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Case Report

Enhancing the three-dimensional visualization of a foreign object using Mimics software

Muhammad Khan Asif[a], *Phrabhakaran Nambiar*[a,b,*], *Iqra Muhammad Khan*[c], *Zeti Adura Binti Che Ab Aziz*[d], *Nora Sakina Binti Mohd Noor*[d], *Palasuntharam Shanmuhasuntharam*[a], *Norliza Ibrahim*[a]

[a] *Department of Oral & Maxillofacial Clinical Sciences, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia*

[b] *Department of Oral Biology and Biomedical Sciences, Faculty of Dentistry, MAHSA University, Jalan SP 2, Bandar Saujana Putra, 42610 Jenjarum, Selangor Malaysia*

[c] *Department of Paediatric Dentistry & Orthodontics, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia*

[d] *Department of Restorative Dentistry, Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia*

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ABSTRACT

A patient was referred to the Oral and Maxillofacial Imaging Division and the attending dental specialist suspected a foreign object at the anterior region of the maxilla. The region was scanned using Kodak 9000 3D cone-beam computed tomography (CBCT) extraoral imaging system (Carestream Health, Inc.) to determine the type and morphometric characteristic of foreign object. The CBCT images failed to determine the identity and nature of the foreign object. CBCT images were then exported to the Materialise Interactive Medical Image Control System (Mimics) software to evaluate whether this software can help in enhancing the visualization of the foreign object in the maxillofacial region. The findings showed that there was an improved visualization of the foreign body and the type of the object could be determined with certainty. The object was identified as an endodontic file and was clearly visible when visualized as a reconstructed 3D model in Mimics software. Although the identification of abnormalities has been dramatically improved using 3D scans, the visualization can be further enhanced using image processing software like Mimics.

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Introduction

Perforation is an artificial communication between the root canal system and the supporting tissues of the teeth [1]. Root perforation requires proper closure in order to secure the tooth and the first step is the perforation detection. Periapical radiograph is among the oldest methods used for radiographic detection of perforations. Parts of teeth or lesions are confined within the cancellous bone and are covered by thick cortices

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* Corresponding author.
E-mail addresses: phrabhakaran@mahsa.edu.my, phrabha@um.edu.my (P. Nambiar).

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Fig. 1 – Periapical radiograph shows the presence of a foreign object, mimicking it is in the maxillary sinus. A gutta percha point is placed in the root of 1st premolar indicating incomplete root canal treatment.

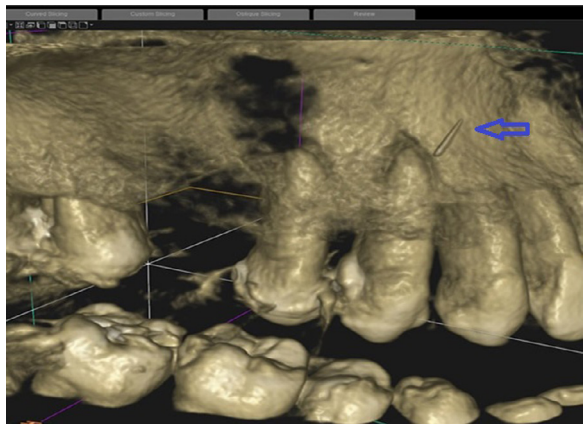

Fig. 3 – 3D view of the foreign object on CBCT image.

which are sometimes undetectable as the X-ray beam records images in a 2-dimensional (2D) view [2]. New methods including multidetector computed tomography scans and cone-beam computed tomography (CBCT) permit far more significant and clearer results as structures can be viewed in a 3-dimensional (3D) format. Researchers even stated that CBCT provides map reading approach which reduces the chances of misdiagnosis [3,4]. The results in a comparative study by Cassetta et al., showed that the lower radiation dose and reduced costs of CBCT make this a useful substitute for CT. However, in order to more accurately define the bone density with CBCT, a conversion ratio needs to be applied to the voxel grey value [5].

