REVIEW ARTICLE

Troubleshooting Cone-beam Computed Tomography Imaging: A Review

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Abstract

Introduction: Artifacts in radiology refer to the unwanted structures or the discrepancies that appear in the diagnostic image, resulting in obscuring the region of interest to be studied. This usually occurs when the gray scale values in the image do not display precisely the diminution values of the content in the persons to be studied. Artifacts sometimes also appear as foreign structures that are not present in the region of interest and are outside structures such as ear rings or other accessories. Since their presence deteriorates the image quality, the knowledge of their presence alerts a radiologist, so that the findings should not get misinterpreted and diagnosis should become flawless.

Aim: The aim of this review is to ascertain the possible factors which give rise to the various artifacts in the radiographic image and lead to the misinterpretation of the CBCT image.

Conclusion: The knowledge of various cone-beam artifacts is essential to limit a clinician in misdiagnosing a pathological condition and to help an astute clinician in proper treatment planning.

Keywords: Artifacts, Cone beam, Resolution, Star effect, Streaking.

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Introduction

Cone-beam computed tomography (CBCT) has become very challenging of late due to the statistics that numerous diagnostic tasks are well made by this modality. As the name suggests, CBCT uses a narrow cone beam that images the patient's head in a circular motion with concurrent movement of the tube head and the detector which will be concentrated on the long axis everywhere in the patient's head. The technology is very promising and gives results in submillimetric accuracy.

The radiographic image construction is centered on the foremost of beam attenuation or fading when it exits the subject. The beam is thought to undergo various interactions earlier, exiting the subject and featuring the image receptor or in terms of CBCT imaging the detector used in image generation. Metal restorations are self-possessed of numerous materials partaking variable density and high atomic numbers which eventually end up diminishing the beam of X-ray added compared to the material with low atomic number within the same article. On the contrary, bone is poised of tissues having atomic numbers on a reasonably higher side compared to the soft tissues; hence, the beam diminution by bone is more as compare to soft tissues. White and shady stripes or light flickers patenting as high-density structures within the same image are most intimidating of all the artifacts and obscure the diagnostic information quite severely.

One of the most important things in the creation of the artifacts is to comprehend that the artifacts are mostly connected to the linear development of the machine tube head and sensor spinning about the subject used to internment the numerous basic images after which 3-D images are remodeled.[1–4]

Beam Hardening Artifacts

Utmost ubiquitous and commonly noticeable artifacts are the dark bands that take place because of beam hardening. The true nature of the X-ray beam exiting the X-ray tube is polychromatic, i.e., the photons in an X-ray beam are at diverse vigor levels, with concentrated levels of energy equating the tube voltage used for that particular scan. The lower energy photons of the beam get attenuated more than higher energy photons or are removed on interaction with the denser objects. This ultimately results in the bigger percentage of higher energy photons striking detector in comparison to the actual number of photons originated from the tube head.

The algorithm used for the image formation is based on the concept of monochromatic beam; hence, it cannot discriminate among expected and true photon energy spectrum of the initial X-ray grey scales and erroneously evaluates the amount of diminution of the beam as it is accepted over the matter, especially the solider matters and allocates an incorrect squat gray-scaled standards for the areas inside the subject. This wrong evaluation along with the rear forecast algorithm forms an image volume resulting in dark areas and streaking in the image which eventually ends up obscuring the relevant information contained in the image (Fig. 1).[5,6]

Metal Artifact

This artifact mainly appears as stellar influence or pewter relic and is most often present when pewter edifices such as crowns, metallic refurbishments, implantations, stents for confining implant site, surgical plates, or screws are imaged alongside other maxillofacial structures. These artifacts are a result of the misapprehension by the image algorithm due to the high atomic number in the 2-D images

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Fig. 1: Beam hardening artifact associated with gutta-percha filling material resembling a root fracture

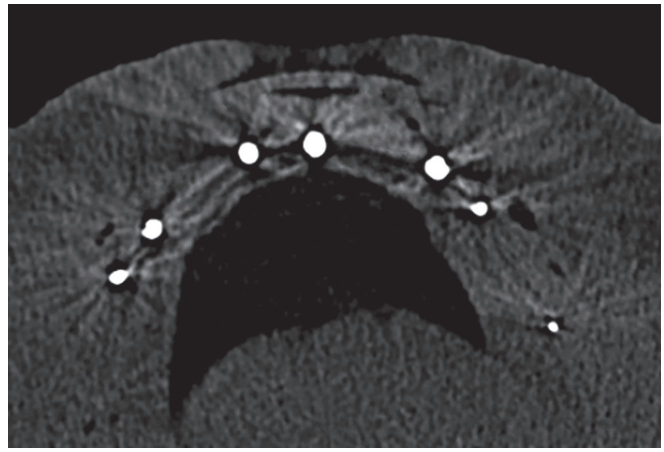

Fig. 2: Star effect/white streaks/metallic artifacts from metallic stents for localization of implant sites

