



A VARIOUS RADIOGRAPHIC TECHNIQUES FOR MEASURING THE MARGINAL BONE LOSS AROUND DENTAL IMPLANTS : LITERATURE REVIEW

Dental Science

Dr. Sanjay B. Lagdive Professor Dept of Prosthodontics and Crown & Bridge Govt. Dental College & Hospital, Ahmedabad

Dr. Rupal J. Shah* Professor & Head Of Dept Dept of Prosthodontics and Crown & Bridge Govt. Dental College & Hospital, Ahmedabad *Corresponding Author

Dr. Dhanji T. Vegad Post Graduate Student Dept of Prosthodontics and Crown & Bridge Govt. Dental College & Hospital, Ahmedabad

ABSTRACT

Radiographic assessment of marginal bone loss is one of the most used criteria in longitudinal control of dental implant osseointegration. Accurate and reproducible results are difficult to obtain due to considerable intra and inter-operator variability. Methods of radiological peri-implant bone loss assessment need to utilize ,intraoral radiography, panoramic radiography, computed tomography, cone beam computed tomography. Intra-oral radiographs of implant were exposed both as direct digital and conventional film radiography.

KEYWORDS

dental implant , marginal bone loss, intraoral radiographs, extraoral radiograph.

INTRODUCTION:

Dental implants have become a predictable treatment option for restoring missing teeth. The purpose of the tooth replacement with implants is to restore adequate functions and esthetics without affecting adjacent hard and soft structures.

The long-term survival of the implant is dependent upon the osseointegration of the implant and hence the quality and apposition of bone around the implant is of utmost importance. The peri-implant bone should be monitored and periodically assessed. However, as bone quality and volume cannot be thoroughly assessed clinically, methods of radiological peri-implant bone assessment need to be utilised, including intraoral radiography (IR), panoramic radiography (PR), computed tomography (CT), and cone beam computed tomography (CBCT).

MATERIAL AND METHOD:-

The most accurate method which can be used for assessing alveolar bone level is to elevate the flap and measure the bone level directly. However, this method causes discomfort to the patient and can damage the tissue.^[1]

Bone probing measurement is closely co-related with the actual bone level measured surgically and is the most reliable method for assessing bone level before and after any surgical procedure.^[2]

RADIOGRAPHIC TECHNIQUES:	
EXTRAORAL	INTRAORAL
Panoramic	Conventional
CT	Digital
CBCT	

INTRAORAL RADIOGRAPHY:- PERIAPICAL RADIOGRAPHY WITH LONG CONE PARALLELING TECHNIQUE:-

Alveolar bone changes surrounding implants can be monitored using digital radiographs or by digitisation of conventional radiographs in order to perform computer-aided subtraction. As about 30-50% of bone mineral must be lost before bony changes are visibly detectable in conventional radiographs (Dreyer 1993), conventional radiographs alone are inadequate to monitor changes in bone volume and density surrounding a natural tooth or implant. Subtraction radiography involves the subtraction of an original radiograph from a subsequent radiograph in order to visualise the changes that have occurred, which are taken in a standardised way.^[3]

In order to obtain standardised periapical radiographs for subtraction, studies utilising this method construct a custom-made acrylic or putty bite block for each area of interest in implant. This bite block is attached to a modified film holder, which provides a rigid attachment of the bite block to a custom attachment on the X-ray machine cone. As

a consequence, the angulations between the X-ray source, the object and the film are standardised. All radiographs are taken using the same X-ray machine at the same setting and the image may be captured on a charge-coupled device, phosphor plate, or plain film. Plain films can be scanned into a computer at 600dpi using a flatbed scanner, thus digitising the image for analysis.^[3,4]

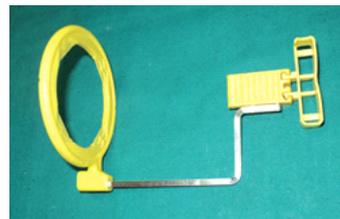


Figure 1. RINN XCP Film Holder, Dentsply



Figure 2. Softened modelling wax attached (for posterior teeth) to Rinn XCP film holder, Dentsply for making custo mized occlusal bite jig.



