Cross-sectional Study of the Factors that Influence Radiographic Magnification of Implant Diameter and Length

Yong-Geun Choi, DDS, MPH, MPH[1]/Young-Kyun Kim, DDS, PhD[2]/
Steven E. Eckert, DDS, MS[3]/Cheong-Hwan Shim, DDS[4]

Purpose: *To study the factors that influence radiographic magnification of implant diameter and length.* ***Materials and Methods:*** *The dental records and panoramic radiographs of 80 patients with 210 dental implants treated with implant-supported prostheses at Bundang Jesaeng Hospital in South Korea from January 2000 through February 2003 were reviewed. The panoramic radiographs were developed under standardized conditions. The patient's gender and the anatomic locations of implants were identified from the dental records. To prevent bias, a blinded investigator measured implant diameter and length on a panoramic radiograph. To evaluate intra-examiner variability, the intraclass correlation coefficient (R_I) was calculated. The Mann-Whitney rank-sum test and the Kruskal-Wallis test were used to determine the statistical significance of the difference between actual length and radiographic length.* ***Results:*** *The intraclass correlation coefficients (R_I) were 0.83 for diameter and 0.87 for length. There was no statistically significant difference in length in regard to gender (*P = *.08). Magnification of diameter did differ on the basis of gender (*P = *.03; 25% magnification in radiographs of women; 20% in men). No difference in diameter was found in regard to anatomic location (*P = *.51), however, while evidence of difference in length in regard to anatomic location was found (*P = *.01).* ***Discussion:*** *Radiographic magnification of implant dimensions in diameter and length can have different influencing factors.* ***Conclusions:*** *This study found that radiographic magnification of implant diameter was influenced by gender, whereas radiographic magnification of implant length was influenced by anatomic location. Each anatomic location had a different amount of radiographic magnification for implant length.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:594–596

Key words: *dental implants, radiographic magnification*

Because of their low cost and availability, panoramic radiographs are frequently used when endosseous dental implant placement is planned. Since panoramic radiographs tend to magnify an object's size vertically and horizontally, diagnostic templates that incorporate spheres or wires of known diameter have been developed.[1] However, the curvature of the alveolus and the inclination of the bone make the dimensions of inclined structures in panoramic radiographs unreliable. In addition, few studies have specified the magnitude of radiographic magnification variability depending on the anatomic location or have investigated the impact of gender on radiographic magnification using large study samples and scientific methodologies. The purpose of this study was to determine the influences of gender and anatomic location on the magnitude of radiographic magnification of implant diameter and length.

MATERIALS AND METHODS

Dental records and panoramic radiographs of all patients treated with implant-supported prostheses at Bundang Jesaeng Hospital in South Korea from January 2000 through February 2003 were reviewed. Eighty patients with 210 implants were included in the study. Patient age ranged from 17 to 70 years

[1]Private Practice, Seongnam City, Kyunggi do, South Korea.
[2]Chairman, Department of Dentistry, Seoul National University Bundang Hospital, Seongnam City, Kyunggi do, South Korea.
[3]Associate Professor, Department of Dental Specialties, Mayo Clinic, Rochester, Minnesota.
[4]Fellow, Department of Dentistry, Seoul National University Bundang Hospital, Seongnam City, Kyunggi do, South Korea.

Correspondence to: Dr Yong-Geun Choi, EB Dentistry, 303 Hana Plaza, Jeongja 1 dong, Bundang gu, Seongnam City, Kyunggi do 463-811, South Korea. Fax: + 82 31 715 5246. E-mail: drchoi@mailsnua.snua.or.kr

and averaged 40 years. Thirty-eight of the patients (48%) were women; 42 (52%) were men.

The apparatus used to obtain the panoramic radiographs was Orthoralix S (Dentsply Gendex, Milan, Italy). According to the manufacturer's manual, 74 kV tube voltage, 10 mA, a 12-second exposure time, and 7-mm adaptation of focal trough to jaw morphology were set. All radiographs were taken with 35 × 43-cm Kodak MXG-I medical x-ray films with Lanex medium (Eastman Kodak, Rochester, NY). Radiographs were developed with a Gendex GXP (Dentsply Gendex) automatic processing unit. Patient age and gender and the anatomic locations of the implants were identified from the dental records.

