Diagnosis and Treatment Planning using Rapid Prototyping Technology in Surgical Endodontics

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ABSTRACT

Medical imaging technologies involve from X-rays to more advanced imaging modalities like computerized tomography (CT) and magnetic resonance imaging (MRI). These new technologies are able to provide detailed three-dimensional (3D) pictures of areas of interest and therefore valuable data for diagnosis and therapeutic management. The construction of a physical model using this data provides numerous advantages like better visualization of complex anatomic areas, pretreatment surgical practice and enhanced communication and patient education. The following paper describes a case report of a large periapical lesion involving upper anterior teeth requiring periapical surgery. The use of rapid prototyping technology aided in the accurate diagnosis and the precise measurements of the size and location of the lesion and its subsequent management.

Keywords: Rapid prototyping, Periapical surgery, Endodontics.

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INTRODUCTION

Diagnosis and treatment planning in complex areas such as the maxillofacial region requires accurate measurement between anatomical landmarks to aid in determining the degree of abnormality and the extent of surgical correction.\(^1\) Traditional presurgical planning is based upon the manipulation of two-dimensional (2D) data obtained by radiographs and photographs. However, the main limitation of this method is the superimposition of images of structures. Three-dimensional (3D) imaging techniques; such as computed tomography (CT) offers multiple advantages like high-contrast resolution and accuracy. The data from a single CT imaging procedure consisting of either multiple contiguous or one helical scan can be viewed as images in the axial, coronal, or sagittal planes, depending on the diagnostic task. These images can also be reconstructed three dimensionally.

Reconstruction of the data into accurate physical models simplifies the surgical and prosthetic procedures. These models support diagnosis, surgical planning and simulation, fabrication of personalized implants and maxillofacial prostheses, and communication between professional and patient to improve comprehension, enhance adequate information about the case, better orientation during surgical procedure and reduce the surgical period by 20%.\(^2,3\)

Rapid prototyping (RP) represents a set of additive technologies based on the construction of physical 3D structures, layer by layer, based on its respective digital models. Firstly, the digital models are sliced and its transversal sections are digitally reproduced through automated process of layer by layer construction in powder solid or liquid. The RP technologies allow fabrication of these 3D structures, known as rapid prototypes, without amendments, with complex geometries, and containing mobile parts, that may be difficult or even impossible to obtain using other construction techniques.\(^4\)

Many studies showed that the prototypes have been used for different applications in the dental-medical area such as maxillofacial and craniofacial surgery;\(^5\) implantology;\(^6\) neurosurgery;\(^7\) orthopedics; scaffolds of ceramic, polymeric, and metallic materials; and also fabrication of personalized maxillofacial prostheses.\(^8\)

This paper demonstrates the use of 3D digital reconstruction and computer-aided rapid prototyping (CARP) model in the diagnosis and treatment planning of a periapical pathology involving upper anterior teeth requiring apicoectomy and curettage.

CASE REPORT

A 21-year-old male patient reported to the Department of Conservative Dentistry and Endodontics with the complaint of discolored upper anterior teeth. He gave a history of trauma with a blunt object 4 years back. Intraoral examination revealed discolored 11 and 21 (Fig. 1). There was a class II Ellis fracture in 11. No tenderness to percussion or palpation was observed. The gingival and attachment apparatus status of 11 and 21 was within normal

![Fig. 1: Intraoral photograph showing discolored 11 and 21](image-url)
limits on clinical examination. The 11, 21, 12 and 22 did not respond to thermal and electric pulp testing. Intraroral periapical (IOPA) radiograph (Fig. 2) revealed periapical radiolucencies in 11, 21 and 22. The 12 appeared to be displaced laterally due to the lesion extending from 11. Orthopantomogram (OPG) (Fig. 3) and maxillary anterior occlusal view radiographs (Fig. 4) were also made. A dental CT helical 64 slice scan was performed using single window using Siemens Somatom Sensation spiral CT scanner (Munich, Germany). The scans were taken with the following parameters: 120 kV, 380 mA and 1 mm thick contiguous slices. The data was obtained in a digital imaging and communications in medicine (DICOM) format. The acquired data were imported into CAD based software (Mimics 11.02 Materialise, Leuven, Belgium). The measurements were made from the 3D CT scan and 3D reconstruction was done (Figs 5 to 8). The model was created using STL format, which was then used to fabricate the model with translucent resin using PolyJet technology (Objet Eden 330-Camsys Technologies, India) (Fig. 9). Solid soft tissue lesion measuring 8.93 mm in the mesiodistal dimension, 14.49 mm in the nasoincisal dimension and 5.62 mm in the buccopalatal dimension was observed in relation to 11 (Figs 10 and 11). Solid soft tissue lesion measuring 4.1 mm in the mesiodistal dimension, 2 mm in the nasoincisal dimension and 4 mm in the buccopalatal dimension was observed in relation to 21. Root canal treatment in 11, 12, 21 and 22 was done followed by apicoectomy and curettage was performed. Healing period was asymptomatic following which crowns were cemented in all the teeth.

**DISCUSSION**

Preoperative radiographic examination is done to gather information for adequate assessment of the tooth. However, multiple radiographs taken at different angles with minimal distortion are needed for highest diagnostic yield. Even then it is difficult to obtain an accurate picture especially in cases of large periapical pathology and in cases of perforation/resorption. Also the knowledge of precise location of important anatomical landmarks at the site of surgery is critical.

RP technology has proven to be an invaluable tool in the field of surgical endodontics. Various uses of RP have been documented in cases of diagnosis of atypical root morphology, determination of exact location of internal resorption/perforation, surgical planning in autotransplantation of tooth. The advantages reported in the studies are reduced surgical period (from 16 to 41%) and planning and review of the surgical procedure previously to the surgery. The biomodeling was reported as an intuitive, user-friendly technology that facilitated diagnosis, operative planning and communication between colleagues and patients. The important factor affecting the accuracy of the models is the data acquisition. The reduction of slice thickness and slice distance will result in a fabricated model with greater accuracy. Another is data processing, including
properly interpolating imaging data between the single slices and correctly segmenting object of interest.

In the present case, using 3D digital reconstruction and CARP model, the accurate measurements of the periapical pathology in 11 and 12 were possible. Also, information regarding the size of the bony defect and the thickness of the bone surrounding the lesion were obtained. These aspects were important factors during the decision making regarding the extent of osteotomy. Graft material placement was not performed taking into consideration of the size of
Fig. 11: Lesion with labiopalatal measurements

the defect. This extent of presurgical planning considerably reduced the operating time considerably and increased the efficiency.

CONCLUSION

Rapid prototype models have proven to be very useful for preoperative model planning and surgery simulation because it makes possible the accurate measurements in complex anatomical areas. A further advantage is the reproduction of closed cavities, and the transparent structure makes the course of intraosseous canals visible, all of which help the clinician to work in a more efficient and precise manner.

REFERENCES


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