# Interproximal bone loss assessment: Comparison of conventional and digital radiographs

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## ABSTRACT

**Aims & Objectives:** Intraoral radiographs are important diagnostic tools that play a major role in diagnosis, treatment plan and prognosis of periodontal diseases. This study assesses the accuracy of intraoral periapical (IOPA) and radiovisiography (RVG) radiographs in detection of interproximal alveolar bone loss using intrasurgical (IS) measurements as the gold standard.

**Methods:** Interproximal alveolar bone loss were measured in 23 patients with moderate to severe periodontitis, using digital vernier caliper for IOPA and linear measurement tool inbuilt in RVG system, from radiographs taken with standardized techniques which were compared with the surgical readings.

**Results:** 106 interproximal sites were measured in IOPA, RVG radiographs and compared with IS method. Paired t test showed significant difference in bone levels between the systems. A contingency analysis of categorical bone levels (early, moderate & advanced) showed significant differences in the imaging systems.

**Conclusion:** Overall radiographic assessment of interproximal bone loss by either IOPA or RVG radiographs shows no total agreement in comparison with IS measurements, although it was found that both conventional and digital radiographs are of use in interproximal bone loss assessment but in different similarities.


**Key words**: interproximal bone loss, IOPA, RVG, IS measurements.

## Introduction

Oral disorders can manifest in different manners, one of which is via alveolar bone loss. Although the identification of periodontal disease is based mostly on clinical examination, radiographs contribute greatly towards assessment of the extent of alveolar bone destruction, in determining the prognosis, to formulate a comprehensive treatment plan and to ascertain the outcome of various therapies.

Conventional radiography comprises of intraoral periapical, bitewing and panoramic views, which have been used since time immemorial in the field of periodontics. These imaging techniques are generally based on silver-halide emulsion technology that has been in use for a long time because of its good image resolution and low cost. However they have some inherent disadvantages which include image acquisition, long processing time, and maintenance of darkroom and disposal of hazardous chemicals(1).

In the last decade a new system called radiovisiography, one of the digital imaging techniques, has been introduced, which intends to minimize the problems associated with conventional radiography. RVG radiography utilizes a computer to process image data, thus significantly reducing the time needed for processing the radiographic image with low radiation exposure and allows for necessary image magnification and measurement. However, RVG radiography is not without its disadvantages, small sensor size which necessitates multiple images to be taken, plastic sleeve which hinders visualization and placement, aggravating gag reflex, requires skilled operator to maneuver the software, furthermore the equipment is expensive(2).

It is a well-established fact that often radiographs tend to either underestimate(3,4) or overestimate(5,6) the amount of bone loss resulting from periodontal disease, frequently misleading the clinician in selection of an appropriate treatment plan. Therefore it is essential to investigate the accuracy of these radiographic techniques that aids us in appropriate planning of patient treatment. While it is known that the gold standard of measuring remaining alveolar bone height is obtained intrasurgically(7), any radiographic technique that coincide with this measurement should be the automatic choice of the clinician.

Hence the present study compared and correlated the measurement obtained by conventional (IOPA) and digital (RVG) radiographs with intrasurgical readings and assessed their accuracy in evaluating the amount of alveolar bone loss.

## Methods

30 Patients with moderate to severe periodontitis were recruited from the Department of Periodontics, The Oxford Dental College. The study protocol was approved by the ethical committee and a patient informed consent was obtained. Systemically healthy subjects between the age of 18 and 55 years with interproximal

bone loss in the posterior teeth were included in the study group. Exclusion criteria involved conditions that interfere with clinical and radiographic evaluation such as orthodontic wire, extensive restorative work, shallow palatal vault and non-identifiable cementoenamel junction (CEJ).

Baseline clinical examination carried out to evaluate the probing pocket depth and clinical attachment level at 6 sites (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual) in all the posterior teeth except 3rd molar, with the help of UNC-15 periodontal probe(7) using CEJ as the reference point. Patients were subjected to phase I therapy and sites with periodontal pockets measuring >5mm were considered for further evaluation.

