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Original Article

# Accuracy of mandibular vertical linear measurement in panoramic and tomography images

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## Abstract

**Introduction:** The measurement precision of jaw is important for surgery or installing implants. Preimplant radiographs are important part of clinical evaluations before implant surgery. For choosing location, we should consider the important anatomical structures like mental foramen, inferior alveolar canal, nasal cavity and maxillary sinus.It is important to know the measurement accuracy of radiographic techniques. The purpose of this study was to compare mandibular vertical linear measurement in panoramic and tomography images.

**Methods:** Three forms of mandible from dry adult human skulls were used in this study (triangle, square and ellipse). For each mandible, surgical stent was made using transparent with gold standard.acryl. A thin tube was placed in the stents in three regions (incisors, premolars and molars) to set gutta-percha. Then, the panoramic view and conventional tomography were obtained. Four oral and maxillofacial radiologists measured the vertical dimension in panoramic and conventional tomography. Finally, each mandible was sectioned in the marked sections and was measured by a digital caliper (gold standard) and compared with conventional tomography and panoramic view .The obtained data was analyzed using SPSS18 software and student t-test, Pearson correlation coefficient and non parametric Mann-Whitney Test.

**Results:** The mean difference between the panoramic and gold standard linear vertical dimension values in premolar and molar regions was above 1mm and above 2mm in incisor region. The mean difference between conventional tomography and gold standard measurements in all three regions was 1mm.

**Conclusions:** The linear measurement of vertical dimension in conventional tomography was more precise than panoramic. The use of a 2.0 mm safety margin in the evaluation of implant sites was recommended.In incisor area, the other radiography methods like CBCT was suggested.

**Keywords:** Implant, Panoramic, Radiography, Conventional tomography

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# دقت اندازه گیری خطی عمودی مندیبل در تصاویر پانورامیک و توموگرافی


## چکیده

**مقدمه:** دقت اندازه گیری فک برای جراحی یا نصب ایمپلنت ها حائز اهمیت می باشد. رادیوگرافی های قبل از ایمپلنت بخش مهمی از ارزیابی های بالینی قبل از جراحی ایمپلنت به حساب می آیند. برای انتخاب محل باید ساختارهای آناتومی مهم مثل سوراخ منتال، کانال آلوئولار تحتانی، حفره بینی و سینوس ماگزیلا را در نظر بگیریم. شناخت دقت و اندازه گیری تکنیک های رادیوگرافی دارای اهمیت است. هدف این تحقیق، مقایسه اندازه گیری خطی عمودی مندیبولار در تصاویر پانورامیک و توموگرافی می باشد.

**مواد و روش ها:** سه فرم مندیبل از جمجمه خشک شده فرد بزرگسال در این تحقیق مورد استفاده قرار گرفتند (مثلثی، مربع و بیضی). برای هر مندیبل، استنت جراحی با استفاده از آکریل شفاف استاندارد طلایی ساخته شد. یک لوله نازک در استنت ها در سه ناحیه قرار داده شد (اینسیزور، پریمولار و مولار) تاگاتا پرکا را تنظیم کنیم. سپس نمای پانورامیک و توموگرافی معمولی بدست آمد. چهار رادیولوژیست دهان و ماگزیلوفیشال بعد عمودی در توموگرافی پانورامیک و معمولی را اندازه گرفتند. در پایان هرمندیبل در بخش های مشخص شده برش داده شد و به وسیله یک اندازه گیری دیجیتال (استاندارد طلایی) اندازه گیری شد و با توموگرافی معمولی و نمای پانورامیک مقایسه شد. داده های حاصل با استفاده از نرم افزار SPSS نسخه 18 و t تست و ضریب همبستگی پیرسون و آزمون من-ویتنی غیرپارامتریک تجزیه وتحلیل شدند.

