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Research Article

Study of Metal Artifacts of Different Alloys of Casting Posts in Diagnosis of Vertical Root Fracture in CBCT

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ABSTRACT

Background: There are several problems often in the detection of vertical root fracture even with three-dimensional CBCT X-ray system. The aim of this study was to determine the effect of metal artifacts of various alloys of casting posts on CBCT images in detection of the VRF.

Methods: 30 healthysingle-root human teeth were selected and their roots were treated. Of each of the four different casts with names of Supercast, Newcast, NPG, Meganium. 30 posts of each cast were created for each of 30 teeth.Then posts of each group were placed into the root canal and CBCT images were taken.Then vertical root fractures in half of teeth were created. The images were evaluated by an oral radiologist as blind.

Results: The results showed that the scan was complete without a post with the lowest absolute and features. In addition scan without a post had the most and scan with Meganium post had the lowest absolute sensitivity.

Conclusion: The casting posts used in the study caused a severe reduction in the specificity and sensitivity of the detection of CBCT method and in the presence of these posts it is better to use other diagnostic methods.In the absence of posts, diagnostic CBCT introduces relatively low diagnostic sensitivity and specificity for dentist which reflects the lack of a reliable method for the detection of vertical root fracture.

Keywords: vertical root fractures, metal artifacts, Cone Beam Computed Tomogeaphy, casting posts

INTRODUCTION

According to the American association of endodontics vertical root fracture is a longitudinal fracture that is located in the root and origin of the apex and extends into the coronal (1). From transverse aspect, this fracture begins from the root canal wall and can be expanded to root surface and also can involve one side (incomplete) or both sides of the root (complete). The vertical dimension can also be in the form of complete or incomplete so that a part or all of the cervicoapical length could be involved. (2, 3). When VRF is created (complete or incomplete) expands in the PDL space and results in extending of soft tissue into the space of fracture and increases the distance between fractures parts. However, due to concerns about the relation of oral cavity with fracture through gum salvex, debris, food and bacteria could be transferred into the channel space and from there to periradicular areas (7) and creates an inflammatory reaction in periodontal tissues, alveolar bone destruction and granulation tissue. Therefore, taking a decision to remove the tooth or root is needed to prevent bone loss. The prognosis of tooth with VRF is very poor, (8) and its current treatment is tooth extraction or

fractured root extraction (7, 9). Given the poor prognosis for the patient with this clinical situation and other national effects, finding an effective and reliable method will be useful in establishing and confirming the diagnosis of fractures (5). It is true that conventional radiographic imaging is the most common modality used to detect fractures of the root, but the root fracture detection in these images is very difficult. Due to the limitations of 2D X-ray radiographs in the diagnosis of root fracture, three-dimensional radiography or CBCT is considered (18). CBCT is a three-dimensional imaging system that has many advantages for the assessment of hard tissue. These images due to high sensitivity and specificity compared with two-dimensional X-ray images to detect lesions has higher diagnostic value. Metal restorations reduces the sensitivity and specificity of CBCT images.Intracanal posts are a type of structures that are used for restoration of the lost structure of tooth. Among used posts, metal posts are the most common and they cause metal artifacts in CBCT images. Metal posts are composed from different dental alloys with magnetic properties and electrical conductivity. These features causes the difference in the artifact. Considering the benefits and usefulness of CBCT in the diagnosis of dental lesions and also extensive use of dental posts with various alloys for restoration of missing teeth, it seems that it is needed to study the effects of alloys types on metal artifacts in CBCT imaging in root treated tooth. In this study, endodontically treated teeth were restorated by the post with common types of alloys and then vertical root fractures were evaluated using CBCT imaging.