Figure 3. LONG CONE PARALLELING TECHNIQUE



Figure 4. Radiographic measurements at the time



Figure 5. Radiographic measurements at 12 months of dental implant placement, better done with grids months after prosthetic loading of the implant.

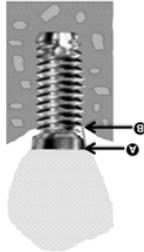


Figure 6. A computer-assisted calibration of reference points (A and B)⁴

According to the longitudinal study of Sewerin on peri-implant bone loss, the distance between a reference point and the marginal bone level around implants could be assessed with a great accuracy by means of the long-cone paralleling technique, conventional or digitalised.^[4]

ADVANTAGE:-

Radiographs with intraoral rectangular film were considered to ensure unbiased and reproducible results. The paralleling technique allows an optimum and reproducible quality of periapical radiograph.

LIMITATION:-

Any deviation from the correct vertical angle leads to errors in the assessments of the marginal bone height.

BITEWING RADIOGRAPHY

Bitewing radiographs differ from periapical radiographs in that they are usually limited to capturing the image of crowns of both maxillary and mandibular posterior teeth along with the alveolar crest in the same radiographic film. Bitewings are commonly used in general practice for dental caries detection as well as for evaluation of alveolar crest height around teeth. Interproximal (bitewing) image more accurately record the distance between the cemento-enamel junction (CEJ) and the crest of the interdental alveolar bone because with interproximal views the beam is oriented at right angles to the long axis of the teeth, thus providing an accurate view of the relationship of the height of the alveolar bone to the root.^[5,6,7]



Figure 7.

Precise detection of proximal caries is considered an advantage of the horizontal bitewing technique while the unobstructed view of the alveolar bone is the advantage of the vertical bitewing technique, which makes the latter a more valuable diagnostic tool for periodontal disease assessment.

PANORAMIC RADIOGRAPHY

Panoramic radiography has been proposed to be an alternative method to measure bone loss. Because of its standardized projection in the vertical plane, it suits well for vertical bone measurement. In addition, panoramic radiographs might be more appropriate in some cases than periapical radiographs because they offer an image of both jaws.^[5,8]



Figure 8. Peri-implant bone loss was evaluated by rotational panoramic radiographs in patients enrolled in a recall program, in addition to intraoral rectangular radiographs.⁸

It was reported that the imaging accuracy of intraoral periapical radiography was 10 line pairs/mm (resolution 0.1mm), versus 5 line pairs/mm (resolution 0.2mm) for panoramic radiographs. Accordingly, an error of approximately 0.2mm with a limited interobserver variation was reported for both intraoral periapical radiography and scanographic X-ray using the film technique, for in vitro peri-implant bone level evaluation.^[5,8]

In conclusion, periapical radiography was reported to be more successful than the panoramic one in the detection of small osseous destruction (4.7x). Panoramic radiography underestimated the osseous destruction, whereas periapical radiography was relatively accurate for this assessment. This was the case regardless of the location of the dental surfaces (jaw, tooth group, mesial or distal) and of the degree of osseous destruction.^[5,8]



Figure 9a to 9c (Left) implant supported film holder. (Center) The holder cast onto an implant gold cylinder screw anchored on the implant with a conventional plastic bite-wing 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).^[8]

ADVANTAGES:-

Panoramic radiographs might be more appropriate in some cases than periapical radiographs because they offer an image of both jaws.

They could also be used in patients with limited mouth opening.

Panoramic radiographs proved to be comparable to regular intraoral radiographs in detection of bone loss around implants in the anterior mandible, where periapical films were difficult to place.^[5,8]

LIMITATIONS:-

The bidimensional view obtained with panoramic radiographs is blurred by the superimposition of the cervical column on the anterior region; therefore, the images seem magnified and distorted.

