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Case Report

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Autotransplantation of Impacted Third Molar Using 3D Printing Technology: A Case Report

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Abstract

Here, we describe a case of autotransplantation of a mandibular horizontally impacted third molar using a 3-dimensional (3D) model based on limited cone-beam computed tomography (CBCT) images for diagnosis, 3D morphological evaluation, preoperative treatment planning, and surgical simulation. A 27-year-old woman visited this hospital for conservative treatment of the mandibular left second molar. Intraoral radiography and CBCT images revealed a C-shaped root canal in the mesial root, and compressive resorption of the distal root due to impingement of the crown of the horizontally impacted lower left third molar. Extraction was therefore planned. Multiple tooth-jaw bone 3D models for preoperative diagnosis were fabricated using a low-cost desktop 3D printer and surgical simulation of autotransplantation performed. The autotransplantation was then performed accordingly. Cone-beam computed tomography images and 3D models were extremely useful in obtaining a stereoscopic understanding of the morphology of the transplanted tooth and its surrounding anatomical structures. At the one-year postoperative recall, the patient was able chew with the transplanted tooth without pain, and no significant abnormalities were detected on intraoral radiographs, indicating a successful postoperative clinical course. Our experience of using 3D models fabricated based on CBCT images using a desktop 3D printer for preoperative diagnosis and surgical simulation suggests that this technique is useful in tooth autotransplantation.

Key words: Autotransplantation — 3D printing — Desktop 3D printer — Computer-aided manufacturing

Introduction

Three-dimensional (3D) models can be checked both visually and tactually, making it easier to grasp positional relationships within the structure represented than with a 3D display on a computer monitor. In the oral and maxillofacial field, such 3D models are used

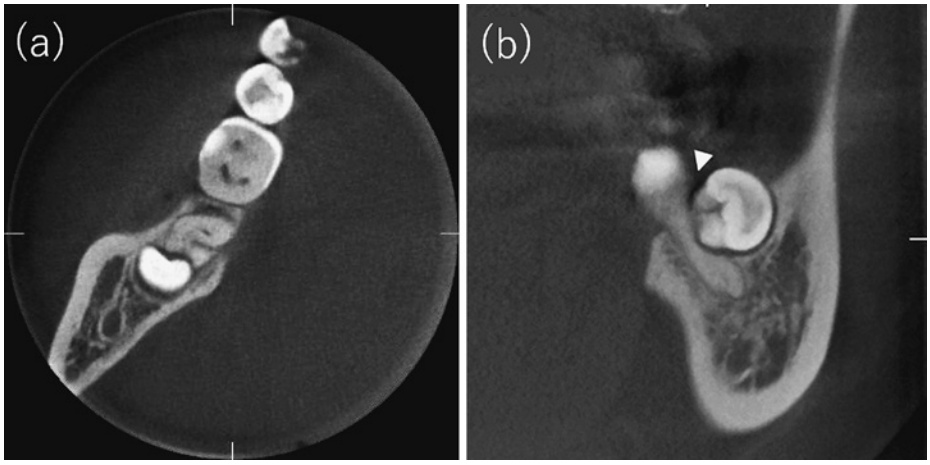

Fig. 1 Cone-beam computed tomography images

Figure 1a shows sections from crown to root and C-shaped root canal in tooth #37. Figures 1a and 1b show compressive resorption extending as far as root canal due to impingement of crown of horizontally impacted tooth (arrowhead).
a: axial view, b: sagittal view

for a wide range of applications, such as patient explanations, preoperative treatment planning, surgical simulation, and medical education[6,8,10,17,18,25,30]. Their application in the dental field is also widening. An earlier study by this team described how 3D models could be fabricated inexpensively and quickly using data obtained by means of multi detector-row computed tomography and/or limited cone-beam CT (CBCT)[10]. The models fabricated using this method are already being used for various purposes in a clinical setting, and this team has previously described their application in diagnosis, endodontic management, and surgical endodontic treatment[11,12].

