Original Article

Investigating The Effect Of Different Inclinations Of Maxillary Occlusal Plane On Estimating The Size Of Gutta-Percha Markers In Cbct Images: An In-Vitro Study

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Abstract:

Background: Due to the importance of CBCT linear measurement accuracy and the lack of standard axial plane inclination, this study aimed to investigate the effect of axial plane inclination changes on linear measurement accuracy in reconstructed maxillary CBCT images.

Materials and Methods: In the present experimental (in-vitro) study, CBCT images were obtained from 3 dry human maxillae. In this study, radiopaque markers (gutta-percha) were used as landmarks. First, real measurements were made by a practitioner using a digital caliper. Then, CBCT was taken in 5 different inclinations of the axial plane (parallel to the occlusal plane as the standard plane and ±7˚and ±14˚). One observer performed radiographic linear measurements. The linear measurements were a total of 540 samples according to 36 markers and 5 different inclinations and 3 replications. Physical and radiographic linear measurements were compared to evaluate the accuracy of linear measurements on 5 different inclinations. Data were analyzed using SPSS software version 16 and ANOVA test.

Results: A total of 540 samples with 5 different inclinations were evaluated. The actual size of the marker length, inclinations estimation and difference estimation showed that the maximum and minimum differences were related to inclinations of -7˚ by 0.009 and inclinations of +7˚ by 0.002, respectively. However, ANOVA test showed that this estimate of differences in various inclinations was not statistically significant ($P > 0.05$).

Conclusion: It seems that changing the inclination from 0 to -14 does not affect estimating the real differences of marker length with the inclination. Therefore, it can be concluded that all vertical measurements are accurate clinically.

Keywords: Cone beam computed tomography, Linear measurements, Maxilla

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Introduction

Maxillary anatomy measurements are not accurate on panoramic radiographs due to magnification and distortion (1). Recently, dentists have a strong tend to replace conventional radiographic methods with digital types of CBCT for diagnosis, treatment plan, and reconstruction (2). The main use of CBCT is in the implant treatment plan (3). Previously, CT scan was used to planning the implant surgery, but nowadays, it has been replaced with Cone Beam CT due to a lower dose, quality equivalent to CT images, better resolution and cost-effectiveness (4-6). The usefulness of 3D computed tomography images in implant treatment plan for accurate linear measurements has been demonstrated in recent years. 3D CBCT images can be used in cephalometric analysis, dimensional measurements of maxillofacial structures and landmarks (7-9). The accuracy of linear measurements in CBCT is very high, which is greater for longitudinal measurements than horizontal (10). In CBCT, there is a possibility of secondary reconstruction for images of craniofacial structures, as well as in sagittal, coronal and Para-axial planes (11). However, when preparing cross-sectional images, a standard axial plan or a defined direction (scanning plane, axial slicing) is not mentioned in the literature. Therefore, the operator can hypothetically place the axial plane parallel to the lower mandibular border or parallel to the occlusal plane, which may have different results in linear measurements (12-14).

A dry human mandible was used in a study to determine the effect of sample inclination on the accuracy and reproducibility of linear measurements of mandibular anatomical structures in CBCT images. The results of the study showed that the mean standard deviation in radiographic image measurements for the horizontal position of the mandible and for the mandible with inclination was 0.36 mm and 0.48 mm, respectively (4). Examination of the accuracy of three-dimensional measurements taken from CBCT images (Surface rendered) for cephalometric analysis of eight dry human skulls showed that the measurements obtained from the CBCT 3D image are accurate and small changes that occur after changing the position of the patient's head, has no effect on the accuracy of measurements (15). The results of another study showed that the actual measurements were always larger than the same dimensions in the CBCT, but these differences were significant only for the base of the skull (internal structures of the skull) and, consequently, the CBCT is reliable for linear measurements of other structures (Dentomaxillofacial) (16). Sheikhi et al. (17) in a study aimed at determining the accuracy of linear measurements in dry human skulls in ideal and deflected positions reported that the measurement accuracy of Gallileous CBCT device are different in various positions of the head, however, the differences were not clinically significant.

A review of the literature raises the question of what is the appropriate and standard axial plane in CBCT images and whether changing the angle of the axial plane has a significant effect on the dimensions obtained in CBCT cross-sectional images or not? Due to the limited and scattered research and lack of reports in this field in Iran, therefore, the present study was designed and conducted to investigate the effect of different inclinations of the maxillary axial plane on linear measurements in CBCT images. The present study is expected to answer the scientific and practical question of which of the five inclinations give a close estimate of distance in order to reduce the problem of estimating the size of markers in CBCT and its known effects.