Some authors complained about its limited benefit owing to inferior image resolution and the inability to modify the radiographic beam angle.^[5,8]

DIGITAL RADIOGRAPHY:-

Digital images were printed with a Kodak 1200 Distributed Medical Imaging printer on blue transparent film, glossy and plain paper. Digital periapical exposures were made with Digora storage phosphor plates. Exposures were made with an intra-oral radiation unit using a cylindrical tube head, 2.5mm aluminium filtration and a focal spot distance of 200 mm. Contrast and brightness of the digital images were adjusted with the Digora Software. Images were printed with a magnification factor of 2. Extra-oral digital scanographic, panoramic and tomographic images were taken with the Cranex Tome multimodal X-ray unit and printed on Agfa Drystar TM 1 B transparent films. Magnification factors, as defined by the manufacturer, were 1.3 for panoramic and 1.5 for scanographic and tomographic images.^[9,10,11,12]

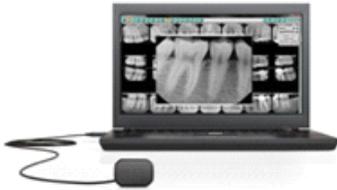


Figure 10. Digital radiography



Figure 11. RVG

TABLE 1- The coefficient of variation (CV), expressed as percentage for intra- and inter-observer reproducibility for measurements of marginal bone level around oral implants on radiographs taken with different techniques.^[9]

	<i>Intra-observer(CV%)</i>	<i>Inter-observer(CV%)</i>
Digital intra-oral images on glossy paper	0.22	0.28
Digital intra-oral images on film	0.51	0.84
Digital intra-oral images on plain paper	0.37	0.54
Conventional intra-oral images on analogue film	0.42	1.34
Panoramic images on film	0.41	0.65
Scanographic images on film	0.29	0.68
Tomographic images on film	0.10	0.15

DIGITAL SUBTRACTION RADIOGRAPHY

Woo et al. (2003) developed and validated a digital subtraction radiography program based upon a Linux system. Digitised images are imported into the subtraction software allowing analysis of the alveolar bone changes. The first step in the software is to align the paired images by selecting the same sets of two reference points. The software then compares the coordinates of the reference points and moves the subsequent image vertically, horizontally, and rotationally until the pairs of images are matched. Pixel-by-pixel movement of the subsequent image can be performed manually whenever necessary. Grey-level normalisation is performed non-parametrically using a cumulative density function (Ruttimann et al. 1986). After normalisation, the images are digitally subtracted. The selected sites are defined as regions of interest on the radiographs. The computer-assisted densitometric image analysis (CADIA) value is calculated for each region of interest according to a formula described by Bragger (1988). CADIA value is used to quantify alveolar bone changes and is presented as a net value between two standardised radiographic images at different time points.^[16,17,18]

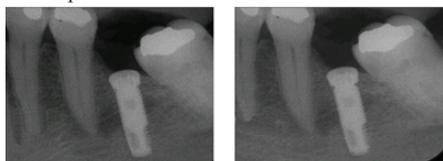


Figure 12. (a) Baseline and (b) follow-up images with the four reproducible anatomical landmarks used for alignment of images.^[18]

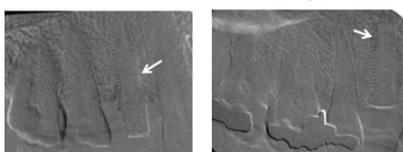


Figure 13. Subtraction radiograph images: (a) the arrow indicates an

area of increased grey levels; (b) the arrow indicates an area of decreased grey levels.^[18]

The use of subtraction radiography is not a new concept and has been utilised in dentistry for several decades (Webber et al. 1990, Grondahl et al. 1983, Hausmann et al. 1985). Grondahl et al. (1987) found that there was a higher inter-observer agreement in estimating periodontal bone changes from subtraction radiographs compared to conventional radiographs.^[16,17]

CONE BEAM COMPUTED TOMOGRAPHY:-

Cone beam computed tomography or volumetric tomography was developed during the 1990s (Arai et al. 1999) and the first machines became commercially available during 2000 (Terakado et al. 2000, Ito et al. 2001a). As the technology developed, scan times became faster and the radiation dose reduced, thus increasing the appeal of CBCT to more practitioners. There are now several machines available on the market, including the i-CAT and Newtom CB3D scanners, and scanners are constantly being refined and upgraded.

