CBCT and caring out virtually planned surgery, we saw that the osteotomy would be minimal to reposition the donor tooth. It was, therefore, decided not to use a printed surgical template to reposition the autotransplant. Sokolowski et al. reported that the mean absolute surface deviation between the 3D-printed replica and the corresponding donor teeth ranged from 0.13 to 0.25 mm (standard deviation = 0.10 to 0.21 mm) [26]. Furthermore the technique ensures reproducible results (intraclass correlation coefficient = 0.935, 95% confidence interval [CI], 0.891–0.978) and is safe [27–29]. However, in the case presented, we had to finalize the receiver site preparation using the donor tooth and so the surface deviations appear to be slightly higher. Therefore, the use of a printed surgical template might have been helpful and in order to obtain a sufficiently large socket to receive the donor tooth and thus avoid compression of the periodontal ligament, the replica would have had to have been oversized by approximately 10%.

Periodontal integration and aesthetic outcomes are other important factors in autotransplantation, both for the tooth and the periodontal tissues, as reported by Czochrowska et al. in two studies [30, 31]. In the first study, periodontal criteria such as absence of recession, physiological probing depth, presence of papilla or crown-root ratio around premolars replacing maxillary incisors were assessed. Identical to the case presented here, there was no significant difference between the transplanted incisor and the contralateral natural central incisor for any of these parameters, and they also confirmed that dental transplantation enabled bone induction and conservation of the alveolar bone process [30]. In the second study, they evaluate aesthetic outcomes with questionnaires comparing the transplanted tooth to the contralateral natural central incisor, and they reported only 18% of mismatched teeth primarily because of suboptimal positioning and restorative build-up of the transplant [31]. Therefore, they concluded that this procedure was well indicated in growing patients, allowing satisfactory periodontal and aesthetic integration.

4 | Conclusion

The case presented, involving the replacement of an avulsed central incisor #21 with an immature microdontic third molar #28, illustrates the possibilities of extending the indications for autotransplantation using virtually planned surgery. When a donor tooth is available, given the high survival rate and low incidence of complications, autotransplantation should always be considered.

Author Contributions

A.B. diagnosed the case, planned and carried out the surgery and the prosthetic restorations, follow-up visit, and wrote the paper; A.L. supervised the surgery and the drafting of the paper; C.M. supervised the prosthetic restauration. K.G. supervised the drafting of the paper; R.R. carried out the root canal treatment; and R.L. helped to plan and carry out the surgery. All authors read and approved the final manuscript.

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TABLE 1 | Evaluated criteria at 4, 7, 9 weeks and 6, 12, 24, 36, 48 months follow-up.

	4 weeks	7 weeks	9 weeks	6 months	12 months	18 months	24 months	36 months	48 months
Transplant survival	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
External or internal inflammatory resorption	No	No	No	No	No	No	No	No	No
Pulp necrosis	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Endodontic treatment completion			Yes						
Mobility (Miller's class)	2	1	1	1	1	1	1	1	1
Ankylosis	No	No	No	No	No	No	No	No	No
Gingival inflammation	Yes	Yes	Yes	No	No	No	No	No	No
Gingival recession	No	No	No	No	No	No	No	No	No
Papillas position maintened	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Patient satisfaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Ethics Statement

As the article is a clinical case report, the ethics committee of the Hospices Civils de Lyon (Lyon University Hospital) ruled that no formal ethics approval was required.

Consent

The patient was verbally informed and provided written consent for autotransplantation of her microdont immature third molar to a maxillary central incisor socket using virtual planning and a 3D printed tooth replica. Written informed institutional consent was obtained from the patient for the publication of personal details and accompanying images in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated or analyzed that related this case report are included in this published article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.