Comparative study of direct digital and conventional intra oral bitewing radiographs in detecting alveolar bone loss

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Abstract

Objectives: The aim of this study was to compare direct digital and conventional intraoral bitewing radiographs in detecting alveolar bone loss. Methods: The study group comprised of thirty-four subjects in which, twenty-six were males & eight were female patients. A set of direct digital radiographs matching the conventional radiographs were taken for each subject with the help of a cone-positioning device. Bone levels were measured on radiographs as the distance from the cemento-enamel junction to the alveolar crest in millimeters at the mesial and distal surfaces of all available teeth excluding third molars. Two examiners measured bone levels twice on each type of imaging system independent of one another. Examiners made comparison between digital radiograph and conventional radiograph. Results: Total numbers of sites measured individually on conventional and digital radiograph were 706. The correlation coefficients between conventional and digital radiograph made by the two examiners were highly significant (p<0.001). Conclusions: Under normal clinical use, alveolar bone levels revealed on intraoral direct digital radiographs differ from those revealed on conventional radiographs.

Key words: Periodontal disease; Alveolar bone level; Direct digital; Conventional intra oral bitewing radiographs.

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Introduction

Periodontal disease is one of the most extensively occurring diseases in the general population. Evidence suggests that periodontal bone loss could commence at an earlier age than previously thought (1). Plaque related gingival inflammation is associated with the release of numerous inflammatory mediators such as interleukin -1(IL-1), tumor necrosis factor – alpha (TNF α) and prostaglandin – E2 (PGE-2). (2) The generated inflammatory mediators reach the alveolar housing of the tooth and disrupt the balance between bone resorption and bone apposition. The net of the result is loss of alveolar bone (3). The diagnosis of periodontal disease, frequently hinges on conventional bitewing radiographs. The distortions with bitewing radiographs are relatively minimal, but their diagnostic accuracy is however notoriously imprecise (4). These diagnostic challenges are well targeted by technological initiative that appears to lie in the existing scientific capabilities. Even more tantalizing is the possibility of exploiting the new digital image technology to facilitate characterization of relatively small site-specific changes (5).

The use of radiographs as a diagnostic tool has become an indispensable routine in medicine and dentistry. The presence and extension of many pathologic or abnormal conditions can be traced by means of radiographs (6). A recent advance in computer technology has led to the development of digital imaging, which has made a significant impact on dental radiographs (7). Direct digital imaging uses a digital sensor or detector in place of film for capturing images. On exposure to X-rays, an electronic image accumulates as a pattern of charge on the detector array. Digital imaging offers some distinct advantages over film in terms of exposure reduction, elimination of processing chemicals, instant or real time image production, image enhancement, patient education utility and convenient storage (8).

Numerous studies have evaluated the use of digital radiography in assessment of crestal alveolar bone loss and most of these were performed in vitro (9). Because of the in vitro nature of most of these studies, the findings may not be clinically applicable Therefore, the present study was undertaken to evaluate the diagnostic efficacy of digital radiographs against that of conventional radiographs for assessment of inter proximal bone loss under normal clinical conditions.

Material and methods

The present study was conducted in department of Oral Medicine and Radiology, D. A. Pandu Memorial R.V. Dental College and Hospital, Bangalore, India. The study group comprised of 34 subjects of both sexes in which, twenty-six were male and eight were female patients. The subjects between the age group of 18-65 years of age with presence of posterior teeth were included in the study. Pregnant women, teeth with over hanging restoration and patients wearing intra oral appliance which would interfere with clinical or radiographic evaluation were excluded from the study. An ethical clearance was obtained regarding exposure of the subject. The participants were explained the need and design of the study and the benefits of undergoing thorough clinical and radiographic investigations. Individuals who agreed to undergo these procedures were instructed to read and sign the consent form. Ramfjord periodontal disease index was used for intra oral examination of the teeth. Radiographs of the posterior teeth (distal of first premolar till the distal of second molar) were made for each subject. Mesial and distal aspects of each tooth were considered as two different sites. The total number of sites measured individually on conventional and digital radiographs was 706 with average number of sites measured per subject was 20.76%.
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**Radiographic Evaluation**

For each subject, two sets of posterior bitewing radiographic images (conventional and digital) were taken at same time. Prior to exposure for radiation, suitable patient protectors like lead apron and thyroid shield were used.

