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Comparison of Vertical Magnification Ratio among Various Areas in Panoramic Radiographs

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Purpose: The objective of the present article is to determine whether there are differences in vertical enlargement ratio among various sites within both jaws in a panoramic radiograph.
Materials and Methods: Two hundred and seventy-threeimplant sites in panoramic radiographs were evaluated by two observers. Magnification ratios at various sites in both jaws were calculated and compared with each other.
Result: The average vertical enlargement ratio in the panoramic radiograph was 1.264 and this value was larger than original ratio 1.250. Although vertical magnification ratio of maxillary molar area was higher than that of mandibular molar area, every group showed similar magnification ratio in clinical respect.
Conclusion: Vertical magnification ratio of the maxillary molar area is statistically higher than that of the mandibular molar area in the panoramic radiograph, but it is clinically negligible.

Key Words: Dental implants; Radiographic magnification; Radiography, panoramic

Introduction

Implant placement has become a common procedure to replace lost dentition nowadays. Radiographic examination is considered a prerequisite for pre-operative planning in implant treatment in order to evaluate bone quantity, quality and anatomical limitations. The most widely used radiographic tool in dentistry is the panoramic radiography, by virtue of its short taking time, low radiation dose, and inexpensiveness. Despite the inherent disadvantages such as distortions due to the two-dimensional nature, panoramic radiograph often gives us sufficient information to analyze available edentulous ridge height by enabling the localization of important anatomic landmarks, such

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as mandibular canal and sinus floor.

Vazquez et al.[1] stated that panoramic radiographic examination could be a standard radiographic examination, especially for implants installed in the posterior segment of the lower jaw, and most patients might not benefit from more extensive imaging techniques that impart a higher radiation dosage. Other authors demonstrated that for simple cases with a wide residual ridge and ample ridge height, clinical examination and panoramic/periapical radiography is sufficient[2-4]. On the other hand, others claimed that taking only panoramic radiography may not be sufficient enough, insisting the need for additional diagnostic tools, such as multislice or cone-beam computed tomography (CT or CBCT), mainly because of the distortion, overlapping of anatomic landmarks and low reproducibility of the image[1,2,5-7].

In order to verify the reliability of panoramic radiograph in implant treatment planning, especially when determining size of the implant, it is essential that we are aware of the extent of image distortion depending on locations within both jaws. Therefore, the aim of this study is to determine whether there are differences in vertical enlargement ratio among various sites within both jaws in a panoramic view.

Materials and Methods

1. Patient and Radiograph Selection

One hundred and fifty-three patients treated with implants in the Sahmyook Adventist Dental Hospital, Seoul, Korea were included in this study. Two hundred and seventy-three implant sites were evaluated from the panoramic radiographs taken between July 2008 and April 2014.

The radiographic images were taken by a digital panorama (ORTHOPHOS-XG5; SIRONA, Bensheim, Germany). The manufacturer's list included the magnification factor for this panoramic image as 1.25. The images were viewed in the imaging software (π-view STAR; Infinitt Healthcare, Seoul, Korea) and in this program implant (R-line; Camlog, Stuttgart, Germany) (Superline/Implantium; Dentium, Seoul, Korea) length was calculated.

The inclusion/exclusion criteria were like the followings. All included subjects were older than 18 years and only premolar and molar areas were investigated. The panoramic images should be clear so that implant margin can be distinguished. Only symmetric images were included. To calculate exact magnification ratio, excessively angulated implants that did not show clear thread line were excluded. Images with absence of adjacent tooth for the reference were excluded as well.

2. Implant Height Measurement in the Radiographic View

Subject was divided into 4 groups (Table 1). The lengths of implants shown on post-surgical digital panoramic radiographs were calculated from the coronal surface of cover screw to the implant tip. Implants made by Camlog have abutment of flat coronal surface so in the measurements of Camlog implant, abutment length was either included or not, which did not appear to affect the accuracy of the measurements (Fig. 1). For more consistent and accurate measurement, constant magnification rate (200%) was applied to each panoramic image.

Implant length measurements were conducted twice by two respective observers, so total number was 4 times of actual implant numbers. Each participant did analysis twice with 1-week interval and measured images were saved as jpeg file.

Table 1. Classfication of the groups according the the implant sites

Area	Premolar	Molar
Maxilla	MxPM	MxM
Mandible	MnPM	MnM

MxPM: maxillary premolar, MxM: maxillary molar, MnPM: mandibular premolar, MnM: mandibular premolar areas.