**Radiographic examination and measurement:**

IOPA radiographs were taken with Ekta speed films using paralleling technique with the aid of positioning device (XCP®, Rinn Corporation, IL, USA). Exposure parameters were 0.6secs, 100mA and 70kvp. The radiographic films processed manually keeping darkroom quality standards(8). RVG (Progeny®, Cygnus-media software) radiographic images were shot that matched the conventional IOPA radiograph using size 2 digital CCD sensor with the exposure parameters, 0.3secs, 100mA and 70kvp. The images were saved on monitor for measurement purpose.

Evaluation of radiographs for acceptable imaging was based on following criteria:

Conventional periapical radiographs(9):

- Constant density and contrast
- No shortening and elongation error
- No overlapping of teeth
- Sufficient imaging of the apex and periapical regions

RVG radiographs(10):

- The radiograph should show the tips of molar cusps with little or none of occlusal surface shown
- Enamel caps and pulp chamber should be distinct
- Interproximal spaces should be open
- Proximal contact should not overlap unless teeth are out of line anatomically.

Radiographs that did not fulfill the above criteria were repeated.

Conventional radiographic measurements: A fixed anatomical point, i.e cementoenamel junction (CEJ), was considered for measurement. The distances from the CEJ to the interproximal alveolar crest were measured on both the mesial and distal aspects using an electronic digital caliper(11) (Digimatic caliper, Mitutoyo Corporation, Japan) with the help of a view box.

- If the CEJ was destroyed by restorative treatment, the margin of the restoration was taken as landmark(12).
- Alveolar crest (AC): the most cervical level along the proximal root surface, where the periodontal ligament started to be of equal width(12). If this was not feasible, then the most cervical level along the proximal root surface, where the lamina was intact with no loss of its continuity(13). If there were more than one images of alveolar crest, then the most apical one was selected(14). (Figure 1)

RVG radiographic measurements: the measurements taken on the conventional radiographs were repeated on the RVG radiographs. The distance from the CEJ to the interproximal alveolar crest on both the mesial and distal aspects of each tooth was marked digitally by a software program inbuilt in the computer. (Figure 2)

Surgical procedure: Defect sites measured from the CEJ to the crest of the alveolar bone along the line angle of the tooth with the help of a UNC-15 probe to the nearest mm.(7) (Figure 3)

All the measurements were subjected for statistical analysis(15).

Figure 1: IOPA Radiograph

Figure 2: RVG Radiograph

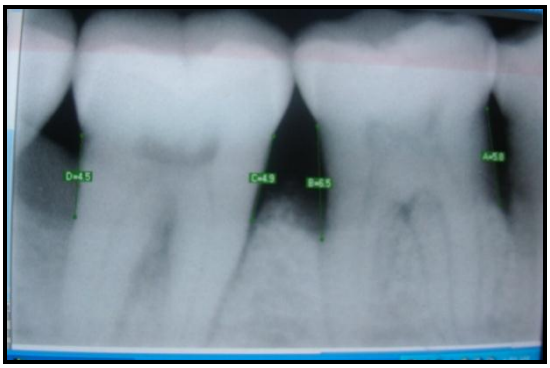

Figure 3: Intrasurgical Measurement with the help of UNC-15 probe.

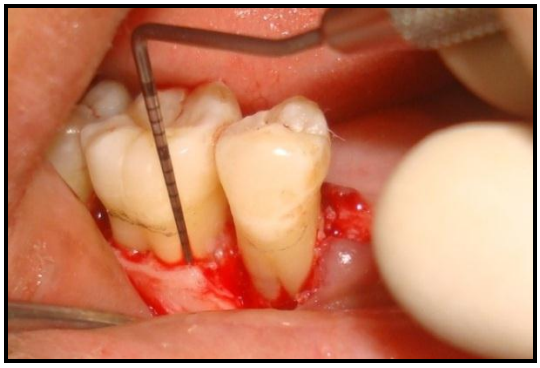

**Table 1: Mean and Confidence interval of Mesial and Distal reading**

| Surface | Range (mm) | Mean (mm) | SD (mm) | 95% Confidence Interval for Mean | | F-value* | p-value** |
|---|---|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound | | |
| Mesial IOPA | 1.84-10.64 | 5.00 | 1.83 | 4.50 | 5.51 | 5.661 | <0.004 |
| Mesial RVG | 3-14 | 6.29 | 2.12 | 5.71 | 6.88 | | |
| Mesial Surgical | 2-10.5 | 5.34 | 2.19 | 4.74 | 5.94 | | |
| Distal IOPA | 2.03-12.8 | 5.43 | 2.47 | 4.72 | 6.14 | 2.644 | >0.075 |
| Distal RVG | 2.1-13 | 6.36 | 2.43 | 5.66 | 7.06 | | |
| Distal Surgical | 2-11 | 5.40 | 2.11 | 4.79 | 6.00 | | |

