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論文内容の要旨

Background and objectives

Multidetector computed tomography (MDCT) is an important imaging modality for the diagnosis of soft tissue and hard tissue lesions in oral and maxillofacial region. However, it has limitations for the dentistry because of its high cost, large apparatus, and thicker slice. Cone beam computed tomography (CBCT) yields lower cost and compacted machine size with high-resolution image of teeth and bony structures, so it is widely used in oral and maxillofacial imaging. The drawback of CBCT is the lower contrast between soft tissues and the lack of the absolute attenuation value.

A streak artifact by metals is one of the image artifacts associated with both CT machines that seriously obstructs the underlying anatomical and pathological structures, and leads to images unsuitable for the diagnosis. Many comparative studies about the image quality between both CT machines have been reported, but the study of the artifact by various dental metals between them has not been studied yet. Moreover, few studies of pixel values in CBCT have been reported, but there were very few studies that evaluated the attenuation values in both CT machines.

Therefore this study had two objectives. The first objective was to quantitatively analyze and compare the streak artifacts by metals in MDCT with CBCT in correlation with a metal type and an imaging parameter, and the second purpose was to evaluate and calculate a conversion function for a pixel value from CBCT images to the CT value (HU) obtained from MDCT.

Materials and methods

1) Metal cubes of aluminum, titanium, cobalt chromium alloy, and type IV gold alloy were placed to the center position of a water-filled cylindrical polypropylene phantom, and placed in the center of each machine, and then scanned at 80 and 100 kVp, 100 and 170 mAs. Phantom scans were repeated seven times on separated days. Thresholds of the attenuation values were calculated by adding or subtracting three times of a standard deviation of a background to the attenuation value of the background of the image without metal at each parameter. The areas above and below the threshold values were defined as a white artifact and a black artifact, respectively. A circular region of interest (ROI), which was 300 pixels in diameter, at the center of each image was selected, and the areas were measured by ImageJ software. Total artifact areas (sum of black and white artifact areas) were also calculated. The results of MDCT and CBCT, various metals, and imaging parameters were statistically compared.

2) The contrast medium with various concentrations (8, 4, 2, 1, 1/2, 1/4, 1/8, 1/16%) was put in the micro test tubes, then each tube was placed to the center position of the same phantom as used in part I, and scanned seven times with both CT machines at 80 and 100 kVp, 100, 120, 150, 170, 200 mAs (102, 119, 153, 170, 204 mAs in CBCT). A ROI (circular 10 pixels) at the center of axial CT images at the center section was set. Then, the CT values and pixel values were measured using ImageJ software, and correlation tests between values measured from both CT machines were performed.

Results

1) The largest total artifact areas was 9286.10 mm^2 when the metal was type IV gold alloy in MDCT scanned at 100 mAs, 170 kVp, and the least total areas was 73.09 mm^2 by aluminum in CBCT at 100 mAs, 170 kVp. Black, white, and total areas in CBCT were significantly smaller than MDCT in most scan conditions except white and total area by aluminum at 80 kVp, 100 and 170 mAs, and 100 kVp, 170 mAs. Regarding the effect of metal type at the same scanning condition, artifacts by different metals in MDCT were significantly different, but in CBCT at 80 kVp, there was no significant difference of some artifacts among titanium, cobalt chromium alloy, and type IV gold alloy. With tube current held constant, higher kVp usually lead to significant reduction of artifact in both MDCT and CBCT. Whereas increasing tube current from 100 to 170 mAs at the same kVp did not significantly reduce the artifact in both CT machines.

2) Maximum and minimum CT values in MDCT were 3.22 (at 100 kVp, 200 mAs) and 1135.42 (at 80 kVp, 120 mAs), respectively. In CBCT maximum and minimum pixel values were -499.95 (at 100 kVp, 204 mAs) and 379.84 (at 80 kVp, 702 mAs), respectively. At the same tube voltage, CT values of various tube currents in MDCT were nearly the same, whereas at the same tube current, 100 kVp gave lower CT values than 80 kVp did. Pixel values measured in CBCT were lower than CT values in MDCT of the same concentration and same parameter, and measured pixel values were lower with either higher tube voltage or tube current. However, at each parameter, pixel values and the CT values were significantly correlated in all parameters ($p < 0.0001$). From the result that measured pixel values in CBCT were varied due to scanning parameter, therefore conversion function for pixel values from CBCT images to the CT values obtained from MDCT could be calculated at each parameter as follows;

kVp, mA (mAs)	Conversion function
80, 100 (102)	y = 2.0081x + 368.57
80, 120 (119)	y = 2.0309x + 434.73
80, 150 (153)	y = 2.0204x + 542.63
80, 170 (170)	y = 2.0175x + 584.62
80, 200 (204)	y = 2.0251x + 671.33
100, 100 (102)	y = 1.8351x + 639.15
100, 120 (119)	y = 1.8387x + 705.15
100, 150 (153)	y = 1.8423x + 802.49
100, 170 (170)	y = 1.8358x + 847.02
100, 200 (204)	y = 1.8339x + 922.4

x = Pixel values in CBCT, y = CT values in MDCT

Conclusion

CBCT produced smaller metallic artifact than MDCT in most metals and scanning parameters. Type IV gold alloy produced the largest artifact areas followed by cobalt chromium alloy, titanium, and aluminum, respectively. Increasing tube voltage could significantly reduce artifact area in most conditions in both MDCT and CBCT, whereas increasing tube current did not show significant reduction of artifact areas. Accordingly, selection of material used for the prostheses that produces small artifact, and imaging with proper parameters can reduce the artifacts occurred on CT images.

Pixel values in CBCT were different from the CT values in MDCT, but strong correlation was found between them. Therefore, conversion functions for pixel values obtained by CBCT to the CT values obtained by MDCT could be calculated at each parameter. However, these functions can be applied with material that has the attenuation value in the range of contrast medium concentration used in this study.

論文審査の結果の要旨

本研究は4種の歯科用金属を用い、異なる電流と電圧によってMDCTとCBCTの金属アーチファクトを定量的に比較し、さらに、造影剤を用いてCBCTのピクセル値とMDCTのCT値との相関関係を評価したものである。

その結果、CBCTの金属アーチファクトはMDCTより有意に少なかった。また、CBCTのピクセル値とMDCTのCT値との間に強い相関関係を認めたため、変換係数を算出することができた。

以上の研究成果は、CBCTの金属アーチファクトがMDCTよりも小さく、CBCTのピクセル値からMDCTのCT値を予測できることを実現したものであり、CBCTの有用性ついて重要な知見あり、博士（歯学）の学位を授与するに値すると認める。