Rotational Panoramic Versus Intraoral Rectangular Radiographs for Evaluation of Peri-implant Bone Loss in the Anterior Atrophic Mandible

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Purpose: *In patients with atrophic mandibles, elevation of the floor of the mouth often prevents intraoral rectangular radiography for longitudinal follow-up studies, while extraoral techniques such as panoramic radiographs tend to produce distorted views of the interforaminal region. In this study, intraoral rectangular radiographs and panoramic radiographs were compared for their accuracy in evaluating peri-implant bone loss.* ***Materials and Methods:*** *In a recall program, 22 patients with 88 screw-type implants (44 MKII and 44 Frios) were followed. Interforaminal marginal bone loss was evaluated by extraoral orthopantomograms and by intraoral rectangular radiographs. In addition, pocket depth, Periotest readings, and bleeding on probing were recorded. For statistical analysis, the Spearman coefficient of correlation was used. The effects on bone loss and clinical variables were computed with a mixed model and the Bland and Altman method.* ***Results:*** *Computed as least square means, the mean difference between panoramic radiographs (2.4 ± 0.2 mm for MKII implants and 1.6 ± 0.2 mm for Frios implants) and intraoral radiographs (2.6 ± 0.2 mm and 1.4 ± 0.2 mm, respectively) was 0.2 mm (range, 0.1 to 0.8 mm).* ***Discussion:*** *In this study, the 2 imaging techniques were comparable clinically in terms of the precision with which they could be used to measure marginal bone loss.* ***Conclusion:*** *For highly atrophic mandibles with unfavorable imaging conditions, rotational panoramic radiographs can be a useful alternative to intraoral small-format radiographs for evaluating peri-implant bone loss.* INT J ORAL MAXILLOFAC IMPLANTS 2003;18:873–878

Key words: *atrophy, dental implants, intraoral radiography, mandible, panoramic radiography*

Annual recalls of implant patients are important for detecting inflammatory processes and peri-implant bone loss and for planning necessary early intervention. Implant success is generally evaluated on the basis of clinical findings such as the severity of peri-implantitis, bleeding on probing, pocket depth, and implant mobility.[1–3] Radiologic follow-up examinations can provide evidence of changes in peri-implant bone over time. To monitor marginal bone loss, conventional imaging techniques such as (intraoral) dental films and (extraoral) panoramic radiographs have been recommended postoperatively.[4–8] However, these provide reliable and reproducible information only if imaging errors related to the beam geometry and resultant asymmetric distortions are precluded. Consequently, rectangular imaging techniques with symmetric distortion (isometric magnification) have been advocated for the evaluation of peri-implant bone loss.[9,10]

Depending on the implant surface, mean marginal bone loss should not exceed 0.2 mm in the first year postimplantation and 0.2 mm annually in subsequent years.[1,2,11–15] Several authors have reported that orthopantomograms (OPTs) are useful for following interforaminal implants in the

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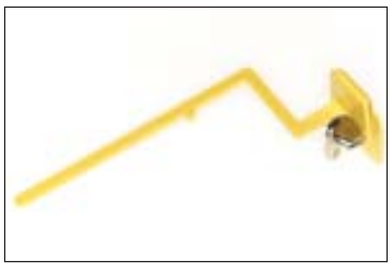


Figs 1a to 1c *(Left)* Implant-supported film holder. *(Center)* The holder cast onto an implant gold cylinder was screw-anchored on the implant with a conventional plastic bitewing holder (Hawe-Neos-Dental, Switzerland) after removing the retention bar. It ensures that the beam is at a right angle with the upper implant edge and the film, so that reproducible intraoral rectangular images can be recorded *(right).*

edentulous mandible.[12,16–18] Others[19] found OPTs problematic because of the superimposition of the vertebral column on the anterior region of the maxillary and mandibular jaws and the resultant variable distortions.

In this study, intraoral rectangular radiographs were therefore compared with panoramic radiographs for evaluating peri-implant bone loss in the atrophic interforaminal mandible. In addition, the radiologic data recorded were correlated with the clinical findings.