Implant diameter and length were measured on panoramic radiographs by 1 of the investigators under standardized conditions using the same view box, light, and evening time period. To prevent systematic error in measuring the specific dimensions, the examiner was blinded to the age and gender of the patients and the reported implant diameters and lengths. To evaluate intra-examiner variability, 17 of the 210 implants were measured again after 30 days. The intraclass correlation coefficient (R_I) was calculated to express intra-examiner variability.[2] The percent magnification was established using the following formula:

$$\frac{\text{Radiographic diameter} - \text{measured diameter}}{\text{Measured diameter}} \times 100\%$$

The Mann-Whitney rank-sum test was used to examine the statistical significance of the difference in radiographic magnification of implant diameter and length in regard to gender. The Kruskal-Wallis test was used to examine statistical significance of the difference of radiographic magnification of implant diameter and length among different anatomic locations. The statistical package used was JMP 5.0.1 (SAS Institute, Cary, NC).

RESULTS

Intra-examiner agreement for the measurement of radiographic magnification was excellent, with correlation coefficients of 0.83 for diameter and 0.87 for length.[3] These data show that random measurement error related to intra-examiner variability was negligible.

The evidence showed that the magnification of implant length did not vary with regard to gender (P = .08). In contrast, diameter magnification did vary with regard to gender (P = .03). In radiographs of women, implant diameter was magnified by 25%; whereas in radiographs of men, it was magnified by 20% (Table 1).

Table 1 Radiographic Magnification of Implants by Gender

	Overall (%)	Female (%)	Male (%)
Diameter	24.0	25.0	20.0
Length	26.9	26.8	26.9

Table 2 Radiographic Magnification of Implants by Anatomic Location

Location	Diameter (%)	Length (%)
Maxilla		
Right		
Anterior	30.7	27.2
Premolar	25.0	29.2
Molar	23.3	30.4
Left		
Anterior	20.0	26.7
Premolar	25.0	30.6
Molar	21.7	30.2
Mandibular		
Right		
Anterior	21.5	29.2
Premolar	30.0	26.2
Molar	20.0	24.0
Left		
Anterior	32.0	23.0
Premolar	25.0	27.3
Molar	20.0	25.5

No difference in magnification of the diameter was found in regard to anatomic location (P = .51). However, differences in magnification of implant length did exist among the different locations (P = .01). Each anatomic location evaluated demonstrated a different amount of radiographic magnification in regard to implant length (Table 2).

DISCUSSION

To plan for the surgical placement of dental implants, the clinician must have knowledge of the volume of bone in the anticipated implant site. Many techniques have been suggested to evaluate the bone. These include dental radiographs, bone sounding, computerized tomography, and exploratory surgery. Each of these methods of evaluation is associated with a different level of reliability and a different physical and economic impact. In selecting a method of evaluation, the prudent clinician should seek the most accurate, least invasive, and least costly approach. Unfortunately no single technique meets all of these criteria. This study evaluated the effect of location and gender on image magnification for one of the most common methods of implant site assessment: the panoramic radiograph.

Every effort was made to prevent or evaluate errors and bias in the collection and measurement of data. After the pattern of distribution of data was found to be abnormal, random sampling error was assessed using a nonparametric method of statistical analysis. Systematic sampling error was minimized by collecting all patients' dental records and panoramic radiographs. Performance bias was controlled because all implants studied were placed by a single surgeon. Detection bias and systematic error in the measurement of the radiographs were controlled by blinding the examiner to the actual implant diameter and length.

Several studies have considered factors that could influence radiographic magnification. Szabo and coworkers[4] studied the magnification ratio by radiographic technique. Patient positioning was emphasized in the studies of Tronje and associates.[5] Treasure and colleagues,[6] McDavid and associates,[7] and Stevens[8] asserted that the usual assumption of 15% radiographic magnification is erroneous and misleading because Stevens found that osseous magnification ranged from 3% to 36%.