3. Calculation of Magnification Ratio

The lengths of actual implant fixture and those measured from the radiographic image were compared and vertical magnification ratios were calculated according to the following (Fig. 2).

Implant enlargement ratio=measured implant length (mm)/actual implant length (mm)

4. Statistical Analysis

Data were exported to a statistical program (IBM SPSS ver. 22.0; IBM Co., Armonk, NY, USA) for the calculation of each group's average and standard deviation (SD) of the magnification factor. One sample t-test was performed for the comparison of the magnification ratio obtained from the measurements and that suggested by the manufacturer (1.25). Besides, group comparison was performed by one-way ANOVA or unpaired t-test. The statistical significance level of $P<0.05$ was used. Interobserver and intraobserver reliabilities

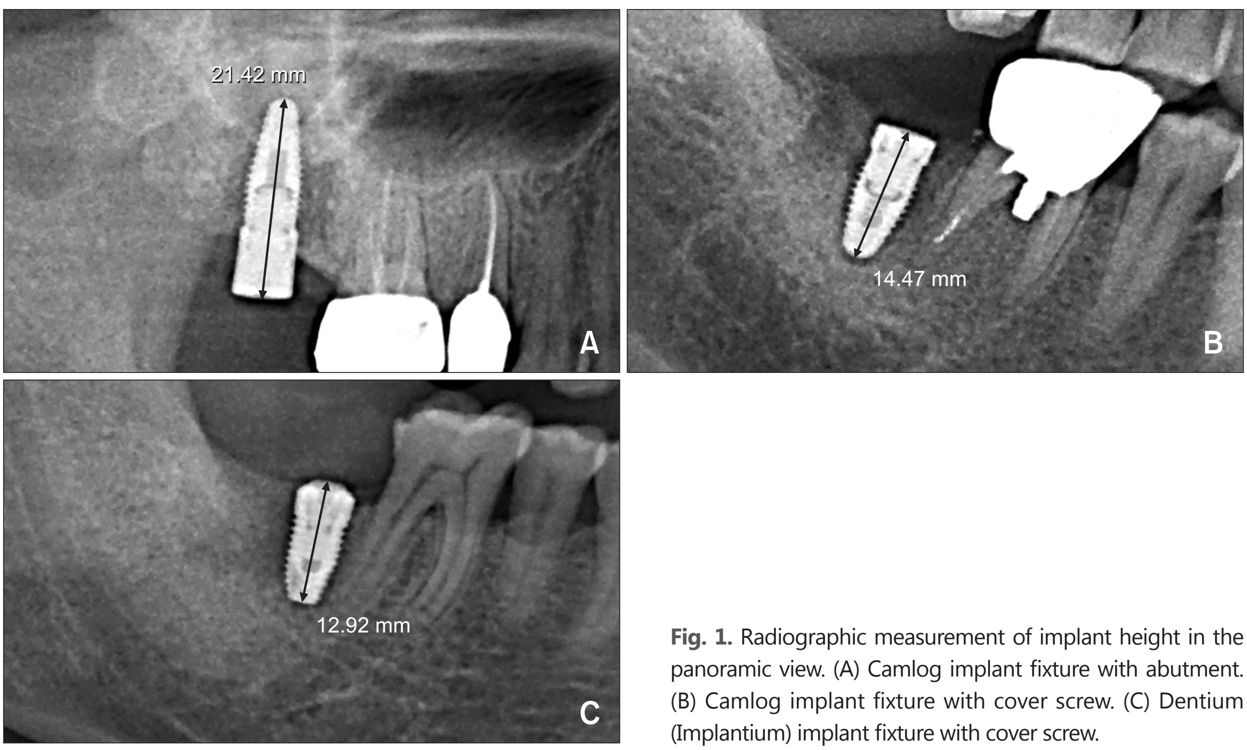

Fig. 1. Radiographic measurement of implant height in the panoramic view. (A) Camlog implant fixture with abutment. (B) Camlog implant fixture with cover screw. (C) Dentium (Implantium) implant fixture with cover screw.