MATERIALS AND METHODS

Twenty-two patients (15 women and 7 men aged 43 to 80 years; mean age, 64 years) with 88 screw-type implants, all of whom were enrolled in a routine recall program, were included in this retrospective study. Of these, 7 were smokers (31.8%), while 15 did not smoke. The smokers smoked a mean of 26.3 (range, 13 to 60) cigarettes a day. The implants, placed interforaminally, were either Brånemark System MKII (length 13 or 15 mm with a machined surface [MS]; Nobel Biocare, Göteborg, Sweden) or Frios (length 12 or 14 mm with a sandblasted/acid-etched surface [SE]; Friatec, Friedrichsfeld, Germany). All patients were fitted with bar-retained overdentures supported by 4 implants.

For intraoral rectangular radiography, a specially designed film holder was used. It consisted of a plastic rectangular bitewing holder (Hawe Neos Dental, Bioggio, Switzerland) press-fitted in the grooves of a cast U-shaped support onto an implant gold cylinder (Figs 1a to 1c). For radiography, the bar was removed and the film holder was temporarily screwed onto the implant with a gold screw. This ensured a reproducible rectangular orientation of the central beam to the level of the upper implant edge and the radiograph film (31×41-mm Kodak Insight Dental Film; Eastman Kodak, Rochester, NY). Peri-implant bone loss was evaluated by intraoral rectangular radiography (Heliodont MD; Siemens, Bensheim, Germany) and by orthopantomography (Scanora; Soredex, Orion, France) (Fig 2).

Panoramic scans and intraoral rectangular radiographs recorded postoperatively and at the most recent recall visit were evaluated. The vertical distance between the reference point (implant-abutment interface) and the corresponding bone-to-implant contact point was measured (radiologic bone loss). To correct for the system-inherent magnification, the implant length was measured on panoramic scans and the implant diameter was measured on intraoral films (Figs 3a and 3b) and divided by the actual implant length or diameter to determine the magnification factor/implant. The bone loss in millimeters detected radiologically was divided by the magnification factor to obtain the actual bone loss. Measurements were made mesial and distal to the implants. All measurements were performed with an orthodontic precision slide jaw caliper with a maximum resolution of 0.01 mm (Zürcher Modell; Planer, Vienna, Austria).

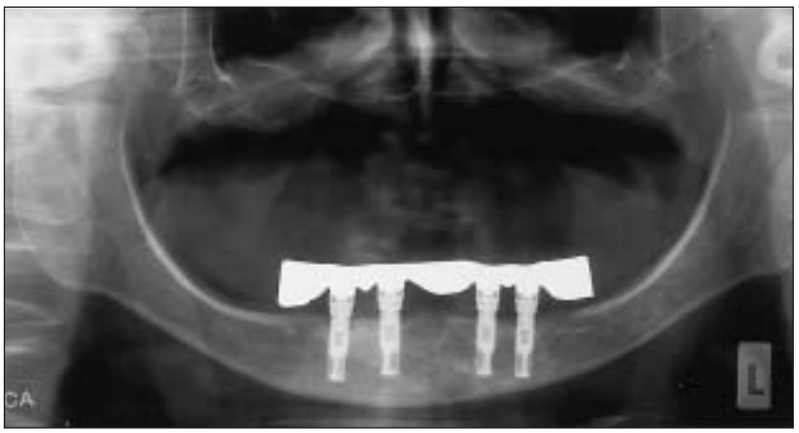
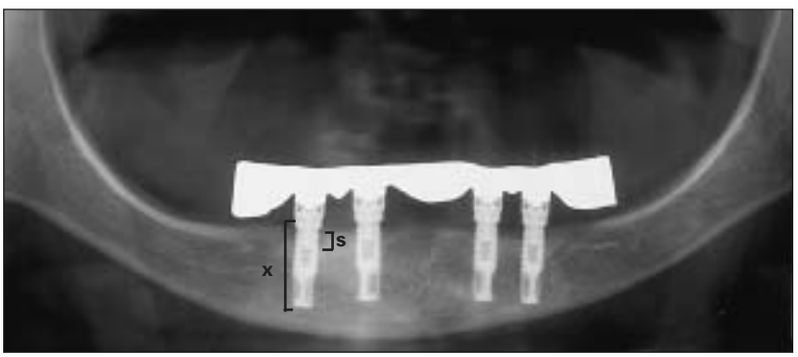
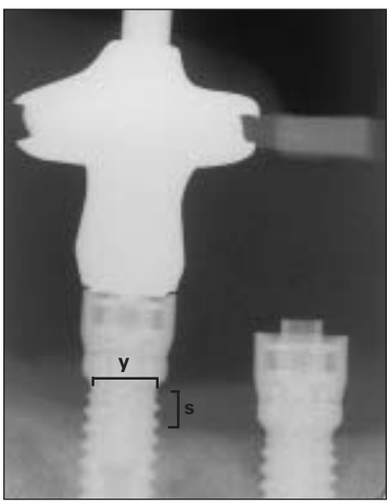