In one of the earliest studies on root perforations, Shemesh et al. showed that CBCT were slightly better than periapical radiographs [6]. However, they cautioned that the risk to misdiagnose strip perforations (at bifurcation) was high with both methods, but CBCT scans showed a significantly higher sensitivity than periapical radiographs. In another study, 16 teeth were submitted to the following simulated endodontic complications: fractured endodontic file; root perforation; cast post with deviation and external root resorption. Periapical radiographs were taken for each tooth at 3 different angles, and subsequently CBCT scans were taken. In the overall assessment, the authors reported that CBCT was superior and could be an alternative to periapical radiographs, especially in the detection and assessment of external root resorption [7]. Subsequently, Abbas et al. in 2015 compared the accuracy of different radiographic methods for detection of

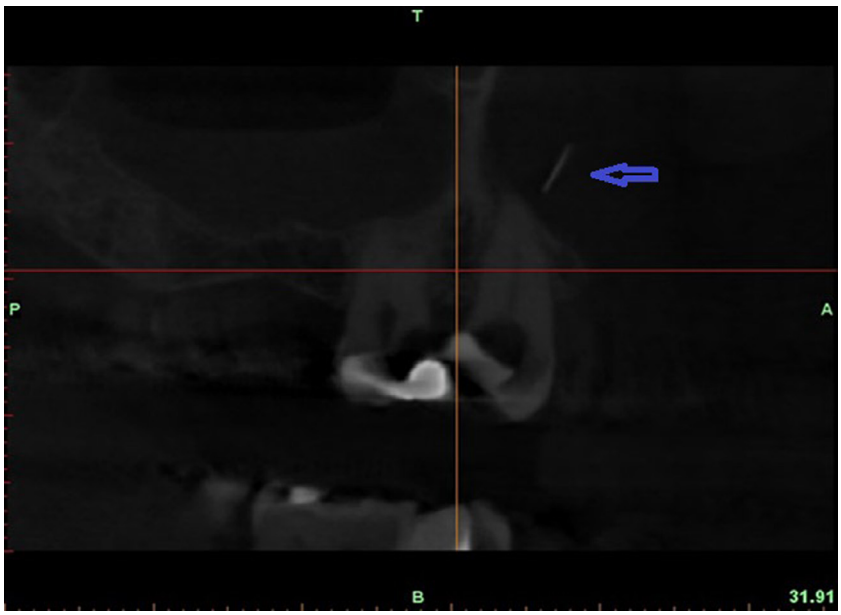

Fig. 2 – The foreign object is indicated by the arrow on the CBCT image.

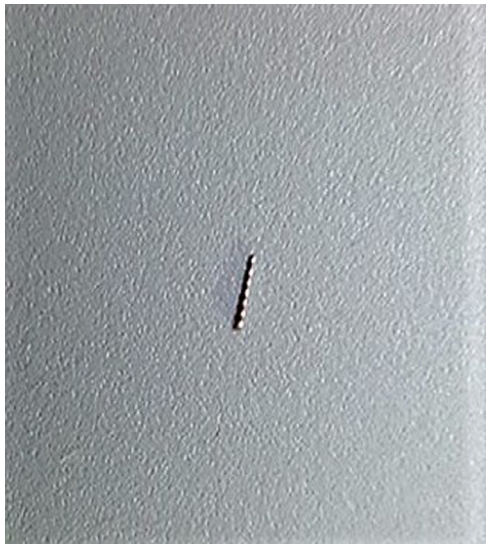

Fig. 4 – 7 mm length of an endodontic file tip removed after surgery.

perforations at the bifurcations (strip) and the roots of molar teeth. CBCT presented with the most promising results compared with images that were obtained using conventional intraoral film, photostimulable phosphor sensor and multidetector computed tomography (MDCT) [8].

Materialise Interactive Medical Image Control System (Mimics) is one of the latest image processing software developed by Materialize NV, a Belgian company specialized in additive manufacturing software and technology for medical, dental, and other industries. Mimics is an image processing software used to create 3D design, 3D surface models, 3D measurements and analysis of images from stacks of any 2D image data (e.g., CT, CBCT). Although CBCT have been demonstrated to give an accurate detection of perforation or fractures at radicular portion of teeth, the quality to precisely determine a miniature foreign object can still be improved. This is the first reported case study demonstrating the visualization of foreign object can be further enhanced when the CBCT image visualization was incorporated with an image processing software.