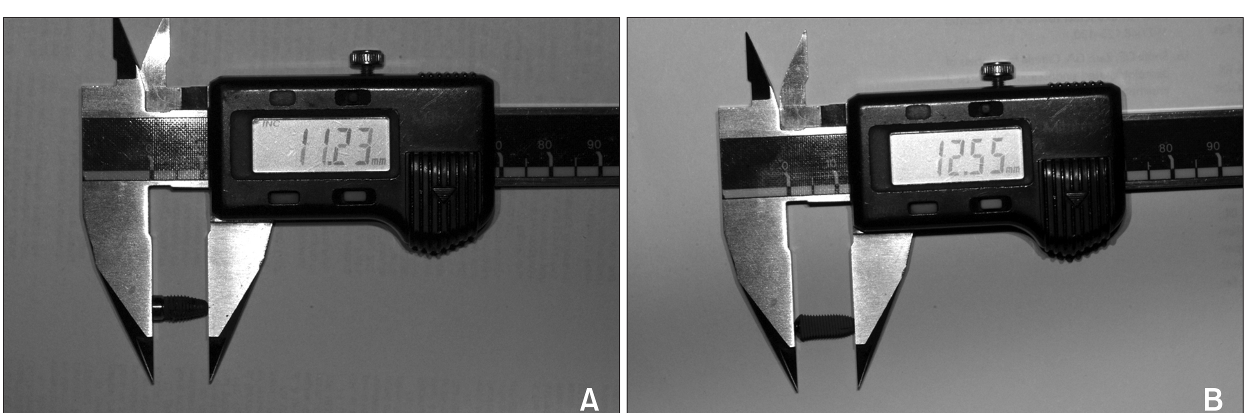

Fig. 2. Clinical measurement of implant height by vernier calipers. (A) Camlog implant. (B) Dentium implant.

were calculated by intra-class correlation coefficient (ICC).

Result

1. Distribution of the Implant Sites

Distribution of the implant sites are shown in the Table 2 and Fig. 3. According to the implant sites four groups were defined as maxillary premolar (MxPM), maxillary molar (MxM), mandibular premolar (MnPM), and mandibular molar (MnM) groups. MnPM group showed the lowest number of implant sites as 19, and other sites the number were over 30.

Table 2. Descriptive statistics of magnification ratio in the four groups

Area	Number	Mean±SD	Min~Max
MxPM	33	1.267±0.023	1.200~1.313
MxM	134	1.268±0.021	1.191~1.315
MnPM	19	1.262±0.023	1.209~1.296
MnM	87	1.256±0.024	1.197~1.319
Total	273	1.264±0.023	1.191~1.319

SD: standard deviation, Min: minimum, Max: maximum, MxPM: maxillary premolar, MxM: maxillary molar, MnPM: mandibular premolar, MnM: mandibular premolar areas.

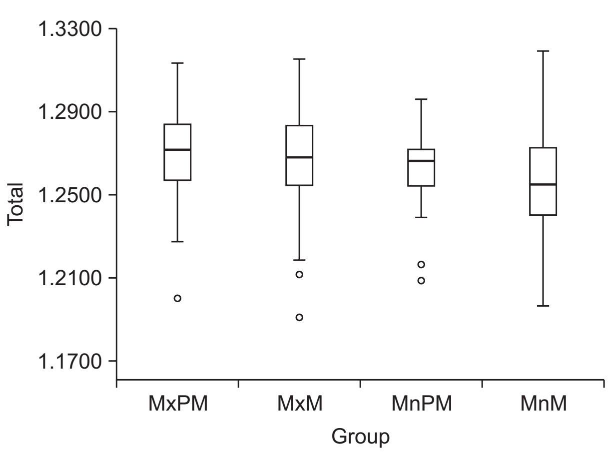

Fig. 3. Distribution of magnification ratio in the four areas. MxPM: maxillary premolar, MxM: maxillary molar, MnPM: mandibular premolar, MnM: mandibular premolar areas.

2. Comparison with Original Magnification Ratio

Average magnification ratio of total area was 1.264 (SD=0.023, n=273), and this value was statistically different with original ratio 1.250. Also other groups showed statistically different with original ratio. MxM area's ratio was the highest value.

3. Group Comparison

MxPM group showed mean enlargement ratio 1.267 (SD=0.023, n=33), MxM group showed 1.268 (SD=0.021, n=134), MnPM group showed 1.262 (SD=0.023, n=19), and MnM group showed 1.256 (SD=0.024, n=87). Only between MxM and MnM groups, there was a statistically significant difference. Other groups didn't show statistically significant difference (Fig. 4).

4. ICC

ICC value was 0.995 among two observer's 1st, 2nd measurement. Therefore, interobserver and intraobserver reliability can be considered proper.