**یافته ها:** نتایج میانگین اختلافات بین میانگین مقادیر بعد پانورامیک و بعد عمودی خطی استاندارد طلایی در نواحی پریمولار و مولار بالای 1 mm بوده است و در ناحیه اینسیزور بالای 2 mm بوده است. میانگین اختلافات بین اندازه گیری های توموگرافی معمولی و استاندارد طلایی در هر سه ناحیه 1 mm بوده است.

**نتیجه گیری:** اندازه گیری خطی بعد عمودی در توموگرافی معمولی دقیق تر از پانورامیک بود. استفاده از یک لبه ایمنی 2 mm در ارزیابی جایگاه های ایمپلنت توصیه می شود. در ناحیه اینسیزور، شیوه های دیگر رادیوگرافی مثل CBCT پیشنهاد می شود.


**واژگان کلیدی:** ایمپلنت، پانورامیک، رادیوگرافی، توموگرافی معمولی

## Introduction

In the past decades, x-rays have been widely used in dentistry (1). Preimplant radiographs are important part of clinical evaluations before implant surgery (2-6). For choosing location, we should consider the important anatomic structures like mental foramen, inferior alveolar canal, nasal cavity and maxillary sinus (7).

Radiologists help clinicians to observe the alveolar ridge and its adjacent structures in three orientations and guide the clinicians to select the correct location, number, size and axial orientation for implant. Some radiographic techniques like panoramic, conventional tomography and cone beam computed tomography can be used for the assessment of anatomical structures. Some studies compared these techniques and other studies compared various panoramic machines to measure mandibular bone height, cortical thickness, and the position of the mandibular canal for pre-implant assessment (8).

In this study, the panoramic and conventional tomography views were used for linear measurement of mandibular vertical dimension. Considering panoramic views, we have found that magnification was different in various regions. Nowadays, some factories produce this machine claiming that the magnification in panoramic is the same in the different regions of mandible. The aim of this study was to assess the accuracy of mandibular vertical linear measurement in the panoramic and tomography images.

## Methods

Three dry mandibles (triangle, square and ellipse) were used in this study. Acrylic stent was made for each mandible. A thin and transparent plastic tube (thinner than 0.3 mm) was placed on acryl in order to set gutta-percha as a marker in molar region. The mandibles were placed on a pvc plate and laid in the panoramic machine in normal situation (so the laser beam middle line was placed in midline and frankfort line was parallel to the floor and y line crosses the maxillary canine).

Panoramic views were obtained with cranex tome machine (soredex, helsinki, finland), standard program (001), 60 kvp voltage, 4ma and 15 seconds and with kodak (ny,rochester). Transparent papers were put in each radiograph on a view box in a semi dark room.

In anterior region, a line from the middle point of labial and lingual ridge crest distance to inferior border of mandible was drawn and the length of line was measured. In premolar region, a vertical line from the middle point of labial and lingual ridge crest distance to the tangent line of roof of mental foramen was measured.

In pre molar region, a vertical line from the middle point of labial and lingual ridge crest distance to the roof of infra alveolar canal in the marked region with gutta percha was measured. The real values were obtained by sawing the dry skull mandibles with laboratory curved saw(jm, japan), measured by caliper(ocean,japan) with precision of 0.02mm, and the values obtained from radiographies were compared.

Measurement method for tomography images:

The tip of alveolar crest in buccal and lingual was connected to each other. In molar region, a vertical line from the roof of infra alveolar canal was drawn to it and measured. In premolar region, a vertical line was also drawn from the roof of mental foramen to crest alveolar. In incisor region from the inferior border of mandible, a vertical line to the mentioned line (buccal and lingual alveolar crest tip connection line) was measured by a graduated ruler.

Finally, the mandible from dry adult human skulls was sectioned using a jm laboratory curved saw with 0.5mm thickness. The section regions in incisors, premolars and molars with the above explanation were measured with precision 0.02 and by 1.50 ocean digital cuils made in Japan and recorded in table1.