Fig. 3: Cone-beam effect artifact

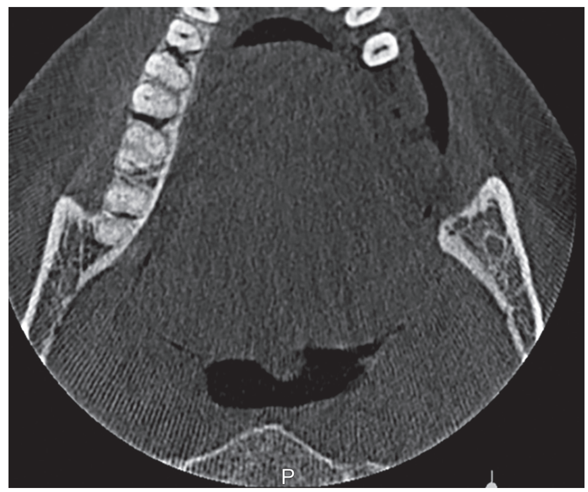

Fig. 4: Aliasing pattern artifact

that are afterward transformed into 3-D volume rendering by the software algorithm (Fig. 2).[7–14]

Ring Artifacts

They are manifested as the picture element in the detector is known as dexel; and when it is dead or misaligned with the X-ray tube head, a defective diminution value is got as the X-ray source and the detector moves around the patient's head. Such artifacts are more often seen in the axial reconstructions and are spotlighted everywhere based on the revolving axis of the CBCT apparatus.[15]

Cone-beam Artifact

Cone-beam artifact is produced due to the swerving cone-shaped X-ray beam used in the image attainment. Because of the swerving beam areas on the external margins of the image, both upper and lower extents become less dense and more blurred (noisy and grainy) compared to those located within (Fig. 3).[1–3]

Motion Artifact

This type of artifact is most common in the disobliging and older age-group patients. Old agegroup who usually tend to suffer from neuromuscular incompetency is the one in which this artifact is most commonly encountered. The artifacts are usually seen as extreme obscuring of the images, binary frameworks of corticated sides, or dual frameworks of the posterior border of the tongue. Many CBCT machines now are armed with a chair and head stabilizing unit, but machines intended on panoramic design are more prone to give rise to scans with this type of defect.[1–4]

Various CBCT machines need flexible scan times. A drop in shot period, by declining the test arc, lessens the quantity of base imaginings obtainable to restructure the 3-D volume, which shrinks the whole image quality.[5]

Aliasing Artifact

Marginal wavy lines scattering away near the margin of a cone-beam image that is typically produced by the undersampling of structures inside the object by the cone-beam unit detector and is closely linked to the magnitude of dexels in the detector with 3-D position of image slice in lieu to image basis and indicator. Other factors on which this artifact is to be contingent are the number of base imageries created and algorithm cast-off for 3-D construction (Fig. 4).[1–4] These artifacts do not look like any naturally happening configurations, but these can be unclear when trying to detect root

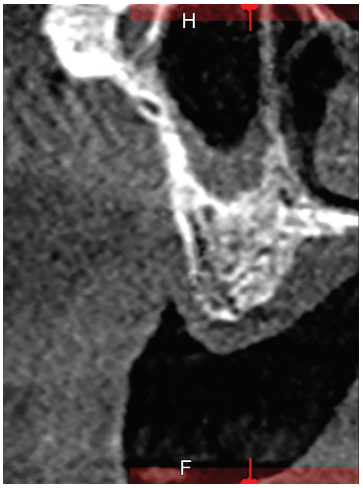

Fig. 5: Image noise resulting in reduced image resolution

fractures. Dexels are the apparatuses inside the sensor that quantify the energy of the instance X-ray or light photons.

Image Noise

The noise of the image complicates to discover the borders of substances inside a radiographic image. Tiresome to discover the ends of matters inside a radiographic image can be made exciting by noise in the image. Noise in a radiographic image can be initiated from several sources, but a major form of image noise is denoted as quantum mottling or occasionally formless noise that is caused by accidental variation in the number of photons in the beam as it exits a subjects and strike image detector. This can tip to images where spatial resolution of smaller discoveries may get reduced but at the same time these images may have enough information for the gross areas to be evaluated such as bony regions for pathology extensions (Fig. 5).[15–21]

Conclusion

Various imaging modalities—periapical, orthopantomograph, cephalometric, CBCT, medical CT, or magnetic resonance image—are not completely free of falsifications or artifacts. Consequently, no imaging disparity provides images that perfectly represent the subject of interest. Each system delivers diagnostic data based on its sturdy and frail facts. Proper technical parameters are important to obtain a clinically acceptable scan with precise identification of artifacts. These include choosing a low- or high-resolution locale. With a selection of an appropriate field of view. Squat spatial resolution practices will be inept to discriminate amid two objects that are close together but unable to recognize a small object, such as a fracture in a tooth. A thorough knowledge with adequate information must be collected in such a manner as to maximize the beneficial outcome for the patient while minimizing the patient's risk. It is obligatory on the dental professional to obtain a detailed awareness of the strengths and weaknesses of radiographic imaging modalities, the proper operation of the various systems, and the knowledge to interpret the radiographic images to obtain the maximum information.

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