MATERIALS AND METHODS

In this study, 30 extracted human single-rooted teeth were considered for root health criteria including lack of decay, destruction and fracture and finally were selected. Selected teeth were cleaned from debris and remaining tissue by Hand scaler. Teeth were kept in 5% sodium hypochlorite solution for 30 minutes to remove organic residues. In later stages of the study, teeth were stored in saline to prevent drying. In the next step, tooth crown were cut perpendicular to the longitudinal axis by the diamond milling so that the remaining root length was 13 mm from the apex to the cut area. All teeth were under endodontic treatment by using passive step back method and coronal part of the roots were prepared by gates glidden drill # 1 to # 3 (Japan-MANI INC) and the apical part up to # 50 K File (MANI INC- Japan) 1 mm to the apex. During the canal preparation stages, canal irrigation was done by using sodium hypochlorite 1% and the canals were dried by paper cone (METABIOMED - KOREA) and were filled by Lateral condensation technique using gutta-percha (ARIADENT - IRAN) and AH26 sealer (ADSEAL, MEABIOMED-KOREA). Then all samples were prepared up to 2/3 canal length (9 mm) by drills 4 # (MANI INC- Japan) to produce acrylic pattern. Post pattern was prepared with acrylic duralay (Aria Dent - Tehran - Iran) for each of the teeth and teeth were under the process of investment and casting and for each tooth 4 casting post made from four different inexpensive alloys used in laboratories were developed. Then, posts became sandblasted .After making posts, each tooth was smeared with vaseline and were placed on a self-cured acrylic blocks (Marlicacropars-iran), which was pressed into 2cm-diameter pipes.15 of the the teeth in the acrylic blocks with root canal posts to create fractures were randomly selected and the post (Nordin, Chailly, Switzerland) was placed. Vertical root fracture was created using insertion device in the School of Dentistry ShahidBeheshti University of Medical Science (Co.KG, Germany Zwcik / Roell, GmbH &). This system creates a compressive force rising into the pin until the voice of fracture being heard. Then force is muted immediately with the diagram on the monitor system. The gold standard for verification of fractures in the teeth was methylene blue coloring and fractures were considered with a magnifying glass. In 15 teeth were not fractured and considered as a control group.then the post of different alloys were put inside the canals of 30 teeth respectively and CBCT scans were done. All CBCT scans were observed by an oral radiologist and the possible fractures of each tooth were assessed.

STATISTICAL ANALYSIS

Mean and standard deviation values (mean ± SD) of forces required for fracturing the roots of

the tested groups and subgroups are expressed in Newton and presented in Table 1. Statistical analysis was performed using two way analysis of variance (two-way ANOVA) to determine significance differences among groups and subgroups, then multiple pairwise comparisons were performed using Tukey test to determine which mean value differed from one another with significance level of $P<0.05$.

RESULTS

Specificity

The investigation showed the absolute specificity in the diagnosis of vertical root fracture in free scan (CBCT scan the original without E) was 0.53 with a confidence interval (.442-.624) and was the highest. However, the absolute specificity for Newcast alloy with confidence of 0.258-0.142 equal to 1.333 was the lowest among alloys. (With most false positive responses).

The absolute specificity of Supercast, NPG alloys and non-berkelium were 0.27, 0.27 and 0.2 respectively and no significant difference was observed and all alloys had the absolute specificity between scan without post and scan with Newcast alloy. Therefore :

Absolute specificity:

free scan> NPG = Supercast = Non Be>Newcast

The complete specificity in the diagnosis of vertical root fracture in free scan (primary CBCT scan without post) was 0.666 with confidence (0.747-0.585) which was the most complete specificity. Complete specificity for Newcast alloy with confidence of 0.414-0.252 was equal to 0.333 which was the lowest among the alloys. (With most false positive responses). The complete specificity for NPG, Supercast and non berelium alloys were 0.4, 0.4 and 0.333 and no significant difference was observed and all alloys had the complete specificity between scan without post and scan with Newcast alloy. Therefore, the results for the complete specificity is identical with absolute specificity:

Complete specificityfree scan> NPG = Supercast = Non Be>Newcast

Sensitivity

The absolute sensitivity in the diagnosis of vertical root fracture in free scan with confidence of 0.624-0.442 was equal to 0.533 which was the highest. Absolute sensitivity of Non Be alloy was 0.06 with a confidence interval of (0.081-0.039) which was the lowest and is associated with most false negative response. The absolute sensitivity of Newcast alloy with Supercast and Supercast and NPG had no significant difference but the amount of Sensitivity of Newcast alloy was significantly higher than the NPG alloy, therefore:

Absolute Sensitivity:

Freescan >Newcast = Supercast = NPG > Non Be

The complete Sensitivity in the diagnosis of vertical root fracture in free scan was 0.8 with confidence of 0858-0.742 which was the highest and is associated with lowest false negative result. Absolute specificity of Non Be alloy was 0.134 with a confidence range of (0.176-0.092) was the lowest and was associated with the most responsive false negative result.The absolute Sensitivity of Newcast alloy was 0.66 which was significantly higher than the Supercast and NPG casts and had no significant difference. Therefore:

Complete Sensitivity

free scan >Newcast>Supercast = NPG > Non Be

Table 1

Type of alloy	Abs. Spec	Comp.Spec	Abs. sens	Comp.sens
Free scan	0.533	0.666	0.533	0.80
Non Be	0.20	0.467	0.06	0.134
Supercast	0.267	0.40	0.267	0.40
Newcast	0.133	0.333	0.333	0.666
NPG	0.267	0.40	0.20	0.40

Table 2

Type of alloy	Kapa Factor
Non Be	0.004
Supercast	0.004-
Newcast	0.053-
NPG	0.019

DISCUSSION

The superiority of CBCT hasshown in comparison to other methods of imaging in the diagnosis of VRF. However, most of studies have not evaluated the effect of fillings and intra-canal insertion on VRF.Although the rate

of artifacts was reduced in the CBCT system than CT, these artifacts are still present in the presence of radioactive materials such as metal posts and can be a factor in false positive and negative results. (56) Therefore, the presence of these materials is essential for the diagnosis of root fractures when preparing CBCT images ,6) . (49 ,41In this study, due to the options provided by observers for the diagnosis of vertical root fractures, the results are as absolute sensitivity and specifity and full feature is expressed. In the sensitivity and specificity of the observer's viewpoint, the presence and absence of fractures were definite, but in the sensitivity and the full feature of the cases, a possible diagnosis was also considered for the presence or absence of fracture.

Relying on accuracy, positive predictive value and negative predictive value as the main comparison index of the accuracy of diagnostic evaluation in laboratory studies with a predetermined ratio of the standard Gold Standard not only does not provide a good overall picture of diagnostic accuracy, but it can lead to mistakes by the researchers due to lower power and the lack of independent, and sometimes opposite, sensitivity and specificity changes. Therefore, these indicators have been published in this research.In the present study, the sensitivity and specificity of absolute and complete diagnosis were less than those that did not use the post. The reason for this is the Beam Hardening caused by the high density of metal posts, as well as the scattering caused by these radioactive materials and artifacts from them. Artifacts can appear in the form of lines or dark areas around the filling material, which are similar to, or covered by, fracturing lines and lead to false positive or negative results(5) .In CBCT imaging, due to the 3-D imaging nature, unlike 2-D radiographs, the path of the fracture line has no effect on its accuracy. Given the fact that in the present study, fracture lines were created by the Instron apparatus, the fact that the fracture line was buccolingual or mesiodistal were not controlled.

The distance between VRF components in the diagnostic accuracy of CBCT is effective according to statement of Ozer (40). Non displaced and hairline fractures can have an effect on the interpretation results. Mild fractures without the displacement of fracture components, usually intra-oral radiography is not detectable. (63)Even in CBCT scans, sometimes there are no break lines. This is overlapping due to the presence of anatomical structures and artifacts that can imitate or conceal the fracture lines. (63)For this reason, in this study, the samples had non displaced fractures and, therefore, were closer to clinical conditions.

