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The effect of mandibular buccal tilting on the accuracy of posterior mandibular spiral tomographic images: An *in vitro* study

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ABSTRACT

Background: Accurate measurement of the height and buccolingual thickness of available bone has a significant role in dental implantology. The shadow of ramus on the mandibular second molar region disturbs the sharpness of conventional tomographic images. The aim of this study was to evaluate the effect of transferring the shadow of ramus from the center of the focal plane, by changing the position of mandible, on the sharpness of the posterior mandibular region.

Materials and Methods: In this experimental study, we used 10 dry human mandibles. Three metal balls were mounted on the midline and mandibular second molar regions bilaterally. Standard panoramic and tomographic images were taken. Then, the mandible was tilted buccaly for 8° – compensating the normal lingual inclination of the mandibular ridge and teeth on this region – and tomographic images were taken again. The height and thickness of bone were measured on the images and then compared with the real amounts measured directly on mandibles. Also, the sharpness of mandibular canals was compared between the two tomographic methods. Findings were analyzed with repeated measured ANOVA test (P<0.05).

Results: The height of mandibular bone, on the images of the tilted tomography technique was more accurate compared to standard (P<0.001), but standard tomography had more accuracy in estimating the buccolingual thickness at the half-height point. Regarding the sharpness of mandibular canals, we found no significant differences between two tomographic methods.

Conclusion: Buccal tilting is recommended when measuring the bone height is more important, but routine standard tomography is preferred when the thickness is requested.

Key Words: Buccal tilt, mandible, positioning, spiral tomography

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INTRODUCTION

Radiography has the most important role in dental implantology.[1-4] Conventional tomography, cone-beam computed tomography (CBCT), and spiral computed tomography (CT) can provide convenient cross-sectional images to recognize the vital anatomical structures and dimensions of the mandible.[4] Accurate dimensions, not overlapping, and evaluation of feasible bucco-lingual dimension are considered as their advantages.[5,6] However, high cost and dosage of X-ray exposure are disadvantages of CT.[2,7,8] In comparison with periapical radiography with rectangular collimation and F-speed film, the X-ray exposure of conventional tomography is 0.2–0.6 per each slice times less, whereas of CBCT and spiral CT are 4–42 and 25–800 times more respectively.[1] Therefore, it was aimed to find an alternative technique with maximum advantages of CT but with less cost and X-ray exposure.

When a few number of implants are needed and the anatomical variation is minimal, conventional tomography is the technique of choice.[6,8-11]

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Conventional tomography provides an image with an error less than 1 mm, and two or three cross-sectional tomographic slices are enough for each implant position.[1] In several studies the mean value of differences in measurement of the bone height has been reported in a range of ±1 mm;[8,11-14] however, it was also reported to be 2.5 mm in another study using linear tomography.[15]

In images of the posterior mandibular region, the shadow of ramus usually disturbs the sharpness. By changing the position of mandible, we tried to transfer the shadow of ramus from the center of the tomographic focal plane to let the measurements be more realistic.[16] The mandibular and alveolar bone and also teeth of the posterior mandibular region have a lingual inclination for 16°;[17,18] we tilted the mandible buccally for 8°, to omit the ramus shadow, taking true cross-sectional images. In previous studies the effect of rotating, but not tilting, the mandible was examined.[19,20]

MATERIALS AND METHODS

In this experimental study, we used 10 dry human edentulous mandibles without any turous, exostosis, or defect. Metallic balls (1 mm in diameter) were fixed by sculpture paste on a point 20 mm distal to mental foramen of both sides of each mandible, and also, a metal ball was fixed on mandibular midline (to facilitate correct mandibular positioning).

While the lower borders of mandibles were parallel to the horizontal plane and midlines were in the direction of device's guide, panoramic images with a magnification of 1.5 and tomographic images with the same magnification in four sections with 4 mm of thickness were taken.

To compensate the lingual inclination of posterior mandibular bone[17] – and fixtures - toward the alveolar ridge, the mandibles were tilted buccally for 8° and tomographic images were taken again with the same manner.

Among the images of each sample, the sharpest[8] with better view of metallic ball (mostly in a complete circle shape) was chosen. The height of bone on Images, considering the magnification of 1.5, and also on dry mandible was measured twice with a 2-week interval by a radiologist.

The thickness of bone at the half-height point and the distance between buccal and lingual cortical plates were measured on the images of both tomography techniques and on dry mandible. All the measurements on images and dry mandible were done with a 0.1 precision caliper. The sharpness of the contour of mandibular canal, were graded as 0, 1, and 2, for nondetectable, detectable, and sharp respectively.

Panoramic radiographs (with regular cassette) and tomographic images (with medium cassette) were taken by Cranex tome (SORDEX OY, Tuusula, Finland). Panoramics and tomograms were taken at minimum X-ray factors (respectively [19 s, 10 mA, 57 kvp] and [46 s, 1 mA, 57 kvp]). Radiographs were processed using an automatic processor (OPTIMAX2010, Germany), with processing solutions (Champion, IRAN) at 33°C, 1.5 minutes.