Case Presentation

A healthy 27-year-old woman was introduced to the Department of Endodontics at Tokyo Dental College Chiba Hospital for conservative treatment of the mandibular left second molar (tooth #37), on which root canal treatment had been performed at a nearby dental clinic. Intraoral radiographic and CBCT images revealed a C-shaped root canal in the mesial root in tooth #37 together with compressive resorption extending as far as the root canal due to pressure exerted by the crown of #38, which was horizontally impacted (Fig. 1a and 1b). It was concluded that conservative treatment of #37 was impossible and extraction therefore advocated, which would necessitate extraction of #38. The possibility of transplanting tooth #38 to replace #37 using tooth-jawbone 3D models and surgical simulation was then considered (Figs. 2–4). Multiple 3D models of these teeth were subsequently prepared based on computer-aided design (CAD) data obtained from CBCT images using a desktop 3D printer. After taking a complete medical history of the patient, the risks and benefits of the procedure were explained using the 3D models and surgical simulation. The patient then provided written informed consent for the procedure.

1. Three-dimensional modeling procedure

1) Creation of 3D computer-aided design data from CBCT image data

A region of interest was established and binarization of images performed using a medical imaging application (Volume Extractor 3.0; i-Plants Systems, Iwate, Japan)[7] and

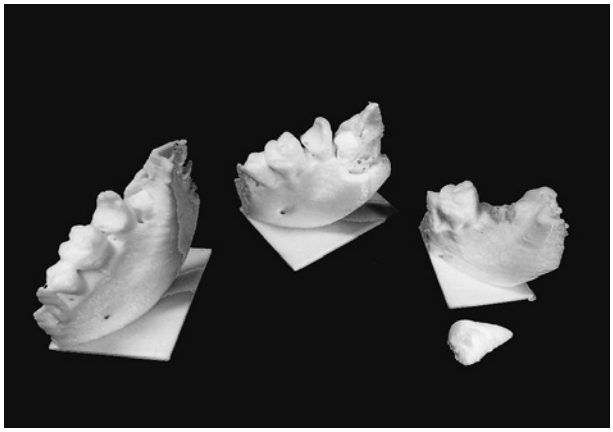

Fig. 2 Tooth-jawbone 3D models fabricated using 3D printer

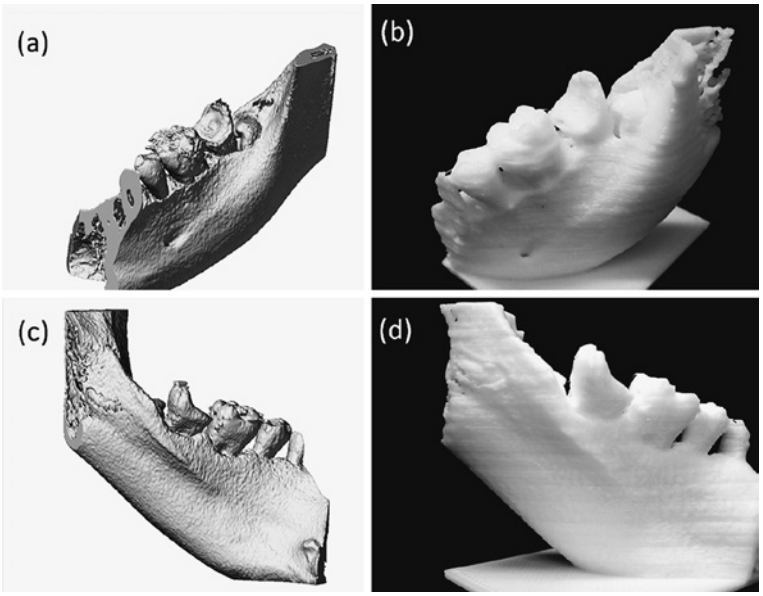

Fig. 3 Three-dimensional volumetric rendering images in POLYGONAL Meister Ver.2, and 3D models fabricated using 3D printer
a, b: Mesiobuccal view, c, d: Lingual view

STL data editing software (POLYGONAL Meister Ver.2; UEL Corp., Tokyo, Japan)[26] to reduce the data volume without changing the shape.