Materials and methods

The present study was performed to investigate the effect of different inclinations of the maxillary axial plane on the estimation of gutta-percha marker dimensions in CBCT images in the radiology department of the Islamic Azad University of Tehran and a private clinic in 2016. The study population in the present study consisted of 3 eligible human maxillary (partial edentulous, with dentate and edentulous areas). Twelve gutta-percha radiolabel markers were affixed to each maxilla, including 6 gutta-percha in the buccal and 6 in the lingual, and then on 5 inclinations (parallel to the occlusal plane, and ±7˚and ±14˚), therefore, a total of 540 linear measurements were performed.

Variables studied and tools for measuring indicators

Independent variables in this study were the five inclinations of the axial plane in CBCT, and the dependent variables including

Table 1. Tools and method of measuring the indicators

Variable	Tools and method of measurement	Unit	Scale
Gutta-percha marker size (gold standard) in buccal and lingual region	Caliper with an accuracy of 0.1 mm	Mm an 0.1 mm	Quantitative-continuous
Gutta-percha marker size in CBCT images at different angles on the buccal side	Difference with actual size less than / greater than 0.5 mm	Acceptable range Unacceptable range	Quantitative-continuous
Gutta-percha marker size in CBCT images at different angles on the lingual side	Difference with actual size less than / greater than 0.5 mm	Acceptable range Unacceptable range	Quantitative-continuous
Axial plane inclinations in CBCT	By conveyor and change the inclination of the axial plane	Parallel to the occlusal plane, and ±7˚and ±14˚	Qualitative-ranking

estimating the linear size of the gutta-percha marker in the buccal and lingual areas of alveolar bone in reconstructed CBCT cross-sectional images, and the intervening variables including the observer, method and measurement conditions such as ambient light, monitor and distance to monitor. Indicators measurement tools are presented in Table 1.

Method

It was hypothesized that if we change the inclination of the axial plane in the CBCT from parallel to the occlusal plane at angles of ±7 ° and ±14 ° relative to it, the linear estimates of the radiopaque markers would be similar to the actual measurements in the maxilla. The present study was performed by in-vitro experimental method with 540 samples for linear measurements. In this study, 3 dry human maxillae were used, which include toothless and toothed areas. 12 gutta-percha markers No. 70 were placed on each maxilla vertically as radiolabel markers by liquid adhesive from the crest ridge. The vertical gutta was first measured by the operator, approximately 10 mm in length, with a ruler. The desired sizes were checked using digital calipers (Guanglu, Taizhou, China) with an accuracy of 0.1 mm. An exact number was obtained from the approximate size and recorded in the actual size of the gutta-percha before exposure to radiation. 6 gutta-percha markers were placed in the buccal region in the canine, premolar and left and right molar positions, and 6 gutta-percha markers in the lingual region were placed in the canine, premolar and left and right molars. Placement in the CBCT device was such that first the plate related to the patient's head was placed in the device parallel to the horizon and zero degrees on the device. Then each sample was placed on the plate so that the sliding lines (positioning line) of the device correspond to the midsagital part and the area of the canines on both sides. Then inclinations of +14, +7, 0, -7, -14 were applied on the plate of the device using a conveyor, and on each inclination, a scan was prepared by the CBCT device (New Tom VGI, Verona, Italy) (15). Exposure conditions was (12 × 8 cm) Fov, exposure time was 3.6 seconds, Kvp (110), mA (2.83), mAS (8.07), voxel size (0.12 mm), focal spot size (0.3 mm), rotation was 360 degree and the software used was NNT Version 3.00. Thus, multiplaner images were made with different inclinations of axial planes and thickness equal to 1 mm and distances equal to 1 mm, and 4 repetition were prepared for each maxilla with the relevant code. Then linear observations and measurements were performed by an observer (oral and maxillofacial radiologist).

The measurement of the markers started from the right side of the maxilla, so that the observer matched the number of each section with the panoramic view at the top of the page, and then the marker number and the resulting measurement were recorded in the relevant information form. The observer was blind to the actual length of the markers. The observer conducted an experimental study on 9 markers that included two linear measurements at 1 week intervals. The length of the gutta-percha was measured from the total length visible in the image. The observation was made using a 19-inch monitor (Philips, brilliance, 19si) with a resolution of 1024 x 1380 in a semi-dark room. The distance from the viewer to the monitor screen was set at 20-30 cm and no time limit was set. The observer has been able to make changes such as contrast and image density (15).