We considered this real measurement as a gold standard and compared it with panoramic and tomography measurements. The obtained data were analyzed using SPSS 18 software and student t-test, Pearson correlation coefficient and nonparametric Mann-Whitney Test.

## Results

The average height of mandibular regions in panoramic and tomography radiography was compared with gold standard measurement (table 1). Generally, in 27 measurement cases, the amount of error in tomographic and panoramic images was 1.13±0.7 and 1.53±1.01, respectively (p=0.01) (table 2). Generally, in 27 measurement cases the amount of error in tomography and panoramic images was 1.13±0.7 and 1.53±1.01 respectively (p= 0.01).


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**Table 1. Height of the measured regions of mandible in tomography, panoramic and dry adult human skulls**

| | Mandible Number | Marker Number | T1 | P1 | T2 | P2 | T3 | P3 | T | P | Gs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 30.00 | 27.30 | 30.00 | 27.69 | 30.00 | 27.30 | 30.00 | 27.43 | 30.85 |
| 2 | 1 | 2 | 12.27 | 12.69 | 12.33 | 12.30 | 12.27 | 12.30 | 12.29 | 12.43 | 13.68 |
| 3 | 1 | 3 | 13.33 | 12.69 | 13.33 | 13.46 | 13.33 | 13.07 | 13.33 | 13.42 | 12.48 |
| 4 | 2 | 1 | 29.33 | 27.69 | 30.66 | 28.46 | 30.66 | 27.69 | 30.22 | 27.95 | 28.80 |
| 5 | 2 | 2 | 15.33 | 17.69 | 15.33 | 16.92 | 16.00 | 16.15 | 15.55 | 16.92 | 15.50 |
| 6 | 2 | 3 | 16.66 | 16.15 | 17.00 | 17.96 | 16.66 | 16.15 | 16.77 | 16.66 | 14.94 |
| 7 | 3 | 1 | 40.66 | 36.15 | 41.00 | 36.15 | 40.66 | 36.15 | 40.77 | 36.15 | 39.00 |
| 8 | 3 | 2 | 18.30 | 17.30 | 20.60 | 17.30 | 20.33 | 17.30 | 19.74 | 17.30 | 18.19 |
| 9 | 3 | 3 | 17.33 | 16.53 | 16.66 | 16.15 | 17.33 | 16.15 | 17.11 | 16.28 | 17.09 |

T: mean of tomography measurements, $t_1$: tomography in stage1, $t_2$: tomography in stage2, $t_3$: tomography in stage3.
P: mean of panoramic measurements, $p_1$: panoramic in stage1, $p_2$: panoramic in stage2, $p_3$: panoramic in stage3.
Marker number: 1: region of incisors, 2: region of premolars, 3: region of molars.
Gs: measurement of dry adult human skulls measurment (gold standard).

**Table 2. Comparison of precision measurement in tomography and panoramic images with gold standard measurement**

| Mandible region | Gold standard measurement mean±SD | Absolute value of tomography differences with gs measurement mean±SD | Absolute value of panoramic differences with gs measurement mean±SD | P-value |
|---|---|---|---|---|
| Incisor | 32.88±5.39 | 1.34±0.56 | 2.37±1.19 | 0.039 |
| Premolar | 15.79±2.6 | 1.07±0.87 | 1.18±0.46 | 0.74 |
| Molar | 14.83±2.30 | 0.99±0.68 | 1.04±0.71 | 0.887 |

## Discussion

Recent studies have compared the accuracy of vertical linear measurement of tomography and panoramic images and with gold standard. In this study, the linear measurement of vertical dimension of mandible in tomography images was more accurate than panoramic. Totally, the measured linear dimensions in tomography were closer to gold standard. The measured bias in regions of incisor, premolar and molar was obtained 1±1 mm.

