



RESEARCH ARTICLE

VALIDITY AND RELIABILITY OF CONE BEAM COMPUTED TOMOGRAPHY FOR ASSESSING MESIAL ROOT CANAL TYPE IN MANDIBULAR FIRST MOLARS

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ABSTRACT

Background: Knowledge of root canal anatomy is essential for the success of endodontic treatment. The introduction of Conebeam computed tomography (CBCT) to dentistry has led to increase the accuracy of internal anatomy assessment. The aim of this study was to evaluate the validity and reliability of CBCT imaging technique to assessing mesial root canal type in mandibular first molars.

Material and methods: 64 mandibular first molars were chosen and fixed in a base plaster model mixed with Sawdust then scanned by CBCT. A radiologist and an endodontist independently assessed the mesial canals morphology, this assessment was repeated seven days later. The canal configurations were categorized using Vertucci's classification and compared to the same teeth after making them transparent and examined by a blind evaluator under stereomicroscope. The results from of endodontist and radiologist's observation in both evaluation were compared to each other and to the gold standard (stereomicroscope data) using the weighted kappa test.

Results: Endodontist's evaluations were both strongly correlated with the gold standard data (spearman correlation coefficient=0.7 and 0.9 for first and second evaluation respectively, $p<0.001$), likewise the radiologist's evaluations had similar results (spearman correlation coefficient=0.8 and 0.9 for first and second evaluation respectively, $p<0.001$). Intra-observer reliability was excellent for both endodontist ($k=0.79$) and radiologist ($k=0.80$).

Conclusions: The validity of CBCT to explore the morphology of mesial root canals of mandibular first molars has been proved in this article.

INTRODUCTION

Extensive researches have been carried out in recent years regarding the anatomical variations of the root canal system in permanent molar teeth. Knowledge of root canal system morphology and its variations is an essential factor for the success of endodontic therapy which also depends on accurate diagnosis, adequate cleaning, proper obturation of the root canals and appropriate coronal seal (Vertucci, 1984). Several techniques are used to assess the internal anatomy of root canal system such as conventional radiography (Rushton et al., 1995), direct digital radiography (Ravi et al., 2016), Contrast medium-enhanced radiographic technique (Shearer et al., 1996). Computed tomography (CT) technique (Subha 2013), Micro-CT technique (Bossu, 2013) and Cone-beam CT Computed tomography (CBCT) (Mota de Almeida, 2014).

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Although evaluation of the root canal morphology by conventional radiograph has been helpful in preoperative assessment, but because it is a two-dimensional view and the problem of image superimposition also compromise the radiographic assessment, there is a high probability that complexities of the root canal system are being missed. Cone-beam computed tomography (CBCT), which was introduced in the field of endodontics in 1990(8), is a non-invasive, three-dimensional imaging technique that is helpful in endodontics with the ability to reduce or eliminate the superimposition of the surrounding structures (Durack, 2012), morphologic assessment (Patel, 2007). Furthermore, when this technique was compared to helical CT scanners, it is provided with a higher image resolution and a noticeable reduction in the radiation exposure (Mozzo et al., 1998). In current study, the validity and reliability of CBCT imaging technique for determining root canal morphology of mandibular first molars were evaluated. Microscopic tissue sections were used as a

gold standard. The inter-rater and intra-rater reliability of two specialists has been monitored and evaluated.

MATERIAL AND METHOD

Sixty-four fully developed apex mandibular first molars, without tooth decay below CEJ level, root canal filling and post were chosen. For disinfection purpose, all teeth were stored in 10% formalin solution for seven days. All specimens were air dried for 24 hours and each eight teeth were embedded in a base plaster model mixed with Sawdust. All the scans were performed by CBCT (VGI Evo, NewTom, Bologna, Italy) in the dental faculty of Shahid Beheshti University of medical sciences with capture parameters set to the standard resolution and operated at 120 kV. After scanning, the data were reconstructed by CBCT software (NNT 5.0, NewTom, Bologna, Italy) and cross-sectional images were available for evaluation. A radiologist and an endodontist, were asked to view the images and independently assess the type of root canal morphology in mesial canals of mandibular first molars.