Similar to conventional multi-slice CT, CBCT allows three-dimensional visualisation of the oral hard tissues, though there are some fundamental differences. Whereas conventional CT scanners use a fan-shaped beam with the transmitted radiation taking the form of a helix or spiral, CBCT scanners utilise a cone beam that encompasses a large volume in a single rotation around the patient (Arai et al. 1999). Volumetric image acquisition is then achieved using an image intensifier or flat panel detector. Data from CT is interpolated by the scanner into a set of slices, producing a volume. CBCT data is reconstructed using algorithms to produce three-dimensional images at high resolution. Additionally, CT scanners require the patient to be supine during image acquisition, whereas the majority of CBCT scanners position the patient in a seated or standing position.^[13]

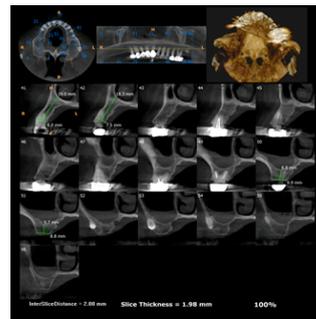


Figure 14. CBCT

Monitoring of peri-implant bone levels and detection of peri-implant diseases could ideally be achieved using CBCT as an adjunct to clinical examination. However, X-ray imaging techniques are prone to produce artefacts with the presence of metal in a radiographic field of view. Beam hardening is the most common associated artefact with implants and occurs when a high-density object in the path of the beam absorbs all the X-ray photons of lower energy. This means that the X-ray beam gradually gets 'harder', that is, contains photons of higher energy. Schulze et al. (2009) found that a typical implant body absorbs large amounts of low-energy radiation whereas high-energy radiation is only marginally absorbed. This resulted in the CBCT analysis overcompensating for this effect, resulting in an artefact on the reconstruction. This can affect the quality of CBCT images and lead to inaccurate or false diagnosis (Zhang et al. 2007).^[13]

Thus, though CBCT scans are reliable and accurate in dental treatment with a rapidly expanding repertoire of applications, there is no evidence supporting the use of CBCT in the post-placement monitoring of implants, despite the increasing usage of CBCT for implant assessment. However, it is still the most accurate and reliable method of assessing 3D bone level changes around an osseointegrating implant, especially in the buccal and palatal/lingual areas.^[13]

ANNUAL PERI-IMPLANT BONE LOSS

Several longitudinal studies consider that radiographic monitoring of bone level changes provides valuable insight into the longevity of oral implants. This indirect assessment is less invasive than the direct visualization of the inter-proximal bone through surgical access.

The early longitudinal studies of Adell et al. in the 1980s established

that the majority of bone loss occurred during the healing and remodeling periods or within the first year of loading. Published data described a mean marginal bone loss of 0.4-0.5mm during the first year post-implantation and 0.05-0.1mm annually thereafter. Similar observations were noted later by other research groups, who defined the following measurements for the one stage ITI implants: 0.75mm after the first year and less than 0.1mm the following years. Another study determined that a mean crestal bone loss ranging from 0.9-1.6mm in the first year after functional loading was acceptable. A mean annual loss of 0.05-0.13mm was reported in various studies with screw-type implants.^[3,4,14,15]

Different values presented in the different studies were related to the variability in analysis methods and data selection. For instance, the Branemark group excluded bone loss occurring during the first year; their results were expressed as mean values, and concerned a population with large inter-individual deviation. For Adell and coworkers, the reported bone loss was 0.1mm with high standard deviations. Measurement errors were reported to be responsible for incorrect judgement of peri-implant bone level. The level at which implants were placed, implant surface textures (machined, different rough surfaces), implant design, and one versus 2-step surgical techniques were other factors that may explain the varying degrees of bone loss measured in the different studies.^[3,4,14,15]

DISCUSSION

Panoramic radiography are less reliable for measuring alveolar bone loss compared with intraoral radiography techniques such as bite-wing and periapical due to the distance from object to the film greater than periapical radiography. The distance between a reference point and the marginal bone level around implants can be assessed with great accuracy by the means of the long-cone paralleling technique with a paralleling device using a digital sliding caliper(Quirynen et al). There are no differences in clinical yield between conventional film and direct digital radiography, the result show that digital techniques have properties and qualities equal or better than film radiography. There was a higher inter-observer agreement in estimating periodontal bone change from subtraction radiographs compared to conventional radiographs (Grondahl et al).

CONCLUSION

Periapical radiographs with long cone paralleling technique assessed the marginal bone level with a great accuracy and higher reliability than other radiographic techniques.