In panoramic images, the measured bias in the incisor region was above 2mm and in the other regions was 1 to 2mm. Also in panoramic, we observed the most biased device to measure was in the incisor region, and the least biased device to measure was in the premolar region. In tomography, the most biased device to measure was in the incisor region, and the least biased device to measure was in the molar region. Also In tomography, the most biased device to measure was related to triangular mandible and the least biased device was related to square mandible. While in panoramic, the most biased device belonged to the ellipse mandible and the least biased device belonged to the square mandible. The measurement of incisor regions in both panoramic and tomography radiography demonstrated the most biased measurement device.

The vertical linear dimension measurment in tomography images was more accurate than panoramic. The difference of linear measures between panoramic and tomography radiography in premolar and molar regions is not significant. In incisor region, panoramic radiography is less reliable than tomography. Therefore, according to measurement, the incisor region has the most biased in linear




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measurement obtained from both techniques (panoramic and conventional tomography) and demonstrated the least precision for pre-implant radiographic assessment. Thus, this study strongly suggests the other radiography methods like cone beam computed tomography for implant site assessment of incisor region.

It is important to mention that, although, cone beam computed tomography (CBCT) has considerable accuracy in linear measurement, but it provides more radiation dose and economic costs for patients than the panoramic and conventional tomography. Also, cone beam computed tomographty is not available and widespread as a frequent technique like panoramic and conventional tomography.

In an investigation using cone beam computed tomography and dry human skulls concluded that although the CBCT image underestimate the real distance between skull sites, the differences were only significant for the skull base and therefore it was reliable for linear evaluation measurements of other structures more closely associated with dento maxillofacial imaging (9).

In 2003 Hatcher et al. declared that CBCT allows the clinicians to adequately assess the implant site(9). In 2010 Naitoh et al. declared that the postoperative findings of incisor implants could be assessed using CBCT (10). Totally the approximate measurements of premolar and molar regions are more reliable. Panoramic systems can be useful for vertical measurements of a potential implant site in the posterior mandible. Some other studies like in Bolin et al. suggest tomography radiography for the evaluation of the available bone height in mandibular region posterior to the mental foramen (11). However, some studies recommended other modalities for more accuracy. In 2012 Alamri et al. declared that CBCTt is the preferred option for implant dentistry, providing greater accuracy in measuring compared to 2d imaging, while utilizing lower doses of radiation in comparison with ct (12_25).

Parnia et al. declared that cross-sectional imaging like computed tomography provides excellent delineation of mandibular anatomy for pre-implant assessment (26). In 2008 Angelopoulos et al .declared that due to the fact that the CBCT images were reformatted, slices of the mandible were free of magnification, superimposition of neighboring structures, and other problems inherent to panoramic radiology. This may result in very clear images that better depict the anatomical structure like mandibular canal (27). Magnetic resonance imaging is showing some promises, but the examinations are not readily available, generally expensive and bone was not provided with good images. Magnetic resonance imaging is excellent for demonstrating soft tissues and therefore may be of great use in identifying the inferior dental nerve and vessels.

All of the above technology is of little value if the information required is not obtained and so information is also provided on imaging of some of the vital structures. Of particular interest is the inferior dental canal, incisive canals of the mandible, genial foramina and canals, maxillary sinus and the incisive canal and foramen of the maxilla (28). Rockenbach et al. pointed out that both techniques were reliable for the accomplishment of vertical linear measurements in the premolar and molar areas (29). Although providing the human dry mandibles was difficult, but using them instead of the phantoms was one of the strong points of this study because of its similarity to the patient's oral condition and measurement bias.

## Conclusion

We conclude that the conventional tomography is more accurate than panoramic radiography in mandibular linear measurement of vertical dimension such as pre-implant assessment. We recommend the use of a 2.0 mm safety margin in the evaluation of implant sites. The incisor region has the most biased in both techniques, so this study strongly suggests the other radiography methods like cone beam computed tomography for pre-implant assessment of the incisor area.

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**Conflict of interest:** We declare that there is no conflict of interest.

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