*Analysis of Variance, **Significant at < 1%

*Tabular representation of the mesial & distal measurements of IOPA, RVG & Surgery in terms of Range, Mean±SD& CI.*

**Table 2: Contingency table of IOPA and surgical for mesial**

| IOPA (Mesial) | Surgical (Mesial) | | | Total | Chi-square value | P-value |
|---|---|---|---|---|---|---|
| | Early bone loss (3mm) | Moderate loss (3.1-6mm) | Advanced bone loss (≥6.1mm) | | | |
| Early bone loss (3 mm) | 10 | 4 | | 14 | 29.774 | <0.001 |
| Moderate bone loss (3.1-6 mm) | 4 | 16 | 9 | 29 | | |
| Advanced bone loss (≥ 6.1mm) | | 2 | 8 | 10 | | |
| Total | 14 | 22 | 17 | 53 | | |
| **IOPA (distal)** | **Surgical (Distal)** | | | **Total** | **Chi-square value** | **P-value** |
| | Early bone loss (3mm) | Moderate loss (3.1-6mm) | Advanced bone loss (≥6.1mm) | | | |
| Early bone loss (3 mm) | 7 | 4 | | 11 | 38.474 | <0.001 |
| Moderate bone loss (3.1-6 mm) | 1 | 18 | 4 | 23 | | |
| Advanced bone loss (≥ 6.1mm) | | 4 | 11 | 15 | | |
| Total | 8 | 26 | 15 | 49 | | |

*Table showing the grades of bone loss as depicted in IOPA and intrasurgical examination*

**Table 3: Contingency table of RVG and surgical for mesial**

| RVG (Mesial) | Surgical (Mesial) | | | Total | Chi-square value | P-value |
|---|---|---|---|---|---|---|
| | Early bone loss (3mm) | Moderate loss (4-6mm) | Advanced bone loss (≥7mm) | | | |
| Early bone loss (3 mm) | 2 | | | 2 | 28.555 | <0.001 |
| Moderate bone loss (3.1-6 mm) | 10 | 19 | 3 | 32 | | |
| Advanced bone loss (≥ 6.1mm) | 2 | 3 | 14 | 19 | | |
| Total | 14 | 22 | 17 | 53 | | |
| **RVG (Distal)** | **Surgical (Distal)** | | | **Total** | **Chi-square value** | **P-value** |
| | Early bone loss (3mm) | Moderate loss (3.1-6mm) | Advanced bone loss (≥6.1mm) | | | |
| Early bone loss (3 mm) | 4 | 1 | | 5 | 29.988 | <0.001 |
| Moderate bone loss (3.1-6 mm) | 4 | 16 | 2 | 22 | | |
| Advanced bone loss (≥ 6.1mm) | | 9 | 13 | 22 | | |
| Total | 8 | 26 | 15 | 49 | | |

*Table showing the grades of bone loss as depicted in RVG and intrasurgical examination*

# Results

Out of the 30 patients with moderate to severe periodontitis, two subjects did not require periodontal flap surgery following phase I therapy and 5 subjects dropped out after phase I therapy. Hence a total number of 23 patients participated in the present study. They contributed to a total number of 106 interproximal sites. The results were computed for intrasurgical, IOPA and RVG separately for mesial and distal surface of the teeth. In addition comparisons were also made of defects with variable depth viz, </=3mm, 3.1mm to 6mm and >/= 6.1mm.

Comparison of mean values of mesial and distal surfaces of IOPA, RVG with IS was made using paired t-test.