Fig 2 Peri-implant bone loss was evaluated by rotational panoramic radiographs in patients enrolled in a recall program, in addition to intraoral rectangular radiographs.





Figs 3a and 3b *(Above)* To correct for magnification, the radiologic implant length (x) was measured on panoramic radiographs. *(Right)* On intraoral films the radiologic implant diameter (y) was measured, because the implant length could not be seen clearly. The measured implant lengths and diameters were divided by the actual implant lengths and diameters to determine the magnification factor for each implant and to compute the actual bone loss from the radiologic bone loss (s) mesial and distal to the implants.

Statistical Analysis

Means were computed as least square means (LSM) and the corresponding confidence intervals for double interactions. The Bland and Altman method[20] was used for concordance testing between the 2 techniques. Potential effects of baseline measurements and the imaging technique on bone loss were computed with a mixed model. Statistical analyses were run on the SAS software package (SAS Institute, Cary, NC).[21] All statistical tests were 2-tailed and $P < .05$ was considered significant.

Table 1 Retention Time in Months

	Mean	Minimum	Maximum
All implants	60.6		
Frios implants	66.9	39.5	86.4
MKII implants	54.4	39.6	77.6

RESULTS

Twenty-two patients contributing 4 implants each were examined. Measurements were made along the mesial and distal implant surfaces. Consequently, 176 data points were evaluable. The implant survival time varied between 39.5 months and 86.4 months (Table 1). None of the implants failed during the follow-up period. The implants had been in place for 39.5 to 86.4 months (mean implant life 60.63 months for all implants; 66.89 months for SE implants and 54.36 months for MS implants). The mean functional loading time was 55.13 months.

All 22 patients (100%) underwent extraoral panoramic scanning. Intraoral rectangular radiography could be performed on 13 of 22 patients (59%), who contributed to the comparative statistical analysis between the 2 radiologic techniques. In 9 patients (41%), rectangular radiography (standard

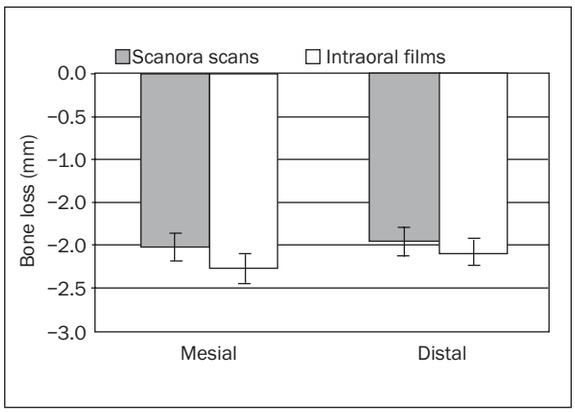


Fig 4 Actual peri-implant bone loss mesial and distal to the implants on panoramic scans versus intraoral rectangular radiographs after correction for the magnification factor/implant. Statistical analysis revealed no significant difference between the 2 imaging techniques in terms of imaging accuracy in the anterior mandible.

periapical films) was ruled out, because severe atrophy of the mandible with elevation of the floor of the mouth prevented placement of the film holder.

In patients with MKII implants (MS), mean peri-implant bone loss was 2.4 ± 0.2 mm on OPTs, versus 2.6 ± 0.2 mm on intraoral rectangular radiographs. Around Frios implants (SE), bone loss averaged 1.6 ± 0.2 mm on OPTs and 1.8 ± 0.2 mm on intraoral films. Statistically, no significant differences were found between the 2 imaging techniques in terms of imaging accuracy (Fig 4).

