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Case Report

Deducing a surgical dilemma using a novel three dimensional printing technique

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Abstract

Persistent apical periodontitis even after nonsurgical retreatment demands for a surgical approach. This requires a thorough diagnosis and planning to eliminate the pathology and induce healing. This is sometimes challenging when the pathology is present in close relationship to the vital structures. In such cases, modern, sophisticated technology such as three-dimensional (3D) printing can come very handy in patient education as well as for planning and mock-up preparation of the surgery. In this case, a nonhealing persistent apical periodontitis in relation to 16 was surgically treated. However, the pathology was in close association with the maxillary sinus hence fused deposition modeling-based 3D printed models were fabricated for patient education and to locate and determine the extent of the lesion. This was followed by the surgical enucleation of the lesion and apicectomy of mesiobuccal and distobuccal roots and mineral trioxide aggregate retro-filling and as the symptoms subsided after the follow-up full coverage metal crown was fabricated and cemented. This technology has opened a new horizon for the use of 3D printing in conjugation with endodontic principles for more predictable endodontic success.

Keywords: Apical periodontitis; cone-beam computed tomography; enucleation; fused deposition modeling; radicular cyst; three-dimensional printing

INTRODUCTION

The principle objective of endodontic retreatment is to treat apical periodontitis caused by reinfection of the root canal system. However, apical periodontitis can still persist even after secondary root canal treatment. The reason for the failure can be attributed to various factors such as intricate anatomy, missed canals, and iatrogenic errors. Even the use of sophisticated armamentarium does not nullify the chances of failure; such cases may then require surgical intervention.[1,2]

The introduction of cone-beam computed tomography (CBCT) specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift from two-dimensional (2D) to three-dimensional (3D) approach to data acquisition and image reconstruction. Interest in CBCT from all fields of dentistry is unprecedented because it has created a revolution in maxillofacial imaging, facilitating the transition of dental diagnosis from 2D to 3D images, and expanding the role of imaging from diagnosis to image guidance of operative and surgical procedures. CBCT before endodontic surgery may allow the endodontist to identify accessory anatomy, untreated root canals, visualize the true extent of a periradicular lesion, and prevent damage to vital anatomical structures.[3,4]

3D scans using CT/CBCT imaging have not only been applied to the visualization of an object but also to the generation of a physical model. 3D-printing technology is used for making a physical model, also known as, rapid prototyping or additive manufacturing has provided new possibilities for the diagnosis, surgical planning, prosthesis design, and student education in medicine and dentistry. The technology is totally different from computer-aided design (CAD) to computer-aided manufacturing, and models can be made

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using stereolithography, fused deposition modeling (FDM), laminated object manufacturing, selective laser sintering, and direct metal laser sintering. In endodontic treatment, a physical tooth model fabricated by 3D printing has been used for patient education and also in various cases such as the diagnosis of atypical root morphology and deciding its management, guided access preparation for calcified canals, determination and locations of root resorption, and surgical planning, guided periapical surgeries, autotransplantation.[5] Zehnder *et al*.,[6] Kfir *et al*.,[7] and Byun *et al*.[8] also used CBCT and intraoral optical scans to produce 3D printed templates/models to gain guided access to root canals, management of anomalous teeth with atypical root morphology.

This case describes a surgical endodontic therapy, which takes advantage of 3D technology that is becoming increasingly accessible in dentistry.

CASE REPORT

A 45 year old male patient with consent form reported to the department with a chief complaint of pus discharge in the upper right back tooth region for 1 year. The past dental history revealed a previously done endodontic treatment with 16. Clinical examination showed a draining sinus tract in the proximity of 16 [Figure 1a]. Gutta-percha (GP) tracing on radiograph showed area near the distobuccal root of 16 to be the cause of the infection with satisfactorily filled root [Figure 1b]. Tenderness on percussion was absent. Hence, the diagnosis formulated was previously treated 16 with chronic apical abscess (American Association of Endodontists 2013). Nonsurgical re-endodontic therapy with 16 was chosen as the first line of treatment. A multivisit re-endodontic therapy with GP removal followed by cleaning and shaping with rotary instrumentation (HyFlex CM) with copious irrigation of 3% sodium hypochlorite and saline with intermediate calcium hydroxide (RC Cal) dressing for 1 month was done and dressing was changed after every 7 days, and the healing of the symptoms were assessed. After the sinus tract healed and the canals were dry, obturation with GP (DiaDent) and resin sealer (AH Plus) with lateral compaction followed by a composite postendodontic restoration with 16 [Figure 1c]. However, the sinus reappeared after 2 months in the same region. Moreover, as the endodontic treatment had failed twice, a surgical approach was then planned. GP was removed again with the help of Protaper retreatment rotary files (Dentsply, USA), and CBCT was advised to rule out hidden pathology. However, the attempt was done for searching any missed canal with the help of radiograph (intraoral periapical radiography and CBCT) as well as dental operating microscope. CBCT was not showing any missed canal on its coronal sections. After confirming, calcium hydroxide dressing was given again until the surgery was done.