2) Three-dimensional printing

Three-dimensional models with lamination pitches of 0.2 mm were fabricated using a desktop fused deposition modeling 3D printer (Value3D MagiX MF-500; MUTOH Industries Ltd., Tokyo, Japan) based on the 3D CAD data (Fig. 5). The models were fabricated with acrylonitrile butadiene styrene resin.

2. Surgical procedure

The surgical procedure was carried out

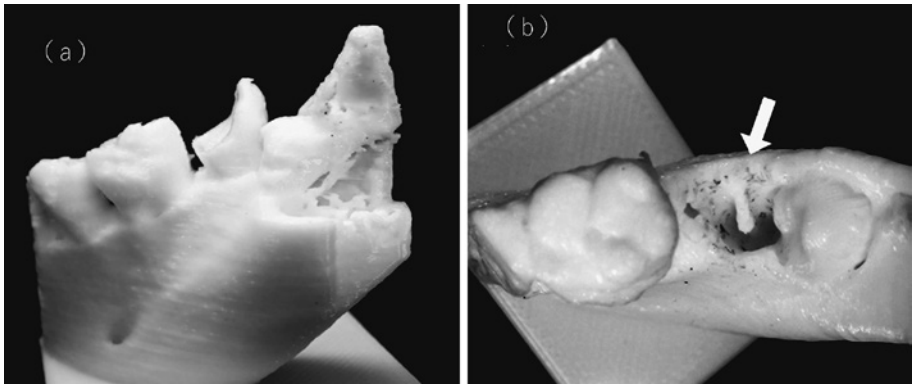

Fig. 4 Three-dimensional models fabricated using 3D printer
a: Horizontally impacted third molar (tooth #38), b: Interradicular septa (arrow)

Fig. 5 Desktop 3D printer Value3D MagiX MF-500

under local anesthesia (2% lidocaine with 1: 100,000 epinephrine). Tooth #37 was extracted and the transplantation socket (recipient site) prepared according to the tooth root form with reference to the 3D model simulation. After careful extraction using dental elevator and extraction forceps to reduce surgical invasion of the surrounding bone, tooth #38 was immediately transplanted into the recipient site. No additional bone trimming of the transplant socket was required, and transplantation was performed to the position designated in the simulation. To ensure proper engagement of tooth #38 in the transplant socket, adhesive resin was used for temporary fixation to the adjacent teeth. Postoperatively, the patient experienced only slight discomfort, and the clinical course was satisfactory. The dental pulp of the transplanted tooth was non-vital at 2 months postoperatively, and root canal treatment was initiated. At 3 months postoperatively, the temporary fixation was removed, root canal filling was completed using the FP Core carrier technique[13], and the occlusal surface was restored with composite resin. At the one-year postoperative recall, the patient was able to chew with the transplanted tooth without discomfort or occlusion pain, and no pathological disturbance was observed anywhere along the circumference of the tooth. No significant findings were observed around the root of the tooth or in the surrounding bone on radiographic images according to oral and maxillofacial radiologists, indicating a successful postoperative clinical outcome (Fig. 6).

Discussion

Autotransplantation is a method of com-

Fig. 6 Preoperative and postoperative intraoral radiographs

a: Preoperative intraoral radiograph, b: Postoperative intraoral radiograph, c: Intraoral radiograph after root canal filling, d: Intraoral radiograph at one-year postoperative recall

pensating for defects of the natural dentition using the patient's own natural teeth[16,20,22]. Much research has contributed to improving the clinical results of autotransplantation[2,3,15,19,24,27,28]. The prognosis with this procedure remains variable, however, and the surgical technique itself requires a high level of skill[28]. Autotransplantation seems to fare better than re-transplantation of teeth, because of the ability to limit the length of time outside the socket and eliminate or reduce contamination of the root. However, with autotransplanted teeth, there is often poor conformity between the recipient site and the root of the tooth to be transplanted, in addition to many other considerations, including the condition of the recipient site (elapsed time after tooth extraction, extent of inflammation before tooth extraction)[5,24,29]. In carrying out autotransplantation in the present case, CBCT images and 3D models were particularly useful in surgical simulation.