Statistical analysis

Data were analyzed using SPSS software version 16 and ANOVA test. Significance level of comparisons was less than 5%.

Results

A total of 540 samples including 5 inclinations of +7, -7, 0, -14, and +14 were examined on 36 markers. The difference of estimates in these inclinations of the maxillary occlusal plane compared to the actual amount is presented in Table 2. The results show that the maximum difference of the estimate was related to the inclination of -7 (=0.009) and the minimum difference of the estimate was related to the inclination of +7 (=0.002). ANOVA test showed that this difference of estimation in CBCT was not statistically significant with these inclinations (P >0.05).

Table 2. Size of gutta-percha markers in terms of actual amount, estimation of differences in various inclinations of maxillary occlusal plane

Inclination	Actual size of marker length (Mean)	Size of markers in the Inclination (Mean)	Estimation of differences
0	10.039± 0.169	10.034± 0.029	0.005± 0.029
7+	10.039± 0.169	10.037± 0.008	0.002± 0.008
7-	10.039± 0.169	10.030± 0.018	0.009± 0.018
14+	10.039± 0.169	10.045± 0.014	0.006± 0.014
14-	10.039± 0.169	10.036± 0.007	0.005± 0.006
P-value			0.66

Discussion

The present study was conducted to investigate the effect of different inclinations of maxillary occlusal plane on the estimation of CBCT image measurements. The results showed that clinically, changes in the inclination of the maxillary occlusal plane in CBCT images had no a significant effect on the accuracy of linear and dimensional measurements in reconstructed cross-sectional images. The results of the present study showed that in different dental areas, the maximum and minimum differences were related to inclination of -7° (=0.009) and inclination of +7° (=0.002), respectively, but these differences were not statistically significant. Due to the importance of accurately measuring distances between anatomical landmarks or measuring bone width in various therapies, many clinicians tend to use linear measurement

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capabilities in FCBCT. 3D and CBCT images are used to measure accurate linear and angular dimensions in craniofacial structures and landmarks in orthodontic treatment and implant surgery (7). Measurement errors in CBCT images will result in treatment failure because, in the implant treatment plan, the high accuracy of linear CBCT measurements prevents surgical injuries such as lower lip anesthesia and sinus perforation. Therefore, the orientation of the inclination of standard axial plane is important when preparing images in CBCT.

In the study of Tomasi et al. (4), no significant difference was observed between linear mandibular measurements with two different inclinations in CBCT images. In the present study, which was performed with 3 dry maxilla in 5 different inclinations, no significant difference was observed between linear maxillary measurements, which is consistent with the mentioned study. In terms of measurement accuracy, Tomasi et al. (4) reported an error greater than 1 mm to be 6.7%. In the present study, no error greater than 0.2 mm was observed in any case. Considering the range of 0.2 mm as a clinically acceptable range in the difference of measurements and also that 100% of the measurements were in this range, is one of the strengths of the present study. Bassam et al. (15) evaluated the accuracy of measuring 3D, 2D and 2 Slice images by changing the position of the patient's head in CBCT. 3D and 2 Slice images did not make any statistically significant difference between the ideal rotated position of the head in the scan. These results are clinically similar to the present study and the study of Tomasi et al. (4). In the study of Sheikhi et al. (17), the measurements were within the clinically acceptable range and the difference was less than 0.5 mm. Considering the study of Tomasi (4), Sheikhi (17) and the present study, by changing the inclination of the axial plane or the position of the patient's head, despite the slight difference between physical and radiographic measurements, CBCT linear measurements are still accurate and are in the clinically acceptable range. This is due to the fact that CBCT software allows the operator to move the axial plane and adjust it in the desired direction (17). On the other hand, in CBCT, unlike CT, there is no spatial distortion due to unisotropic voxels, so the reconstructed CBCT images have no distortion and the subject position has no effect on the linear measurement accuracy of the reformatted images (4). It is suggested that studies with more samples be done in this field. Also, a separate study should be performed by mimicking the attenuation of soft tissue radiation to investigate the possible effect of soft tissue on the accuracy of measurements.

Conclusion

The results of the present study showed that by changing the inclination of the axial plane from the standard state (parallel to the occlusal plane), the measurements were accurate and within a clinically acceptable range. In other words, by changing the angle of the axial plane relative to the standard mode, dimensional measurements are still accurate.

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Declaration of Conflicting Interests: All the authors declare that there is no conflict of interest for this project

Data availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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