On CBCT evaluation, a periapical radiolucency was revealed extending from the mesial border of 16 to the mesial border of 18 [Figure 1d-f]. The lesion was in close proximity to the maxillary sinus lining with an indistinct separation between the two. Hence, it was a challenge for the operator to ascertain the extent of the lesion and conclude whether the lesion encroached the sinus lining or not. This dilemma and limited information on the surgical procedure and the expected outcome made it difficult for the patient to accept

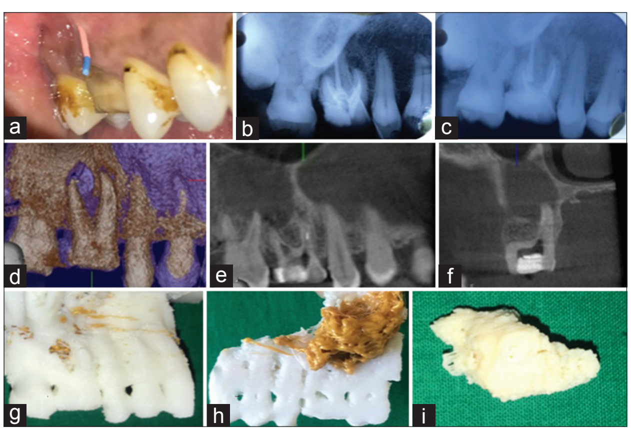

Figure 1: (a) – Clinically sinus tracing, (b) – radiograph of sinus tracing, (c) – obturation with 16, (d and e) – sagittal view of cone-beam computed tomography, (f) – coronal view of cone-beam computed tomography, (g) – three-dimensional full model, (h) – cross section of three-dimensional model, (i) – three-dimensional view of lesion

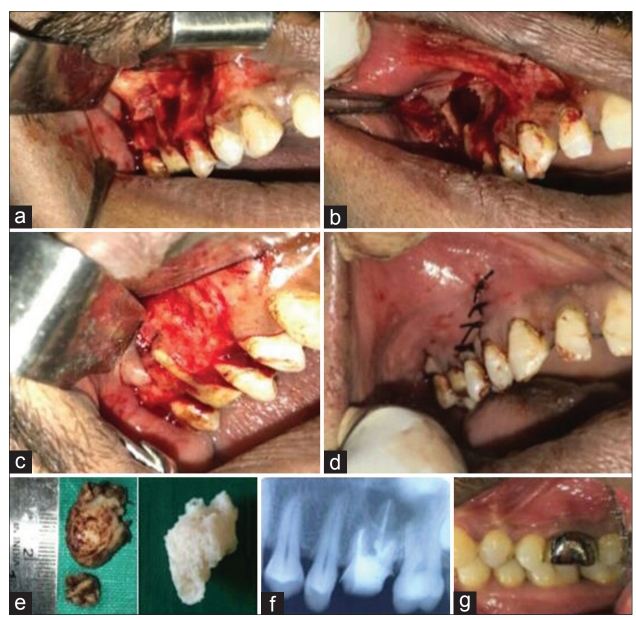

Figure 2: (a) – Full-thickness flap reflection, (b) – enucleation of cyst, (c) – root resection, root-end cavity preparation with mineral trioxide aggregate retrofilling, (d) – surgical closure, (e) – comparison of cyst with three-dimensional printed, (f) – postoperative radiograph, (g) – clinical photograph after prosthesis

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the surgical treatment when the same was explained to him. The above circumstances made us opt for 3D printed models. These models (full model, cross section, and pathology) of the concerned region were helpful for the operator to determine the exact location, extent, and relation of the pathology to the maxillary sinus. From surgical point of view, since the maxillary posterior region presents its own difficulties, the models helped in decision-making regarding the bony window size. These models proved to be a boon as a definitive and predictable treatment plan could be formulated, and it served as a handy patient education tool. The patient could understand the need of surgery and expected outcomes of the same. Hence, it helped both the operator and the patient in multiple dimensions [Figure 1g-i]. 3D models exposed the presence of a pathology that was distinct from the maxillary sinus and was 2 cm × 2.5 cm in dimension [Figure 1i]. After obtaining the patient's consent and the preliminary investigations, surgical enucleation was planned. However, before surgery, calcium hydroxide was washed away from the canal with the help of sodium hypochlorite and saline, and the canals were dried using absorbent paper points. This was followed by obturation of the canal by GP (DiaDent) and resin sealer (AH Plus) with lateral compaction and postendodontic restoration using composite resin. The pathology was then enucleated by reflecting a full-thickness envelope flap extending from distal border of 14 to distal border of 17 under administration of infiltration local anesthesia (lidocaine with 1:80000 epinephrine) [Figure 2a and b], and the mesiobuccal and distobuccal roots were resected at 2 mm. After that 3 mm of root-end cavity preparation with ultrasonic posterior retro tip, each followed by retrofilling with mineral trioxide aggregate (MTA) was done [Figure 2c]. Cavity was then irrigated with betadine and saline protecting the MTA with the help of a gauze piece after which the flap was repositioned and sutured using 3-0 silk suture by intermittent suturing technique [Figure 2d]. Postoperative antibiotic regimen was prescribed, and sinus protocol was advised. The patient was also advised to maintain the oral hygiene and a regular dental checkup. The histopathological analysis of the excised pathology confirmed the diagnosis of a radicular cyst. The patient was then recalled after 1 week for suture removal and follow-up that showed a healed sinus tract. 1, 2, and 3 months of follow-up showed no recurrence of any signs or symptoms. Hence, a full coverage metal crown was fabricated and cemented with 16 [Figure 2f and g].