**Standardization of radiographic technique**

The distance from focal spot to open end of the cylinder was 20cm, the distance from the open end of the cylinder to the film was standardized to 18cm by using a cone-positioning device for both the procedures.

**Conventional Radiographs:** To obtain conventional images, Kodak Ekta speed plus (Kodak, Rochester, New York) No.2 adult size films were used. The film was placed in a bitewing film holder (Rinn film holder, Gendex, Dentsply) with a bitewing metal guiding arm attached to a cone-positioning device (Xcp-Ds, Gendex, Dentsply), which would hold the tube head during exposure. The film was exposed using standardized bitewing technique using an intraoral radiographic machine (Trophy, Radiologie, 70Kvp, 8ma with 1.5mm aluminum filter). A vertical angulation of +5degrees and horizontal angulation of 0 degree with projection of central ray to the film and tooth of interest was made with exposure time of 0.6seconds.

**Digital Radiographs:** A second set of digital radiographs of same region as the conventional radiographs were made under the same condition. Instead of radiographic film, a size 2-intra oral digital sensor was used (Charge Coupled Device, Gendex, Dentsply). The sensor was positioned vertically in the same bitewing film holder as that used for conventional radiograph with 0.3 seconds exposure time. Digital images were obtained using Vixwinpro software programme supplied by the manufacturers.

**Radiographic Measurements:**

Two examiners performed the radiographic measurements of alveolar bone levels. Each examiner measured bone levels twice on each type (Conventional and Digital) of imaging system. Both examiners conducted their measurements independent of one another and the second reading was done independently from the first reading. After an initial agreement on identifying the cemento enamel junction (CEJ) and the position of alveolar crest in relation to CEJ, both examiners used similar criteria when rejecting certain teeth or surfaces (third molars & over hanging restoration).

**Conventional Radiographs:** The conventional bitewing radiographs were observed on the screen of an illuminated viewer box under optimal viewing conditions. A magnifier was not allowed during the measurement. An absolute method that measures the distance from the alveolar bone to a reference point (usually the CEJ) in mm by superimposing a transparent millimeter ruler on the radiograph was selected to measure the distance from the CEJ to the nearest millimeter of the alveolar crest. Mesial aspect of each tooth was considered as one site and distal aspect of each tooth was considered as another site. So, total 706 sites were measured individually on conventional and digital radiographs.

**Digital Radiographs:** The images obtained on the monitor of a personal computer were used (Samtron 55V, NVIDIA Geforce Samsung). The same measurements taken on the conventional radiographs were repeated on digital radiographs. The distance from the CEJ to the interproximal alveolar crest on both mesial and distal site of each tooth was determined digitally by Vixwinpro software programme (Visualix USB, Gendex).

Brightness and contrast were adjusted when needed at the time of image capture prior to measurement. The
examiners measured all the images at $\times 1.05$ magnifications. Examiners were not allowed to alter brightness and contrast during measurement. The examiners performed their measurements independently from each other and the second reading was done independently from the first reading. Intra observer differences for the second observations for each examiner were compared individually for conventional and digital radiographs by calculating the mean of the observations. Paired $t$-test and Pearson’s correlations test were used to assess the intra examiner reliability between two observations made by the two examiners on conventional and digital radiographs.

**Results**

Two examiners performed the radiographic measurements of alveolar bone levels. For analysis, these observations were averaged over mesial and distal sites over all the teeth in an arch.

*Comparison of Intra observation made by examiner 1:*

**Conventional Radiograph:** The difference found between the mean values for two observations at different sites were not statistically significant, except maxillary molars where there was a significant difference between the two observations ($P=0.033$) as presented in figure 1.

