Original Study

EVALUATION OF THE AMOUNT OF ARTIFACTS AROUND DIFFERENT IMPLANTS IN CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Aim: The aim of the current study was to determine artifacts induced by titanium and zirconium implants in cone beam computed tomography (CBCT).

Materials & Method: A dried human mandible was used to determine artifacts induced by titanium and zirconium implants in CBCT (control groups). Titanium fixtures (4x8mm) were allocated into the mandible and scanned for 4 times using CBCT (Vatech). Same procedure performed for zirconium implant. The images were evaluated by two observers using Matlab software. The crest of each implant was elevated for determine gray value in distal, mesial, buccal and lingual squared positions. The gray value among experimental groups (control and case) was analyzed using one way analysis of variance.

Results: According to the results, significant differences observed on artifact implants in Zirconium (214.3±2.9) and Titanium (134.3±9.6) compared to the control group (90.2±0.4) in mesial position (p=0.000). Significant differences observed on artifact implants in Zirconium (221.6±2.8) and Titanium (144.4±13.5) compared to the control group (94.7±1.9) in distal position (p=0.000). Significant differences was observed using LSD on mesial and distal positions among Zirconium, Titanium and control group (p<0.05).

Conclusion: These results suggested implant type had the greatest effect on metal artifact intensity in this study. In CBCT, titanium displays the least amount of artifact while Zirconium had highest artifact.

Key words: Artifact, Implant, Cone beam computed tomography.

Introduction

There is growing interest to transform conventional dental impression technique into a digital-based rapid prototyping printed dental plastic.[1] Traditional impression-based dental model is a time consuming system and application of the digitalization system provides great impetus on the current time consumed.[1] Panoramic radiography, conventional linear or complex motion tomography and computed tomography (CT) are widely using in the dentistry.[2] Since last decades, there is a shift on this techniques to 3D photographs.[3] A relatively new imaging technique is the CBCT which enables 3D imaging of bony structures of the skull, dentistry and maxillofacial surgery treatments. There is a growing interest on application of the CBCT technology compared to the CT scan in orofacial clefts, craniofacial anomalies and orthognathic treatments.[4] The CBCT is an adapted from conventional medical spiral CT systems with the x-ray source shooting out multiple diffuse x-ray beams around the head to capture the primary raw images.[5]

Artifacts are problematic in the dentoalveolar area due to metal objects like metallic restorative materials, posts, cores, and dental implants.[6] The artifacts are produced because of the high density of the metal. Since metals severely attenuate X-ray beams, beam attenuation in structures adjacent to the metallic structures is not recorded properly.[7] Presence of metal in computed tomography (CT) and CBCT scanned areas lead to production of dark and light bands which decrease image quality. Due to its ability to provide cross-sectional images at lower radiation doses, CBCT has broadened diagnostic possibilities in dentistry.[8] Benic *et al*[9] studied artifacts induced by titanium dental implants in CBCT and revealed artifacts around titanium implants were distributed in a geometrical pattern. In assessment of metal artifact reduction around dental titanium implants in CBCT, it is reveled significant difference was found among mean gray values of scans with no implants inserted and with implants inserted. CBCT scanner does not significantly correct the gray values affected by the metal artifact in the vicinity of an implant in human dry mandibles.[10]

Materials & Method

A dried human mandible was used to determine artifacts induced by titanium and zirconium implant (Super line Dentium, Implantium, Seoul, Korea) in CBCT during 2017. Titanium fixtures (4x8mm) were allocated into the mandible. Then to minimize experiment error, this group scanned for 4 times using CBCT. Same procedure performed for zirconium implants. The images were evaluated by two observers using Matlab software. The crest of each implant was elevated for determine gray value in distal, mesial, buccal and lingual squared positions. The gray value among experimental groups (control and case) was analyzed using one way analysis of variance (ANOVA) and is presented as the mean±Sd. For treatments found to have an effect according to the ANOVA, mean values were compared with LSD test. p<0.05 were considered to indicate significant differences between the treatments.

Results

The results of the one way ANOVA analysis on effect of the implants on artifact of the CBCT images is presented in table 1. According to the results, significant differences observed on artifact implants in Zirconium (214.3±2.9) and Titanium (134.3±9.6) compared to the control group (90.2±0.4) in mesial position (p=0.000). Significant differences observed on artifact implants in Zirconium

(221.6±2.8) and Titanium (144.4±13.5) compared to the control group (94.7±1.9) in distal position (p=0.000). In the buccal position, the artifact implants in Zirconium (52.6±1.9) and Titanium (52.6±1.9) was the same, however significant difference detected with control (90.9±1.1) group (p=0.000). There was no significant difference between Zirconium, Titanium implants and control group in lingual position (p>0.05). [Table 1]

Position	Abutment (n=8)	Mean ± Sd	*f* value	*p* value
Mesial	Zirconium	214.3±2.9		
	Titanium	134.3±9.6	943.11	0.000
	Control group	90.2±0.4		
Distal	Zirconium	221.6±2.8		
	Titanium	144.4±13.5	508.18	0.000
	Control group	94.7±1.9		
Buccal	Zirconium	52.7±1.9		
	Titanium	52.6±1.9	1438.13	0.000
	Control group	90.9±1.1		
Lingual	Zirconium	74.9±10.6		
	Titanium	77.4±7.5	3.47	0.05
	Fixture	74.5±0.8		

Table 1:. The results of the one way ANOVA analysis on effect of the implants on artifact of the CBCT images.