Mean values compared on the mesial surface: revealed that mean values of IOPA radiographs coincided better with IS values, whereas the values obtained in RVG did not. There was no statistically significant difference between the readings of IS and IOPA, the disagreement between RVG and other mean values were statistically highly significant (Table 1)

Mean values compared on distal surface: the IS and IOPA mean values coincided greatly whereas the values obtained by RVG were far off the mark as compared to the other two entities. Whereas IS and RVG showed significant difference at 95% confidence levels (Table 1).

In order to have a better understanding of the accuracy of the radiographic techniques in estimating different depths, the defects were grouped as follows(13)

Early/ mild bone loss: ≤3mm
Moderate bone loss: 3.1-6mm
Advanced bone loss: ≥6.1mm

The values were compared with the help of contingency table.

When the mesial surface readings were compared between IOPA and IS, early/mild bone loss showed 71% agreement, moderate amount of bone loss showed 72% agreement and 47% match in advanced bone loss category (Table: 2). When the measurements on the distal surfaces were compared between IOPA and IS, there was 87% agreement in early/mild bone loss category, 69% in moderate category and 53% in advanced category. (Table: 2)

The measurements obtained from RVG when compared with IS measurements on mesial surfaces it was found that there was only 14% agreement in the early bone loss category, 86% in moderate bone loss category and 82% in severe bone loss category (Table: 3). When the measurements on the distal surfaces were compared between RVG and IS, there was 50% agreement in early/mild bone loss category, 61% in moderate category and 86% in advanced bone loss category. (Table: 3)

Overall, the measurements revealed that IOPA measurements matched closely with IS values in early to moderate bone loss category, whereas the measurements obtained through RVG matched IS values in moderate to advanced bone loss category. However, none of the radiographs totally tallied with the surgical measurements.

# Discussion

Patients with moderate to advanced periodontitis who fulfilled the inclusion criteria underwent phase I therapy and were later subjected to radiographic measurements. The measurements that were obtained from the radiographs were evaluated with the intrasurgical measurement and the two values were compared and tallied.

For the purpose of measurements fixed anatomical landmarks such as CEJ & AC were used, which reduced the need for occlusal stents for standardization. For IOPA radiographs digital vernier caliper was used to obtain the required measurements, which is easy as well as quite precise. Various studies have used other methods such as, the use of grid, graph sheets, profile projector and computer assisted evaluation(16).

However these methods do not offer a particular superiority over the others. Hence the technique that has been used in this study is routine, practical and can be employed in day to day practice. This has been corroborated in the report of Farah M et al(11).

Similarly all efforts were made to standardize the technique and interpretation of RVG. The equipment used was progeny® with Cygnus media software, which is considered as standard RVG equipment available(2).

The results obtained in this study showed that in general there was no total agreement between the reading obtained by any type of radiograph and the actual bone height. The IOPA radiographs matched closely with that of intrasurgical values in early to moderate bone loss but, never the less they tended to underestimate the amount of bone loss particularly in advanced bone loss group. These findings have been corroborated in many earlier studies(2-4,7). The reason for underestimation in advanced bone loss could be attributed to the anatomical variations which occur with increasing depth of bone loss e.g: pattern of bone loss, curvature of root.

On the contrary RVG readings matched IS measurements in moderate and advanced bone loss category while overestimating the sites with early bone loss. These results are in consistency with the findings in the studies conducted by Wolf et al(5) and Talaiepour A. R et al(6). The reason for such discrepancy noted in RVG measurements may be attributed to the variation in the sensor size and flexibility in the sensor and image resolution.

# Conclusion

As the technologies emerge and the options of improvising one's clinical perspective increases, so does

the ambiguity of selecting the best tool for a better choice of treatment. Though, both the radiographs have limited role particularly when it comes to precise measurement of alveolar bone loss. The measurements obtained by either of the radiographs showed virtually agreeing values with the intrasurgical measurements but, in different categories of bone loss.

## Clinical significance

**Rationale for the study:** presently there is impedance for digital radiographs.

**Principle finding**: IOPA & RVG radiographic measurements do not completely tally with IS measurements.

**Practical implications**: Conventional IOPA when taken with standard measures shows measurements as close to IS measurements.

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