**Digital Radiograph:** The difference found between the mean values for two observations at different sites were not statistically significant except for maxillary molars where there was a significant difference between the two observations ($p=0.059$) (figure 2).

**Pearson’s correlation coefficient** was used for assessing the relationship between conventional and digital radiograph for first examiner. The correlation coefficients between the two observations for conventional and digital radiograph made by the first examiner were highly significant ($p<0.001$).
Comparison of Intra observation made by examiner 2

Conventional radiograph: There was a significant difference seen between the two observations in maxillary molars (p=0.008), mandibular molars (p=0.006) and mandibular premolars (p=0.03) (figure 3).

Digital Radiograph: The difference found between the mean values for two observations at different sites was not statistically significant (figure 4) except for maxillary premolars where there was a significant difference between the two observations (p=0.001) and for mandibular premolars (p=0.08). Pearson’s correlation coefficient was used to assess the relationship between conventional and digital radiograph for second examiner. The correlation coefficients between the two observations for conventional and digital radiograph made by the second examiner were highly significant (p<0.001). Pearson’s correlation was used to assess inter-examiner reliability where the first examiner underestimated while, second examiner overestimated the measurements.

Two examiners made comparison between Digital radiograph and conventional radiograph separately by using paired t-test.

Comparison made by first examiner (figure 5):

On conventional radiograph, the mean value seen for maxillary molars was 4.04 ± 1.46 SD, the mean value for mandibular molar was 3.30 ± 1.49 SD, for maxillary premolar was 3.68 ± 1.44 SD, for mandibular premolar 3.93 ± 1.49 SD.

On digital radiograph the mean value seen for maxillary molar was 4.17 ± 1.46 SD, for mandibular molars 3.42 ± 1.49 SD, for maxillary premolars, 3.76 ± 1.41 SD, for mandibular premolars the mean value was 3.93 ± 1.51 SD. The difference found between the mean values for conventional
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and digital radiograph at different sites were not statistically significant (p<0.001).

**Comparison made by second examiner (figure 6):**

On conventional radiographs, the mean value seen for maxillary molars was 3.96 \(\pm\) 1.53 SD, the mean value for mandibular molar was 3.21 \(\pm\) 1.49 SD, for maxillary premolar was 3.68 \(\pm\) 1.59 SD, for mandibular premolar 3.89 \(\pm\) 1.46 SD.

On digital radiograph the mean value seen for maxillary molar was 4.16 \(\pm\) 1.53 SD, for mandibular molars 3.40 \(\pm\) 1.47 SD, for maxillary premolars, 3.76 \(\pm\) 1.45 SD, for mandibular premolars the mean value was 4.07 \(\pm\) 1.51 SD. The difference found between the mean values for conventional and digital radiograph at different sites were not statistically significant (p<0.001), except Maxillary premolar (p=0.48).

The correlation coefficients between conventional and digital radiograph made by the two examiners were highly significant (p<0.001).

**Discussion**

Periodontitis is defined as “an inflammatory disease of the supporting tissues of the teeth caused by specific microorganisms or group of specific microorganisms, resulting in progressive destruction of periodontal ligament and alveolar bone resulting in progressive destruction of periodontal ligament and alveolar bone with pocket formation, recession or both (1). Periodontal disease affect 5-30% of adult population and the prevalence of chronic Periodontitis increase with age and is most common in males than females (10). Clinically periodontal disease manifests as an inflammatory reaction in the periodontium. The disease is usually pain less and most patients are unaware of its presence. Gingivitis is the first clinical sign, although some form of Periodontitis may be seen without gingivitis (2). The cause of periodontal disease arises from interplay of various host, bacterial and environmental factors. Plaque forming bacteria play an intimate role in the initiation and progression of periodontal destruction (4). They colonize along the root and tooth surface, resulting in apical migration of the epithelial attachment, subsequent pocket formation and loss of bone (2,4). Dental radiograph is the traditional method used to assess the destruction of alveolar bone associated with periodontal disease. They are generally preferred due to their sharpness and to demonstrate structural details (11).