Cone-beam computed tomography is an extra-oral imaging system specifically designed for 3D imaging of the oral and maxillofacial structures[4]. The use of CBCT in dentistry has markedly changed diagnostic procedures. In recent years, it has also been applied in the field of endodontics[21,23]. Most of the limitations associated with conventional radiography, such as compression of a 3D object into a 2D image, image distortion, and anatomic superimposition, are overcome with this method. Technological developments in recent years have made it possible to fabricate 3D models based on these images. The use of 3D models greatly contributes to improvements in the reliability and predictability of surgery[9–12,14]. They are useful in designing a transplantation socket that conforms closely to the shape of the root of the tooth to be

transplanted, and as a result, operation time is shortened.

To our knowledge, only a few studies using 3D models in tooth transplantation, such as in the present case, have been published to date[9,29]. The desktop 3D printer used in the present case offers an economic advantage, as it facilitates the production of various 3D models while keeping fabrication costs low. Compared with high-end/professional 3D printers, however, there is concern that the shaping accuracy and model resolution of desktop/low-end/personal 3D printers may be lower[8,18]. We acknowledge this concern about the dimensional accuracy of the objects modeled when targeting fine structures, such as the teeth and jawbones. One study using a desktop 3D printer similar to that used in the present case to model the mandible found that the modeling resolution exhibited almost the same accuracy as the spatial resolution of CBCT, suggesting that it was sufficient for clinical use[17]. Taking this into consideration in conjunction with the results of our own previous research[10–12] leads us to concur with their conclusion. As reported previously, the use of 3D printing technology in endodontics is increasing[1,6]. The present findings suggest that the desktop 3D printer used in this study merits further research aimed at exploring how its application might be expanded.

Conclusion

Three-dimensional models fabricated using desktop 3D printers based on CBCT images provide stereoscopic understanding of the morphology of the transplanted tooth and its surrounding anatomical structures. Such models are a useful tool in the surgical simulation of tooth autotransplantation.

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Conflict of Interest

The authors wish to declare that there is no conflict of interest in connection with this article.

References

1) Anderson J, Wealleans J, Ray J (2018) Endodontic applications of 3D printing. Int Endod J (online first, https://doi.org/10.1111/iej.12917)
2) Andreasen JO, Kristerson L, Andreasen FM (1988) Damage of the Hertwing's epithelial root sheath: effect upon root growth after auto-transplantation of teeth in monkeys. Endod Dent Traumatol 411:145–151.
3) Andreasen JO, Paulsen HU, Yu Z, Ahlquist R, Bayer T, Schwartz O (1990) A long-term study of 370 autotransplanted premolars. Part I. Surgical procedures and standardized techniques for monitoring healing. Eur J Orthodont 12:3–13.
4) Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K (1999) Development of a compact computed tomographic apparatus for dental use. Dentomaxillofac Radiol 28:245–248.
5) Bauss O, Zonios I, Rahman A (2008) Root development of immature third molars transplanted to surgically created sockets. J Oral Maxillofac Surg 66:1200–1211.
6) Dawood A, Marti BM, Sauret-Jackson V, Darwood A (2015) 3D printing in dentistry. Br Dent J 219:521.
7) Doi A, Takahashi T, Mawatari T, Mega S (2012) Development of volume rendering system using 3D texture display techniques and its applications. Med Imag Tech 30:83–91.
8) George E, Liacouras P, Rybicki FJ, Mitsouras D (2017) Measuring and establishing the accuracy and reproducibility of 3D printed medical models. Radiographics 37:1424–1450.
9) Jang JH, Lee SJ, Kim E (2013) Autotransplantation of immature third molars using a computer-aided rapid prototyping model: a report of 4 cases. J Endod 39:1461–1466.
10) Kamio T, Hayashi K, Onda T, Takaki T, Shibahara T, Yakushiji T, Shibui T, Kato H (2018) Utilizing a low-cost desktop 3D printer to develop a "one-stop 3D printing lab" for oral and maxillofacial surgery and dentistry fields. 3D Print Med 4:6.
11) Kato H, Kamio T (2015) Diagnosis and endodontic management of fused mandibular second molar and paramolar with concrescent