Case report

A patient was referred to the Oral and Maxillofacial Imaging Division and the attending dental specialist suspected a foreign object at the anterior region of the maxilla. (Fig. 1). There was a need to know what the foreign object was as the patient gave a history of failed root treatment procedure for the right maxillary second premolar. The region was scanned using Kodak 9000 3D CBCT extraoral imaging system (Carestream Health, Inc.). The scanning parameters that were employed during the scanning were tube voltage of 70kV, tube current of 10 mA, field-of-view (FOV) of 5×3.8 cm, voxel size of 76 μm and 14 bits. The images were reconstructed using the proprietary Kodak Dental Imaging Software 3D module version 3.1.9. The patient stood in a vertical position. Patient's head was stabilized using custom made head-retainers and chin rest. The imaging procedure was carefully monitored throughout the scanning (10.8 sec) to avoid motion artifacts. Once the volumetric data was acquired, various image manipulations were performed. Unfortunately, it was not possible to discern whether the foreign object is a broken needle, endodontic file, susuk (charm needles) [9], gold thread or any other object (Figs. 2, 3).

Surgery was performed under local anesthesia and the foreign object was removed. The surgeon recognized that it was

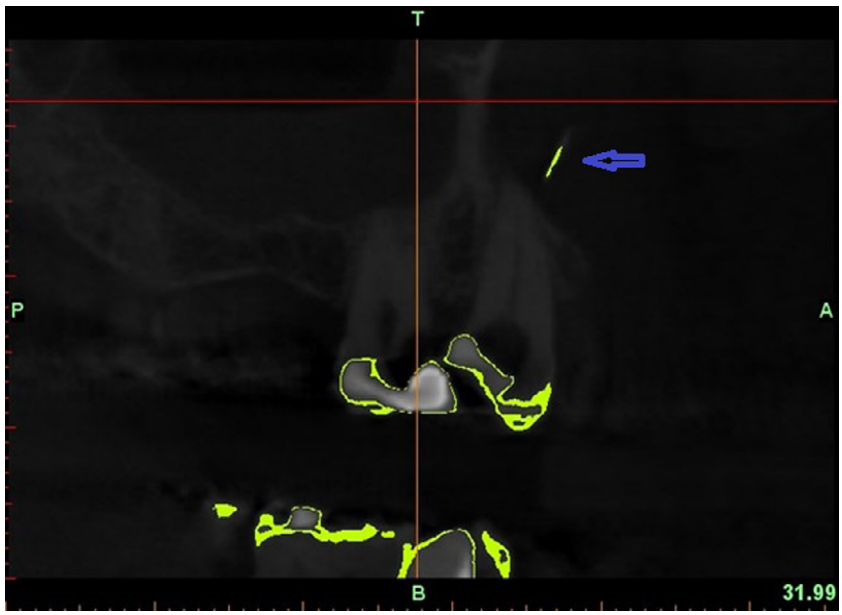

Fig. 5 – New mask created (Sagittal view).