In the study of Ozer et al. (40) about the CBCT function in various sizes of vecsel, higher sensitivity and specificity compared with present study were due to the absence of intra-canal filling or posts that create metal artifacts. While several studies have shown that with the presence of posts, the mentioned indexes are reduced. Cost and colleagues demonstrated that in a group of non-post test, there was a high accuracy compared to the post-test group, and this difference was statistically significant and showed that postural status significantly reduces the sensitivity and recognition of this method which confirms this study(49) .

The present study shows that the CBCT radiography method, even in the absence of the post, has a low sensitivity and diagnostic feature, due to the presence of gutta-percha at the end of the endodontically treated root canal, or the inherent self-imaging artifacts of CBCT and this condition become intense with the presence of a post inside the canal of the tooth. In a study by Melo et al. (45), CBCT diagnostic ability was not affected by postures or gutta-percha. These contradicts in the results of the current study could be due to the use of casting posts in the present study, which are probably more bulky and also have a mass of alloy as blind attached to the inside of the canal, which can cause a lot of artifacts in radiography.

In the present study, the used posts were nickel chromium or without beryllium, as well as alloys containing copper NPG, all had significant artifacts around them, which significantly reduced the sensitivity and specificity of CBCT imaging. In a study by Esterla et al. to evaluate the effect of the type of posts on the amount of artifacts, the highest amounts of artifacts were reported for gold and

silver alloys and the lowest for carbon fiber posts.

In the present study, there is no significant difference in the sensitivity and specificity of CBCT in post-scan scanning and the results suggest that CBCT is not an ideal diagnostic method for root fracture diagnosis. In the study of Yousefzade et al. (6), the diagnostic ability of CBCT has been shown to be higher than hypersensitivity. This contradiction may be due to the size of the sample, the number of observers, or the design of the study. The mentioned study was an in vivo study with teeth with normal root fractures, while the present study is an in vitro study with instron induced root fracture. When fractures are deliberately created, the fracture separation will be greater than the natural fracture, and this can affect the results. In this study, the presence of various intra-canal post showed a significant decrease in both the sensitivity and specificity, while in the study of Hassan et al. (55), the presence of root filling significantly reduced the specificity of the detection of VRF, but had no effect on sensitivity. In another study by Da Silveria et al. (52), the presence of root or posterior filling within the canal had a greater effect on the reduction of the specificity than the diagnostic VRF sensitivity.

In the present study, we showed a significant decrease in the sensitivity and specificity of the imaging technique, and the difference was not significant in reducing these two indicators. The result of a low diagnostic feature is that the tooth is considered as a broken tooth and leads to tooth extraction. In this study, among the four alloys, in the beryllium-free alloy, the values of the diagnostic value were significantly higher than the diagnostic sensitivity, which could be recommended to reduce false positives that could lead to excessive tooth extraction. It is suggested to use a bromine-free nickel-chromium alloy compared three other alloys.

The results of diagnostic sensitivity in this study indicate that the non-post scan is naturally the most sensitive, then the NewCast alloy with a density of 7 had the highest sensitivity among the 4 alloys and then Supercast and NPG with densities of 8.7 and 9.7 and in Ultimately, the beryllium-free alloy with the highest density in the alloys had the least sensitivity and the highest artifacts. Therefore, the difference in the values obtained can be attributed to the diagnostic sensitivity to the difference in the density of the alloys.

CONCLUSION:

The presence of intra-canal posts from any of the alloys used in the study significantly reduces the rate and diagnostic sensitivity of the CBCT method, and it is advisable to use other diagnostic methods in the presence of these posts. Also, in the absence of a post inside the canal, the CBCT diagnostic method provides a relatively low diagnostic sensitivity and specificity for the dentist indicating that this method is not reliable for root fracture detection.

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