Data were analyzed with repeated measured ANOVA test.

RESULTS

Based on interclass coefficient correlation, the reliability of the two of measurement was more than 93%.

Measurements of height of the bone showed a mean value of 17.32±3.1 mm for standard tomography, 17.61±3.27 mm for tilted tomography, and 18.27±3.33 mm for dry mandible.

The analysis of data revealed no significant difference between the mean values of height of bone on the two different tomographic images (P=0.158), but significant differences between dry bone and both images were seen (P<0.001). In both methods, underestimating was more than overestimating (0.8 mm to –2.7) [Figure 1].

The mean values of buccolingual thicknesses of bone at the half-height point on standard and tilted tomographs, and dry mandible were 9.27±1.32 mm, 8.91±1.40 mm, and 9.58±1.58 mm, respectively. Data analysis showed a significant difference in the thickness of bone between three measurements (P<0.001) [Figure 2]. This difference was mainly between tilted tomography and both standard tomography and dry mandible (P<0.001), while there was no significant difference in measurements between standard tomography and dry mandible (P=0.11).

The sharpness of the image of mandibular canal was not significantly different between two tomographic methods (P=0.166) [Figures 3 and 4]; however, in 60% of tilted (12 cases), but in 35% of standard tomographic images (7 cases) the contour of canal was completely sharp.

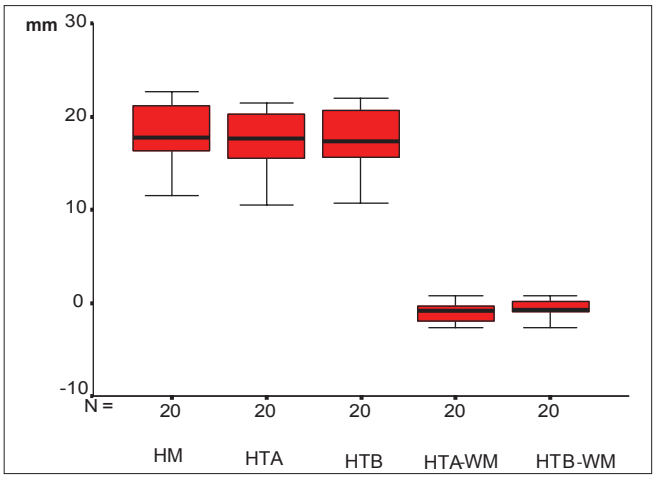

Figure 1: The heights of bone (crest-to-lower border of mandibule) in two tomographic methods and in dry mandible, H: height of crest-to-mandibular lower border/TA: standard tomography/TB: tilted tomography/M: dry mandible, HTA-HM: Subtraction of HTA and HM/HTB-HM: Subtraction of HTB and HM

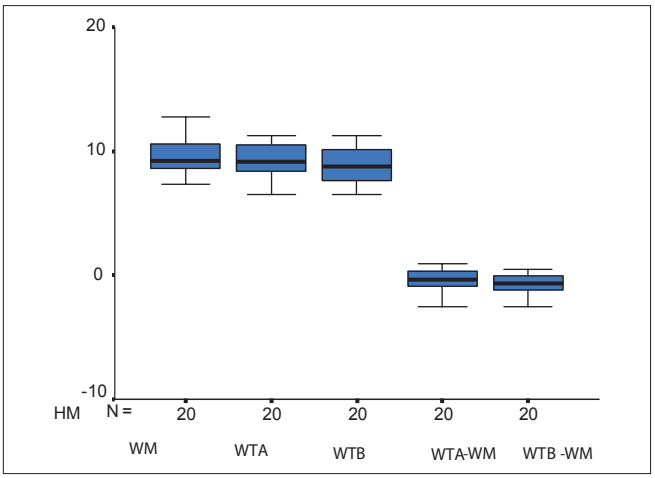

Figure 2: The alveolar ridge's buccolingual thicknesses in half-height of alveolar crest-to-mandibular lower border in two tomographic methods and in dry mandible, W: thickness in half-height of alveolar crest-to-mandibular lower border/TA: standard tomography/TB: tilted tomography/M: dry mandible WTA-WM: Subtraction of WTA and WM/WTB-WM: Subtraction of WTB and WM

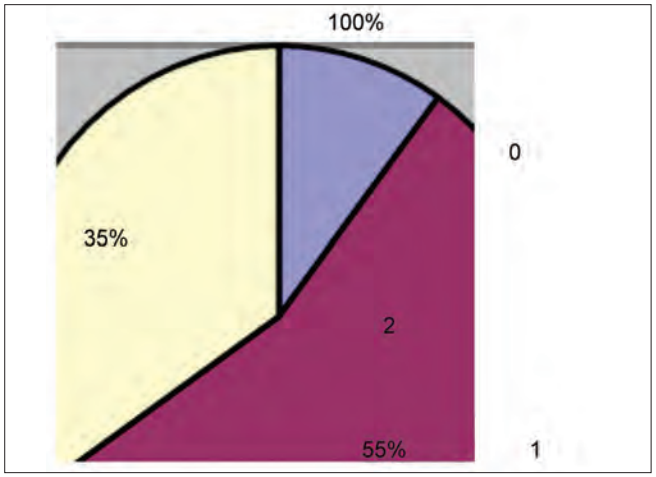

Figure 3: Canal counters' sharpness in standard tomography, Non-detectable canal counters (0)/detectable canal counters (1)/sharp canal counters (2)