REFERENCE:-

- 1) Monali AS, Sneha SS, Deepak D. Dentascans-Is the investment worth the Hype??. *Journal of clinical and Diagnostic Research*. 2013; 7(12):3039-3043.
- 2) Savitha B, Priyanka V, Hiroj B, Alka W. Bone levels-From Hypothesis to Facts. *IOSR Journal of Dental and medical sciences*. 2013; 6(5):19-23.
- 3) shikha Nandal, Pankaj Ghalaut, Himanshu Shekhawat. A radiological evaluation of marginal bone around dental implant: An in -vivo study. *national journal of maxillofacial surgery (vol-5) issue 2(jul-dec2014)*126.
- 4) Clarissa D. Koller, Tatiana Pereira-Cenci, NoeliBoscatto. Parameters associated with marginal bone loss around implant after prosthetic loading. *Brazilian Dental Journal* (2016) 27(3):292-297.
- 5) L. Akesson, M. Rohlin, J. Hakansson and K. Nasstrom. Comparison between panoramic and posterior bitewing radiography in the diagnosis of periodontal bone loss. *J dent*, 1989; 17: 266-271.
- 6) Cek Dara Manja, M. Edwin Fransiari. A comparative assessment of alveolar bone loss using bitewing periapical and panoramic radiography. *Bali medical journal (Bali med j)* 2018, volume-7, Number 3:636-638.
- 7) Dr. Gazala Yasmeen. Evaluation of diagnostic accuracy of digital bitewing radiography in assessing alveolar bone level in comparison with transgingival probing. *International journal of applied dental sciences* 2018; 4(3) : 217-223.
- 8) Werner Zechner, Georg Watzak, Andre Gahleitner, Dieter Busenlechner. Rotational panoramic versus intraoral rectangular radiographs for Evaluation of peri-implant bone loss in the anterior atrophic mandible. *International journal oral maxillofacial implant* 2003;18, 873-878.
- 9) E De Smet, R Jacobs, F Gijbels and I Naert. The accuracy and reliability of radiographic methods for the assessment of marginal bone level around oral implant. *DentomaxillofacialRadiology*(2002) 31, 176-181.
- 10) Morner-Svalling A-C, TronjG , Andersson LG, Welander U. Comparison of the diagnostic potential of direct digital and conventional intraoral radiography in the evaluation of peri-implant condition. *Clin.oral implant Res*, 14, 2003: 714-719.
- 11) Zarb, G.A and Schmitt, A . (1990) The longitudinal clinical effectiveness of osseointegrated dental implants. The Toronto study.1.Surgical results. *Journal of prothetic Dentistry* 63:451-457.
- 12) Del Balso, A.M., Grenier, F.G and Licata , M. (1994) Role of diagnostic imaging of the dental implant patient. *Radiographics* 4: 699-719.
- 13) L Ritter , M C Elger, ,D Rothamel, T Fienitz, M Zinser , F Schwarz and J E Zoller. Accuracy of peri-implant bone evaluation using cone beam CT, digital intra-oral radiographs and histology. *Dentomaxillofacial Radiology*. 2014 jul ; 43(6):20130088.
- 14) W Geraets, L Zhang, Y Liu and D Wismeijer. Annual bone loss and success rates of dental implants based radiographic measurements. *Dentomaxillofacial radiology* (2014) 43, 20140007.
- 15) Young -Chul Jung, Chong-Hyun Han, Keun-Woo Lee. A 1- year radiographic evaluation of marginal bone around dental implants .*international journal of oral and maxillofacial implants* 11(6), 1996..

- 16) Webber RL, Ruttimann UE, Grondhl H-G. X-ray image subtraction as a basis for assessment of periodontal changes. *Journal of Periodont Res.* (1982), 17:509-511.
- 17) Wenzel A Sensor noise in direct digital imaging (the Radio-Visiography, Sens-A-Ray, and Visualix /Vixa systems) evaluated by subtraction radiography. *Oral surg oral med oral patho*(1994). 77:70-74.
- 18) LS Carneiro, HA da Cunha, CR Leles, EF Mendona. Digital subtraction radiography evaluation of longitudinal bone density changes around immediate loading implants: a pilot study. *Dentomaxillofacial Radiology* (2012) 41,241-247