Discussion

In this study, we calculated magnification ratios from four different sites, in respective premolar and

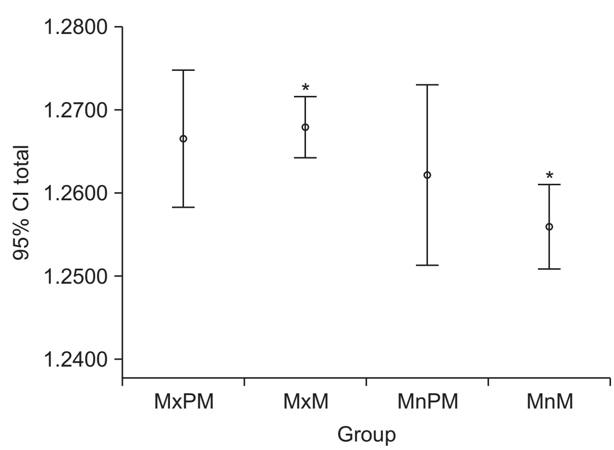

Fig. 4. Each group comparison (95% confidence interval [CI] for the mean) of the enlargement ratio. MxPM: maxillary premolar, MxM: maxillary molar, MnPM: mandibular premolar, MnM: mandibular premolar areas. *Statistical difference between groups.

molar areas in maxilla and mandible, using implant as a reference material in panoramic radiographs. This study revealed from a statistical point of view that vertical magnification ratio of the MxM area was significantly higher than that of the MnM area in panoramic radiographs.

Panoramic radiography shows a magnifying effect during the image formation due to the distance between the radiation source, the object and the image receptor[8]. Whilst the particular anatomical area of a patient's head located within the image layer would appear without distortion on the radiograph, the positional discrepancy between the jaw and the image layer produces various magnification ratios depending on locations within a jaw.

Magnification factor in panoramic radiograph can be calculated in two dimensions-horizontal and vertical factors. Many previous literatures described that vertical magnification factor is reliable and constant when patient is in upright position, whereas horizontal magnification has wide variation[5,9-12]. However, previous studies showed conflicting results on vertical magnification rate differences among various sites. Gomez-Roman et al.[13] calculated magnification ratios using implants and reported vertical magnification ratios were higher in the maxilla than in the mandible. Kim et al.[14] measured vertical enlargement of implants already placed in the oral cavity, and found a tendency of slightly greater enlargement in maxilla than in the mandible.

In contrast, several studies revealed that there was no difference in vertical magnifications regardless of the locations in the oral cavity. Schropp et al.[9] found that there were no vertical magnification ratio differences between maxilla and mandible, or among variable positions in the same arch. Other studies also showed no differences among variable positions in the mandible[4,12].

In our study, similar magnification ratios were shown in all areas. Although vertical magnification ratio in the MxM area was statistically higher than that in the MnM area, this difference was only 0.012. Therefore it is difficult to state its clinical significance. We measured vertical magnification ratio in the premolar and molar areas, and total mean vertical magnification ratio was 1.264, with ranges from 1.191 to 1.319. Considering that the magnification ratio given by manufacturer is 1.25, one should always be cautious when determining size of the implant using only the panoramic radiograph and the magnification ratio suggested by the manufacturer because of its variation.

Many studies used various reference markers, such as metal ball, metal bar, gutta percha and implant, for analyzing magnification ratio[9,11,15,16]. The advantages of metal ball are its symmetrical shape and easy to measure. However, information on the marker's angulation cannot be obtained. Gutta percha has a rope shape but it is too thin for measuring angulation or height. Autoclavable metal bar is convenient for the measurement and easy to analyze angulation with[9,17,18]. Implant used in this study can be a good reference material because of the accurate height manufactured by delicate machine, Their cylindrical shape is also favorable structure for analyzing angulation.

In the present study, the number of premolar sites was too small compared to other sites. Many panoramic images were excluded because of the inadequate angulation. More data from premolar sites are needed to obtain reliable result. Moreover, because the thickness and shape of image layer of panoramic x-ray machine may be variable according to the manufacturer, it is difficult to apply the present findings to anonymous system. Additional research is recommended for other company's machines.

Conclusion

Within the limit of the study, vertical magnification ratios were similar among various tooth sites in the panoramic radiography. Although vertical enlargement ratio of the MxM area was statistically higher than that of the MnM area, it is considered clinically negligible.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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