The canal configurations were categorized using Vertucci's classification as follows:

- Type I. A single canal extends from the pulp chamber to the apex.
- Type II. Two separate canals leave the pulp chamber and join short of the apex to form one canal.
- Type III. One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal.
- Type IV. Two separate and distinct canals extend from the pulp chamber to the apex.
- Type V. One canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina.
- Type VI. Two separate canals leave the pulp chamber, merge in the body of the root, and re-divide short of the apex to exit as two distinct canals.
- Type VII. One canal leaves the pulp chamber, divides and then rejoins within the body of the root, and finally, revived into two distinct canals short of the apex.
- Type VIII. Three separate and distinct canals extend from the pulp chamber to the apex.

To determine the repeatability of the evaluations, the same two observers viewed and evaluated the images seven days later again. After completion of CBCT-scan evaluations, all teeth were removed from the model and were cleaned carefully with dental brushes and an ultrasonic scaler. In order to achieve complete debridement, all specimens were placed in 5.25% Sodium Hypochlorite solution for 48 hours. For proper decalcification, Specimens were stored in 5% Nitric Acid solution for 72 hours, following by injection of Methylene blue dye into pulp cavity. Specimens were first dehydrated in Ethyl alcohol solution for one hour and soaked in Methyl salicylate solution. After two hours the specimens had become transparent and ready for evaluation by stereomicroscope (Nikon ZMS1000). Finally, a blind professional evaluator determined root canal system of each specimens using the stereomicroscope, so that this data would be comparable to the CBCT scan results. The data was analyzed using SPSS v18 (statistical package for social sciences version 18). The results

of endodontist and radiologist observations in the first and second evaluations were compared to each other and to the gold standard (stereomicroscope data) using the weighted kappa test. Scoring levels were determined due to kappa level as: 0 - 0.2 = weak; 0.2 - 0.4 = fair; 0.4 - 0.6 = moderate; 0.6 - 0.8 = good; 0.8 to 1 = very good. The alpha error rate of 0.05 was also applied.

RESULTS

In the gold standard evaluation, 25 teeth (39.1%) had type II, 37 teeth (57.8%) had type IV and 2 teeth (3.1%) had type VIII canal configuration. The first and second endodontist evaluations are demonstrated in figure 1 while both radiologist evaluations are shown in Figure 2.

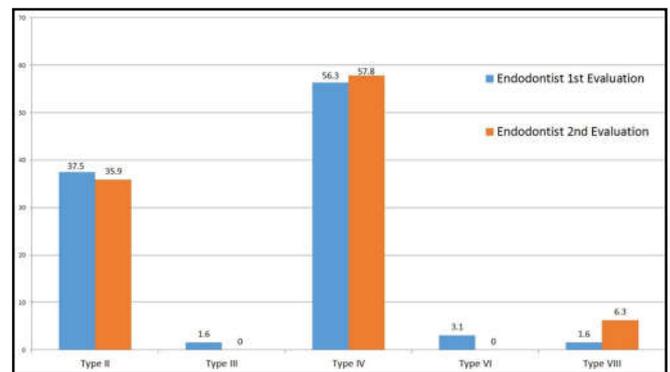


Figure 1. The first and second endodontist evaluations

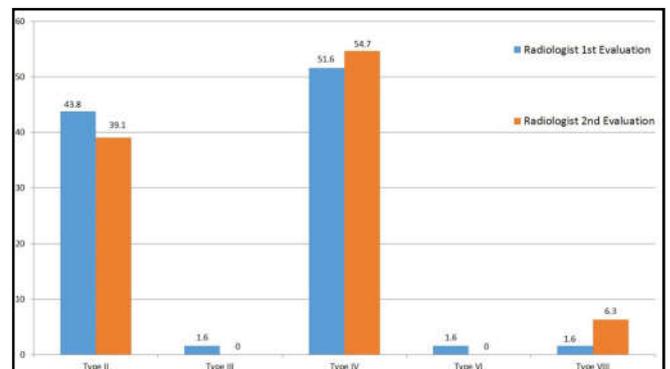


Figure 2. The first and second radiologist evaluations

Endodontist first and second evaluations were both strongly correlated with the gold standard (spearman correlation coefficient=0.7 and 0.9 for first and second evaluation respectively, $p < 0.001$). Same results were obtained validating the radiologist's evaluation by the gold standard (spearman correlation coefficient=0.8 and 0.9 for first and second evaluation respectively, $p < 0.001$). Using weighted-kappa value test, the endodontist and radiologist results showed excellent intra-observer reliability ($k=0.79$, $k=0.80$ respectively). However, the inter-observer reliability of the endodontist and the radiologist was moderate ($k=0.55$).