Gomez-Roman and colleagues[9] published a study in which radiographic magnification was specified by anatomic location. A dry skull with 26 implants, with no soft tissue or simulated soft tissue, was examined. The vertical enlargement ratio ranged from 1.21 to 1.29. The horizontal enlargement ratio ranged from 1.15 to 1.35. Radiographic projection conditions were modified to compensate for the missing soft tissue cover. No statistical tests were performed to determine statistical significance of difference of radiographic magnification in various anatomic locations. On the basis of this study, the authors proposed an enlargement of 1.3 in the vertical axis and 1.35 in the horizontal axis.

In contrast, the current study investigated the impact of gender and anatomic locations on magnification in panoramic radiography. The specifications of the projection conditions recommended by the manufacturer were used.[10] Statistical significance tests were used to compare the difference in radiographic magnification in regard to gender and anatomic location. Differences between the imaged implant length and diameter and the actual length and diameter were found. Gender was correlated with magnification differences in implant diameter, while anatomic location of the implant was correlated with magnification differences in implant length.

The effect of different radiographic equipment was not studied in this report. It is likely that the use of different equipment would have an effect on magnification, as focal trough can vary from machine to machine. Therefore, the magnification reported in this study cannot be extrapolated to other brands of equipment without further study. Also, magnification may be influenced by the patient's jaw size, jaw shape, and positioning with respect to the x-ray equipment. Since this study did not collect data regarding these variables, further study is demanded.

In the current study, the differences in magnification that were observed may be related to the location of the target object, an endosseous implant, within the focal trough. Location within the anatomic arch can affect magnification of implant length by a minimum of 20% and a maximum of 32% using the equipment specified in this study. The clinician is cautioned to study the effect of magnification before making clinical decisions based on panoramic radiographs. Furthermore, acceptance of a "standard" magnification figure, even if it is an accurate average, could place implants in unfavorable positions when vital anatomic structures are in close proximity to the anticipated implant site.

CONCLUSIONS

This study found that radiographic magnification of implant diameter was influenced by gender, whereas radiographic magnification of implant length was influenced by the anatomic location of the implant in this patient population under the stated conditions.

REFERENCES

1. Misch CE. Contemporary Implant Dentistry, ed 2. St Louis: Mosby, 1999:76–77.
2. Feinstein AR. Principles of Medical Statistics. Boca Raton, FL: Chapman & Hall, 2002:430.
3. Burdock EI, Fleiss JL, Hardesty AS. A new view of interobserver agreement. Pers Psychol 1963;16:373–384.
4. Szabo G, Keck B, d'Hoedt B. Praimplantologische Diagnostik mit individuellen Rontgenschablonen im Orthopantomogramm. Z Zahnarztl Implantol 1991;7:33–36.
5. Tronje G, Welander U, McDavid WD, Morris CR. Image distortion in rotational panoramic radiography: I. General considerations. Acta Radiol Diagn (Stockh) 1981;22:295–299.
6. Treasure P, Chandler NP, Wilson CG. Image shift of intracoronal pins viewed on bite-wing and panoramic radiographs. Oral Surg Oral Med Oral Pathol 1994;77:80–85.
7. McDavid WD, Dove SB, Welander U, Tronje G. Dimensional reproduction in direct digital rotational panoramic radiography. Oral Surg Oral Med Oral Pathol 1993;75:523–527.
8. Stevens PM. Radiographic distortion of bones: A marker study. Orthopedics 1989;12:1457–1463.
9. Gomez-Roman G, Lukas D, Beniashvili R, Schulte W. Area-dependent enlargement ratios of panoramic tomography on orthograde patient positioning and its significance for implant dentistry. Int J Oral Maxillofac Implants 1999;14:248–257.
10. Dentsply Gendex Orthoralix S Operating Manual. Milan, Italy: Dentsply Gendex, 1996:17–58.