To establish the relative accuracy of OPT measurements, the bone level postimplantation was compared statistically with that seen at the follow-up visits. This showed peri-implant bone loss at baseline to correlate highly significantly (P = .004) with increased bone loss on follow-up OPTs.

The difference in marginal bone loss between MKII and Frios implants was statistically significant on both intraoral radiographs (P = .025) and OPTs (P = .017).

No differences were found between the mesial and distal measuring points of the same implant. Neither OPTs nor intraoral periapical radiographs showed significant differences in mesial and distal bone loss between baseline and follow-up films (P = .685).

The oral hygiene score was 0 around 39 implants (44.32%), 1 around 33 implants (37.5%), and 2 around 16 implants (18.18%). Pocket depth and peri-implant bone loss were significantly correlated both on OPTs (P = .017) and on intraoral small-format radiographs (P = .013).

In summary, no significant differences were found between the 2 imaging techniques in terms of the correlation between clinical parameters and radiologic bone loss.

DISCUSSION

Intraoral rectangular radiography is an integral component of radiologic follow-up studies to monitor peri-implant bone loss over time. The effects of the projection and the beam angle on the interpretation of nonstandardized films has been reported by several authors.[14,22,23] Based on these reports, intraoral rectangular radiographs were advocated to rule out intraobserver and interobserver variability and ensure unbiased reproducible data.

Orthopantomography is an alternative radiologic procedure. Because of its standardized projection in the vertical plane, it is well suited for vertical measurements.[24,25] Because of its complex rotational scanning mechanism, modern OPTs have been found to offer high image quality and accuracy.[26] The inherent symmetric imaging error in the vertical plane can be corrected by the magnification factor. This can be computed reliably by comparing the radiologic implant length with the actual implant length relative to a reference point. Schmelzeisen and coworkers[27] found that the implant-abutment interface was the most reliable reference point.

Panoramic radiographs may be superior to intraoral rectangular films in that they produce readable images of the maxillary and mandibular jaws and can be used even in patients with limited mouth opening.[28] But they provide 2-dimensional views, which tend to be out of focus because of the superimposition of the vertebral column on the anterior region, are distorted geometrically, and magnify the structures imaged.[4,27,29–31] These distortions have been reported to interfere with the evaluation of peri-implant bone loss. While Janson and associates[31] found that the radiologic bone loss seen on OPTs agreed with the actual clinical loss in no more than 60% of cases, the present investigation showed panoramic radiographs to be comparable to intraoral small-format radiographs for following up peri-implant bone loss in the anterior mandible. Batenburg and colleagues[7] reported that atrophy-related elevation of the floor of the mouth makes intraoral rectangular radiography difficult or rules it out altogether. In such situations, extraoral imaging was found to be superior to intraoral small-format radiography, which was not applicable in all patients (59% in this study) because of atrophy-related elevation of the floor of the mouth. Sivasriyanond and

Manson-Hing[32] reported that the imaging accuracy of intraoral periapical radiographs was 10 line pairs/mm (resolution 0.1 mm), versus 5 line pairs/mm (resolution 0.2 mm) for panoramic radiographs. However, the technologic superiority of intraoral films versus rotational panoramic radiographs may be irrelevant for longitudinal follow-ups, because Bragger and associates showed that alterations in marginal bone height of less than 0.2 mm were not reliably evaluable during follow-up.[6] The usefulness of OPTs for vertical and preimplantation bone measurements has been well documented by several authors.[18,33–35]

CONCLUSION

In this study, panoramic radiographs appeared to be comparable to intraoral small-format films in terms of the precision of evaluating peri-implant bone loss. No differences were found between the 2 imaging techniques when correlating the radiologic peri-implant bone loss with clinical parameters. Particularly in the highly atrophic interforaminal mandible, panoramic radiographic scans can be a useful alternative to intraoral periapical films for evaluating peri-implant bone loss in patients with poor imaging conditions (eg, elevation of the floor of the mouth).

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