Although radiographs cannot accurately reflect the bone morphology, they provide useful information on the interproximal bone levels. Moreover, they provide information of the periodontium that cannot be obtained by any other non-invasive methods (12). However it is well known that substantial volume of alveolar bone must be destroyed before the loss is detectable on radiographs (13). Specifically more than 30% of the bone mass at the alveolar crest must be lost for a change in bone height to be recognized on radiographs. Therefore, conventional radiographs are very specific but lack sensitivity (12, 13).

Over the past few years, systems that can generate digital images without the need of radiograph film have become available for use in clinical practice. This new technology offers many advantages over conventional radiograph (14). It eliminates the need for film and film processing, and it allows for low radiation exposure. The mean amount of radiation dose used by digital radiograph is 22.3% of that of conventional radiograph (15). The generated image is available immediately for evaluation on a computer screen and can be manipulated digitally to enhance viewing (14, 15).

This present study was undertaken with an aim to compare direct digital radiograph with conventional intra oral radiograph in detecting alveolar bone loss.
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Bitewing radiographic technique was selected in our study, as initial periodontal changes are better visualized by this technique (16). This technique was standardized using the same film holding device in order to avoid geometric errors, which would in turn effect the measurements. It was stated that, a film exposed using standardized geometry has advantages over non-standardized techniques. Standardized radiographic films help in identifying the smallest amount of bone loss in the shortest time. (17)

Absolute method was selected to measure bone levels on conventional radiographs, it was reported that the absolute method to be used when investigating the susceptibility of different teeth to periodontal break down and in clinical trial of comparative nature. Further, the data indicated that measurements done on millimeters had a better reproducibility and readability than using relative measurements (18).

Two examiners performed the radiographic measurements of alveolar bone levels. Each examiner measured bone levels twice on each type (Conventional and Digital) of imaging system and the second reading was done independently from the first reading. Pecoraro et al., performed a similar kind of study to compare observer’s reliability in assessing alveolar bone height on direct digital and conventional radiographs (19). When comparing the overall average measurements of each examiner, it was found that the first examiner tended to underestimate measurements while second examiner overestimated the measurements. The inter observer variability observed in the present study is in agreement with the past study (19). Similarly Kaeppler et al., demonstrated poor inter observer agreement for rating the visibility, indicating that the two observers might represent the extremes of a wide range. The authors concluded that intra examiner reproducibility is superior to inter examiner reproducibility (20).

The difference between conventional and digital radiographs was compared by the examiners for each of the divided site. Both measures ordered the relative degree of bone loss in a similar fashion. However, the digital radiographs have consistently shown higher readings, similar results were noticed by Kaeppler et al., in his in vitro study; their results showed that the accuracy of linear measurement was high in digital radiograph when compared to conventional radiograph under standardized norms (20). This is a preliminary in vivo study to compare the direct digital and conventional intraoral bitewing radiographs in detection of alveolar bone loss. With the results of the present study we would conclude that, under normal clinical use the average alveolar bone level measurements varied significantly between conventional and digital radiographs in multiple regions of the teeth. However the digital radiographs have consistently shown higher readings. The limitation of this study was of not using a gold standard. Further studies on large samples with active periodontitis before and after treatment with gold standard are needed to be included in the study to conclude the results of digital images.

The digital radiographs can be preferred over conventional radiographs for the following reasons. The ability to enlarge and adjust the contrast of the image, easy of taking the measurements with the ruler icon, reduction in the exposure to the patient, elimination of processing and convenience of having immediate access to radiographic records stored on the computer.

**Conclusions**

Under normal clinical use, alveolar bone levels revealed on intraoral direct digital radiographs differ from those revealed on conventional radiographs. Further studies on large samples with active periodontitis before and after treatment are needed to be
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included in the study to conclude the results of digital images.

References