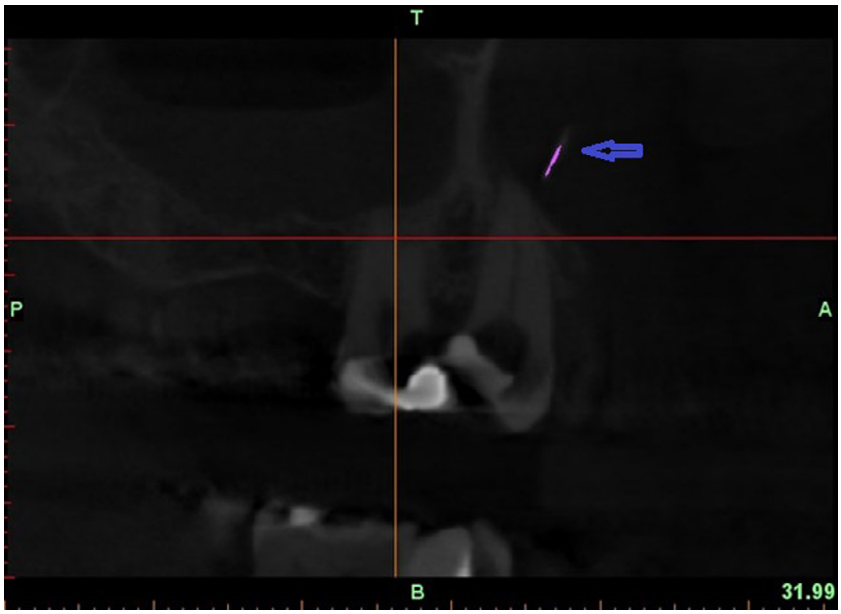

Fig. 6 – Region growing phase of endodontic file after multiple slice editing.

the endodontic file (tip), which could have been perforated through the apex of the premolar tooth and was lodged into the soft tissue in front of the tooth (Fig. 4). As there was a difficulty to know the foreign object with certainty, Mimics software (version16.0) was employed to further identify the object.

The acquired CBCT data was imported as a DICOM file to Mimics software to perform the analysis. The image was properly oriented in XYZ axes. A new mask was created for the foreign object using a customized threshold values (Fig. 5). In the multiple slice editing phase, the masks were segmented (slice by slice) and separated from the surrounding structures. Subsequently the broken segment was grown in the region growing phase of the software (Fig. 6). After growing the region, the 3D model of the foreign object was created. The final 3D model can be clearly visualized as a fragment with serrated margin which consistent with an endodontic file (Fig. 7).

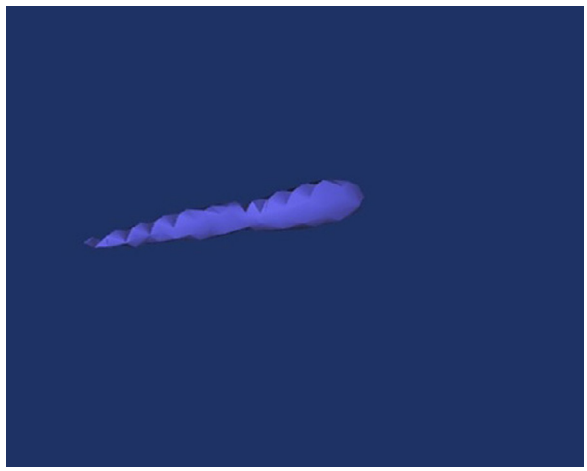

Fig. 7 – The serrated margin of the endodontic file clearly visible on the MIMICS image.

Discussion

Abnormal and pathologic regions should be carefully investigated to ensure accurate diagnosis. For many decades' periapical radiographs are in use for diagnoses and prognoses. Nowadays, 3-dimensional imaging modalities show much promising outcomes as they can provide comprehensive details of the region of interest. Abnormalities that were otherwise not visible on periapical radiographs/images can be clearly seen in CBCT scan [10]. Additionally, it is becoming easier to detect foreign objects, perforations and root resorption. The visualization of 3D structures can be further improved by a third-party image processing software such as Mimics software [11]. Mimics software can be used for processing and editing anatomical data derived from acquired imaging data. This software enables image segmentation, measurement, designing, 3D printing and modeling. This study highlights the capability of the software to determine with certainty the foreign object which could be seen on the manipulated 2D and 3D CBCT image. This study shows the potential of Mimics software in improving the resolution qualities of CBCT images and helped to improve diagnoses.

It must be noted that in South East Asian countries it is believed that susuk (charm needles) or gold thread improves the beauty of the wearer and these objects are intentionally placed in the facial tissues. These are left in-situ unless it gets infected or requested removal by the wearer. This was one of the reasons to determine if the foreign object was a broken needle, endodontic file, susuk (charm needles) or gold thread in the present case study.

Conclusion

Images from scanning modalities like CBCT need further improvement to determine the structure or any foreign object to be seen clearly. The development of image processing software in enhancing image visualization such as Mimics software may provide an additional benefit to imaging dentistry.

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