The LSD results for artifact in Zirconium, Titanium and Fixture using CBCT imaging is presented in table 2. As seen, significant differences was observed on mesial and distal positions among Zirconium, Titanium and control group (p<0.05).

Position	Abutment	Mean differences	*p* value
Mesial	control- Zirconium	124.1	0.000
	control- Titanium	44.1	0.000
	Zirconium - Titanium	80	0.000
Distal	control- Zirconium	127.9	0.000
	control- Titanium	49.7	0.000
	Zirconium - Titanium	77.2	0.000
Buccal	control- Zirconium	-38.2	0.000
	control- Titanium	-38.3	0.000
	Zirconium - Titanium	0.1	0.918

Table 2: The LSD results for artifact in Zr, Ti and Fixture using CBCT imaging.

Based on the results, positive correlation observed in mesial, distal ,buccal and lingual between two observers (p = 0.000). [Table 3]

Position	Pearson's correlation	*p* value
Mesial	0.999	0.000
Distal	0.998	0.000
Buccal	0.999	0.000
Lingual	0.997	0.000

Table 3: The results of Pearson's correlation between two observer

Discussion

The CBCT was evaluated in staging periodontitis, determining alveolar bone defects and bone assessment around dental implants.[11] Presence of the artifacts complicates CBCT interpretations.[12] There is growing interest on use of ceramic material for their advantages such as natural color, high flexural strength and hardness.[13] However, ceramic materials interferes with the image formation process in CBCT.[12] As observed, significant differences observed on artifact implants in Zirconium and Titanium compared to the control group in mesial, distal , buccal positions. Significant differences was observed using LSD on mesial and distal positions among Zirconium, Titanium and control group. On evaluate zirconium implant artifact production in CBCT images, Vasconcelos *et al*.[12] reported despite zirconium implants produce image artifacts in CBCT scans and in the current study the Fixture- Zirconium had highest artifacts than Fixture- Titanium. Sancho-Puchades *et al*.[14] reported gray value were higher for zirconium dioxide implants than for titanium implants and our result was in agreement to this report. Zirconium underperforms in comparison with titanium, in terms of artifact production.[15] So, dental material professionals must try to minimize this undesirable effect.[15] Duttenhoefer *et al.* [16] investigated magnetic resonance imaging (MRI) in zirconia-based dental implants and revealed MRI is valuable imaging alternative for zirconia-based implant dentistry because of the excellent contrast, limited artifacts, radiation-free and accurate implant assessment. However, titanium implants were not suitable for MRI.[16]

Despite zirconium implants invariably produce artifacts various parameters may be adjusted so that real gain in image quality ensues. Gröbe *et al*.[11] studied accuracy of bone measurements in the vicinity of titanium implants in CBCT and revealed this method is accurate to measure thin bone structures in the titanium implants. Recently, Moshfeghi *et al*.[17] studied amounts of artifacts produced by different cements including glass ionomers, mineral trioxide aggregates, zinc oxide eugenol, TempBond and polyester using CBCT and revealed the materials type of can influences gray scale value. Gray level is a calibrated sequence of gray tones, ranging from black to white. These are the digital numbers of each of the pixel units that together make up a remotely sensed frame.[17] Benic *et al*.[9] studied artifacts induced by titanium dental implants in CBCT and reported artifacts around titanium implants in CBCT images were distributed based on geometrical pattern which our results was similar to this report. Because of the gray value alterations in artifact- affected areas vary at different circumferential positions around the implant in the current study we determined gray value in mesial, distal, buccal and lingual circumferential positions which enables the clinician to better interpret CBCT images. Based on the results, positive correlation observed in mesial, distal and lingual between two observers.

Kuusisto *et al*.[16] evaluation of intensity of artifacts in CBCT by radio-opacity of composite simulation models of implants in vitro artifacts were clearly present in CBCT images caused by titanium and zirconia. The intensity of artifacts increased when the radio-opacity of the composite material increased.[16] The density response in CBCT examinations depends on the total mass inside and outside the area of interest.[16] Smeets *et al*.[18] studied artifacts in multimodal imaging of titanium, zirconium and binary titanium–zirconium alloy dental implants and revealed titanium and titanium–zirconium alloy resulted in less streak artifacts in comparison with zirconium in the CT, while in CBCT, titanium–zirconium alloy induced more severe artifacts than zirconium and titanium. The zirconium implant diameter used in their study was greater than the diameters of titanium and titanium–zirconium implants, which might also have led to an increase in artifact induction and impaired comparability.[19] In CBCT, titanium displays the least amount of artifact induction, which clearly increases when imaging titanium–zirconium alloy implants, similar to zirconium.[20] Limitation of the present study was its in vitro set-up, which only partially simulated a clinical situation of CBCT scanning. It is important to be aware that in CBCT images, artifacts are always present in the close proximity of dental implants.[9] So, the results should determine during the peri-implant and other conditions. In conclusion, the evaluation of Zirconium implants on CBCT images showed a wide range of artifact production than titanium implants.

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