supernumerary tooth using cone-beam CT and 3-D printing technology: a case report. Bull Tokyo Dent Coll 56:177–184.
12) Kato H, Kamio T (2016) The potential application of 3D printing technology in surgical endodontic management. J Jpn Endod Assoc 37:97–105. (in Japanese)
13) Kato H, Nakagawa KI (2010) FP core carrier technique: thermoplasticized gutta-percha root canal obturation technique using polypropylene core. Bull Tokyo Dent Coll 51:213–220.
14) Keightley AJ, Cross DL, McKerlie RA, Brocklebank L (2010) Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report. Dent Traumatol 26:195–199.
15) Kristerson L, Lagerstrom L (1991) Autotransplantation of teeth in cases with agenesis or traumatic loss of maxillary incisors. Eur J Orthodont 13:486–492.
16) Lovius BBJ, Atheron JD, Wynne THM, Finch LD (1974) Autogenous tooth transplantation: a clinical and histological investigation. Br J Orthod 1:27–33.
17) Maschio F, Pandya M, Olszewski R (2016) Experimental validation of plastic mandible models produced by a "low-cost" 3-dimensional fused deposition modeling printer. Med Sci Monit 22:943–957.
18) Mitsouras D, Liacouras P, Imanzadeh A, Giannopoulos AA, Cai T, Kumamaru KK, George E, Wake N, Caterson EJ, Pomahac B, Ho VB, Grant GT, Rybicki FJ (2015) Medical 3D printing for the radiologist. Radiographics 35:1965–1988.
19) Monsour FNT, Adkins KF (1985) Aberration in pulpal histology and dentinogenesis in transplanted erupting teeth. J Oral Maxillofac Surg 43:8–13.
20) Natiella JR, Armitage JE, Greene GW (1970) The replantation and transplantation of teeth: A review. Oral Surg Oral Med Oral Pathol 29: 397–419.
21) Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K (2015) Cone beam computed tomography in endodontics—a review. Int Endod J 48:3–15.
22) Schwartz O, Bergman P, Klausen B (1985) Autotransplantation of human teeth: life-table analysis of prognostic factor. Int J Oral Surg 14:245–258.
23) Shahbazian M, Jacobs R, Wyatt J, Willems G, Pattijn V, Dhoore E, Van Lierde C, Vinckier F (2010) Accuracy and surgical feasibility of a CBCT-based stereolithographic surgical guide aiding autotransplantation of teeth: *in vitro* validation. J Oral Rehabil 37:854–859.
24) Sugai T, Yoshizawa M, Kobayashi T, Ono K, Takagi R, Kitamura N, Saito C (2010) Clinical study on prognostic factors for autotransplantation of teeth with complete root formation. Int J Oral Maxillofac Surg 39:1193–1203.
25) Syam WP, Mannan MA, Al-Ahmari AM (2011) Rapid prototyping and rapid manufacturing in medicine and dentistry: This paper presents an overview of recent developments in the field of rapid prototyping and rapid manufacturing with special emphasis in medicine and dentistry. Virtual Phys Prototyp 6:79–109.
26) Tanimoto S (2012) Collaborative research on polygon engineering with RIKEN. UNISYS Tech Rev 32:283–292. (in Japanese)
27) Tsubura S, Ikeda Y (2003) The effect of a tooth gingival transplantation on periodontal healing. Dent Traumatol 19:209–213.
28) Tsukiboshi M (2002) Autotransplantation of teeth: requirements for predictable success. Dent Traumatol 18:157–180.
29) Vandekar M, Fadia D, Vaid NR, Doshi V (2015) Rapid prototyping as an adjunct for autotransplantation of impacted teeth in the esthetic zone. J Clin Orthod 49:711–715.
30) Winder J, Bibb R (2005) Medical rapid prototyping technologies: state of the art and current limitations for application in oral and maxillofacial surgery. J Oral Maxillofac Surg 63:1006–1015.

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