DISCUSSION

Two main goals were aimed through this research simultaneously. The first was to assess the efficacy and reliability of CBCT imaging method in evaluation of root canal

anatomy and the second was to determine the inter-rater reliability and repeatability of two distinct professional evaluators. CBCT is an imaging modality that offers superior performance over conventional radiographic techniques in assessing of anatomic variations (12). CBCT has shorter scanning time and lower radiation dosage when compared to conventional CT Scans. CBCT is a practical non-invasive tool in endodontics that provides three-dimensional images and eliminates the superimposition of anatomic structures (Patel, 2014 and Patel, 2009). Various ethnic backgrounds seems to be responsible for different result of morphological studies in mandibular first molars (de Pablo, 2010). In the present study, type IV configuration in mesial root was most prevalent (57.8%) followed by type II (39.1%) which creates the impression to be consistent with most previous studies as in Jordan (Al-Qudah, 2009). Turkey (Demirbuga, 2013) Korea (Kim et al., 2013) and Taiwan (Chen et al., 2009). However, some earlier studies in Kuwaiti (Zaatar, 1998) and Saudi Arabian (al-Nazhan, 1999), populations have showed different findings. Aside from the gold-standard results, CBCT seem to be a valuable device for assessing root canal morphology (Patel S, 2010). (Michetti, 2010), stated that CBCT is an interesting and reliable measuring tool to explore root canal anatomy. Zhang et al examined 389 mandibular molars and concluded that CBCT is an effective and valuable tool for dentists through root canal treatment (Zhang, 2011). According to spearman's correlation, coefficients of both evaluators in our study (an endodontist and a radiologist) were acceptably more than 0.6, CBCT could be considered as a valid and reliable device when it comes to root canal anatomy evaluation of mandibular first molars. It has been proved that routine diagnostic methods like digital or conventional radiography has not enough validity in detecting root canal configurations. Wu et al., (2006), founded that digital radiography had a limited value in evaluation of root canal configurations in maxillary first premolars, poor kappa values were reported for the agreement between the gold-standard and digital radiography, obtained by two evaluators (0.2481 and 0.379). In another study, Omer et al. (2004), reported low kappa values for both evaluators (0.37 and 0.41) when compared a clearing technique with conventional radiography in assessing the root-canal morphology of maxillary first and second molars. In present study, intra-observer reliability is satisfactory for both evaluators (kappa value= 0.8). The inter-observer reliability, however, showed a moderate agreement between the radiologist and the endodontist (kappa value= 0.55). Although the radiologist has demonstrated a higher reliability, the insufficient number of evaluators implies that no confident judgment could be reached to prioritize the radiologist's over the endodontist's evaluations. Proper educational programs and training for radiographic assessment can reduce observer variation to an acceptable level and increase the reliability and validity of the ratings (Saunders, 2000). Although CBCT has been widely accepted and also administered in almost every field of dentistry, there are serious concerns about radiation risk. While Li G (2014), has warned about higher effective dose of CBCT than conventional dental radiography, some other studies have suggested that by expert adjustment of radiation parameters such as mAs and Field Of View (FOV) in the CBCT scanners, depending on the imaging and individual patient needs, favorable results can be achieved along with reduction in patient's absorbed dose (Akyalcin, 2013 and Lorenzoni, 2012) Besides the concern of radiation risk, CBCT

has some other drawback including lower spatial resolution compared to conventional or digital intraoral radiography and scattered radiation that lead to noises and artifacts which affect image's quality (Farman et al., 2005 and Scarfe, 2008). For the present study, the scanning process was almost unsusceptible to artifacts, because the teeth had been extracted and not surrounded by tissues. Moreover, the specimens were fixed with no degree of movement which reduces the artifacts compared to 20 to 40 seconds of patient exposure.

Conclusion

Despite all the advantages and disadvantages of CBCT imaging, the validity of this technique for assessing the morphology of mesial root of mandibular first molars has been proved in this article. Moderate inter-rater reliability of evaluators, the sophisticated nature of CBCT devices recommend comprehensive educational sessions for post-graduate students in related specialty courses.

Conflicts of interest

We affirm that we have no financial affiliation or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years. Any other potential conflict of interest is disclosed.

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