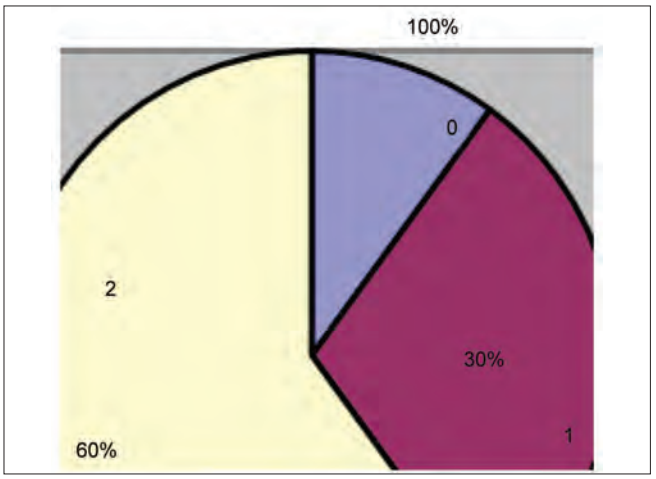

Figure 4: Canal counters' sharpness in tomography with tilt, Nondetectable canal counters (0)/detectable canal counters (1)/sharp canal counters (2)

DISCUSSION

Numerous studies have shown different accuracy of panoramic, periapical, and spiral tomographic images in implantology.[8,16,21-25] Many studies have expressed that the CT is better than conventional tomography in determining the position of mandibular canal, height, and thickness of bone;[26,27] however, conventional tomography, with lower cost and less exposure of radiation, is more acceptable.[12] Main reasons of controversies between different studies are based on patients' positioning, proper exposure factors to achieve better contrast, spiral or hypocycloidal movements,[21] image layer thickness,[9] mandibular positioning, and observers' experiences.[13]

In several studies, different amounts of overestimating (0–3 mm) and underestimating (0–3.7 mm) have been reported.[10,14,28,29] Lindh mentioned that sometimes artifacts or bone marrow space are considered as the canal and this leads to overestimation.[28] Mahdizade and Dalili believed another cause of overestimation that was referred to the radiologists' experience in interpreting the tomographic images.[14,29] In our study, underestimation was found more than overestimation in both tomographic methods. It might be related to

the avoidance of overestimating to minimize the risks during surgery. Serhal presented the curve of Spee as the cause of overestimating.[11]

In spiral tomography, the mean value of differences (MD) in measurements of the bone height has been reported in a range of ±1 mm[8,11-14] and ±2.5 mm.[15] Estimating the height of bone we found the results of standard tomography (MD: 0.9 mm) less accurate than those of tomography with tilted mandible (MD: 0.6 mm). Perhaps tilting the mandible eliminates the shadow of ramus from the image of the crest which makes it sharper and lets it be measured more accurately; this is the probable reason of the difference between two methods.

To improve the quality of images and views of mandibular canal, Dalili suggested to have the lower border of mandibule horizontal.[29] Naitoh studied the effect of the angle of the objective plane on the quality of image of linear tomography and suggested a range of 4.2° (2.5 to -1.7). This small range of angle mentioned the importance of the correct positioning.[19] Dabbaghi *et al*., who had studied the role of mandibular rotation for ±10° on the quality of images of spiral tomography, suggested the zero angle (factory suggested position) and because of significant differences, the researcher rejected the negative angles.[20]

Estimating the buccolingual thicknesses of bone at the half-height point we found the standard tomography (MD: 0.3 mm) more accurate than tomography with tilted mandible (MD: 0.67 mm). Apparently, transferring the shadow of ramus to the mandibular external border by tilting the mandible and consequently reduced sharpness of this region makes it difficult to estimate the thickness of bone.

In the case of the sharpness of the mandibular canal images Serhal believes that the cross-sectional images of the second and third molar regions can be distorted and be more oval rather than circular because of the patient's bad position.[10]

We found no significant difference between the sharpness of canal in two tomographic methods, although in 60% of tilted and 35% of standard tomographic images, the contour of canals were completely sharp, which is also explicable with the hypothesis of eliminating the shadow of ramus from the region. Therefore further studies with more samples are suggested.

CONCLUSION

Finally, it can be concluded that 8° buccal tilt of mandible, seemingly by eliminating the shadow of ramus, improves the estimation of the bone height and sharpness of the image of mandibular canal, but it is not helpful in estimating the bone thickness. In other words, buccal tilt is recommended when accurate bone height estimating is more important but routine standard tomography is preferred when the bone thickness is requested.

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