DISCUSSION

Persistent apical periodontitis is preferably treated by root canal retreatment.[1] However, posttreatment failure can still occur when treatment has been performed to a good standard. The infected site (s) may not be accessible by conventional therapy and therefore may require surgical intervention.[9] This case presented a surgical dilemma that made it challenging to operate due to its location and proximity to the maxillary sinus, and it became mandatory to clear the understanding of the pathology present. CBCT scans helped in locating and determining the extent of the pathology. However, due to the closeness of the maxillary sinus and the consequences of the same, the patient was not convinced for the surgical treatment.

CBCT has increased accuracy, higher resolution, and reduced scan time. CBCT eliminates superimposition of surrounding structures. It has a rapid scan time as compared with panoramic radiography and gives complete 3D reconstruction and display from any angle. CBCT is accurate and reliable in detecting apical periodontitis, vertical root fracture, and resorptive defects and gives a better view of root and pulp canal anatomy when compared to radiography. The accuracy of CBCT was 86% compared to 66% for periapical radiographs. Even though CBCT helped in accurate diagnosis and in treatment planning, the experienced operator will face a problem when he/she is treating unusual/difficult cases.[2]

Actually, 3D printed models are a replica of actual anatomy of the tooth which we get from CBCT. CBCT images are sent to 3D-printing laboratory in the form of DICOM files. In the laboratory, they are converted into Standard Tessellation Language (STL) format. STL images are represented in the form of Facets (collection of triangles) such as the CBCT images in the form of voxels. With the help of software after taking soft-tissue details, it is sent for the 3D printer for preparation of model. Model derived can be used as mock-up model, for patient education or for student's education or as a guide. Operators can perform the procedure on the model, and the same approach will be applied for the patient.[10] In this case, the FDM technology 3D-printed model of different sections of the pathology was fabricated that alone gave an exact idea about the dimensions and position of the lesion in relation to sinus and was also helped in educating and convincing for the patient to go for the surgical treatment without any fear of entering the sinus. After enucleation, even the size of the excised lesion was almost similar to that of the 3D-printed model of the lesion[9,10] [Figure 2e]. This also approves of the accuracy of the 3D-printing technology as they have shown to have a discrepancy of < 0.1 mm.[11] As the models were fabricated for the education and diagnosis purpose, FDM technology was used.

In the todays era of digital dentistry, intraoral and CBCT scanners are becoming more mainstream, and dental professionals are becoming well acquainted and adapt at working with large volumes of digital data.[10] Hence, developments and access to scanner technology and CAD software have made this technology easier to use.[12]

Enucleation was chosen as the treatment of choice due to good healing with primary closure of the wound and thorough evaluation of the cystic lining.[9] Two millimeter of root resection followed by 3 mm of root-end cavity preparation with posterior retro tip was done. Edge of

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resection is flat (0°) since it minimizes apical leakage.[13] MTA was used for retrofilling because of its biocompatibility and chemical bonding with the tooth and also bioactive potential. It shows the formation of calcium-phosphate precipitation at the interface. This interface layer reduces the risk of marginal percolation and gives promising long-term clinical success.[14] Hence, 3-month follow-up after the use of a combination of novel 3D-printing technology and endodontic principles gave very satisfactory and promising results.

CONCLUSION

CBCT is a diagnostic tool that may allow for the management of teeth with complex anatomy. 3D-printed models may be a valuable aid in the process of assessing and planning effective treatment modalities and practicing them *ex vivo* before actually performing the clinical procedure. Unconventional technological approaches may be required for detailed treatment planning of complex cases. The use of 3D printing in diagnosis, treatment of unusual and complex anatomy, surgical planning, patient education, and as mock-up models are the various applications that can help us achieve accurate and more predictable success in endodontics.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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