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Present Status of Conventional Radiographic Techniques in Oral Implantology: A Review

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Abstract: *The placement of dental implants requires meticulous planning and careful surgical procedures. A combination of a limited bone volume and poor bone quality may lead to less predictable bone apposition and early implant failures. A thorough radiographic assessment is paramount for evaluating these factors and informing patients of their prospects for successful rehabilitation with dental implants. A preoperative radiographic evaluation aims to identify pathological lesions, assess the quantity and quality of the alveolar bone, identify critical structures at the potential implant sites, and determine the orientation of the implants. Bone quantity and quality will influence the choice of implants with respect to their number, diameter, length and type. Many imaging modalities have been reported to be useful for dental implant therapy, including periapical, panoramic, cephalometric and tomographic radiography, computed tomography (CT), CBCT, magnetic resonance imaging (MRI), spiral , linear tomography, sectional tomography, interactive CT, imaging stents and softwares. The imaging modalities range from two dimentional projections to complex three dimensional imaging. The two dimensional modalities like conventional radiography are readily available, cost effective with least radiation exposure, but have some limitations.This articles aims to review the status of various conventional radiographic techniques for oral implantology.*

Keywords: *Oral Implantology, Orthopantomograph, Intraoral X rays, lateral cephalometry, Occlusal view*

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I. Introduction

The use of dental implants in oral rehabilitation has currently been increasing since clinical studies with dental implant treatment have revealed successful outcomes [1] Successfully providing dental implants to patients, who have lost teeth and frequently the surrounding bone relies on the careful gathering of clinical and radiological information, on interdisciplinary communication and on detailed planning. One of the most important factors in determining implant success is proper treatment planning. The objectives of diagnostic imaging depend on a number of factors, including the amount and type of information required and the period of the treatment rendered. After a decision has been made to obtain images, the imaging modality is used that yields the necessary diagnostic information related to the patient's clinical needs and results in the least radiologic risk.[2]

The ideal imaging technique for dental implant care should have several essential characteristics, including the ability to visualize the implant site in the mesiodistal, buccolingual and superioinferior dimensions; the ability to allow reliable, accurate measurements; a capacity to evaluate trabecular bone density and cortical thickness; reasonable access and cost to the patient and minimal radiation risk.[3] However, there is no ideal imaging technique in the field of oral implantology that would be acceptable for all patients. In dental and medical radiology, a recommended principle when selecting the appropriate radiographic modality is based on radiologic dosage. Obviously, the goal is to choose a radiographic method providing sufficient diagnostic information for treatment planning with the least possible radiation dose and costs for the patient.

Traditionally, conventional radiographic images (two dimensional) e.g., periapical, occlusal, panoramic and cephalometric images have been used to assist practitioners in planning implant treatment. Clinicians have been diagnosing, treatment planning, placing and restoring dental implants using periapical and panoramic radiographs to assess bone anatomy for several decades. Two dimensional images have been found to have limitations because of inherent distortion factors and the non-interactive nature of film itself provides. With the advent of technology, Digital Subtraction Radiography (DSR) was introduced to dentistry in 1980s.[4,5]

With conventional radiography, a change in mineralization of 30-60% is necessary to be detected by an experimented radiologist .[6] Also the lesions restricted to cancellous bone could not be detected because of its less mineral contents than cortical bone but with DSR the alveolar bone changes of 1-5% per unit volume and significant differences in crestal bone height of 0.78 mm can be detected.[7] In addition, defects of at least 0.49mm in depth of cortical bone can be detected whereas a lesion must be at least 3 times larger to be detectable with the conventional radiography techniques.[8] Furthermore, it can be used to assess the bone at each of three phases of implant treatment, evaluation & maintenance. For a successful DSR, identical contrast and density of the serial radiographs, are essential prerequisites, and long experience shows that this technique is very sensitive to any physical noise occurring between the radiographs and even minor changes leads to large errors in results. Magnetic resonance imaging (MRI) has potential for pre-implant imaging due to the lack of ionizing radiation, but acquisition times can be as long as 30 minutes and there is limited bone information available. MRI is not useful in characterizing bone mineralization or as high-yield technique for identifying bone or dental disease. The reverse is true for CT, as the presence of sclerotic bone in the mandibular body makes the inferior dental canal more obvious.

Diagnostic radiography is essential for implants in pre-operative, intra-operative and post-operative assessment by use of a variety of imaging techniques.[9] Since conventional radiographic modalities provide a two-dimensional (2D) representation of three dimensional (3D) structures. Therefore, 3D information is essential for the implantologist before placement of osseointegrated dental implants.[10] Hence, the advancement of radiographic technology including computed tomography, cone beam CT, DentaScan, Spiral tomography, Linear tomography, Sectional/Transtomography, Interactive computed tomography, imaging stents and softwares are increasingly considered essential for optimal implant therapy.[11] Therefore, the aim of the present review is to examine in depth of the benefits of various radiographic imaging techniques available for implant therapy.

As a personage, the accumulation of wear and tear often results in the loss of teeth. Sometimes teeth are knocked out through trauma, but more often they simply fall out through neglect or are extracted because they are no longer viable. This loss of teeth impacts on the patient's everyday life as their speech, appearance and food choices are affected [12, 13] Although removable dentures are an obvious solution, many people opt for the permanence of dental implants. Dental implant technology has undergone dramatic changes in the past few years and has become a significant treatment planning option in restorative dentistry. Long-term success rates are reported to approach 95% or more [13]·In the past, success has been attributed to increasingly sophisticated imaging technology that has been applied to all phases of implant therapy. Successful implant imaging must recognize that the imaging as well as implant process is prosthetically driven. Because the ultimate objective of fixture placement is a fundamental esthetic and maintainable restoration, no imaging technique is perfect with each examination carrying some risk of false negative or false positive results .[14] Therefore, the patient's specific needs must be carefully considered. It is indeed a disservice to the patient to use recommended imaging technique based on only consideration of radiation dose, cost or proprietary interest. Several imaging techniques are currently available for presurgical and post surgical examination. These may vary from simple two-dimensional views such as panoramic radiographs to more complex views in multiple planes depending on the case and experience of the practitioner.

Selection of a Radiographic Method:

Selection of radiographic methods should be based on basic principles of radiography like

There should be adequate number and type of images to provide the needed anatomic information, In whatsoever technique used, the patients X-raybeam and imaging receptor should be positioned to minimize distortion, ALARA principle should govern the selection if more than one technique is feasible. The ALARA (As Low As Reasonably Achievable) philosophy recognizes that, no matter how small the radiation dose, some adverse effect may result. Consequently, any dose that can be reduced without difficulty, great expense, or inconvenience should be reduced.

Purpose of Radiography:

The purpose of imaging the implant site is

I. To decide whether the implant treatment is appropriate for the patient.
II. To know the location of vital anatomical structure (inferior alveolar nerve, extension of maxillary sinus).
III. For the assessment of quantity of bone, height of alveolar process, buccolingual width and angulation,
IV. To identify any possible pathological conditions.
V. To estimate the number, length and width of the implant.
VI. Possible need for additional treatment for instance bone augmentation procedure and to estimate the prognosis.

Imaging Objectives:

The decision of when to image along with which imaging modality to use depends on the three phases:

1. Preprosthetic implant imaging (Phase 1): The objectives of this phase are to determine the quantity, quality, and angulation of bone; the relationship of critical structures to the prospective implant sites ;and the

presence or absence of disease at the proposed surgery sites.

2. Surgical and Interventional implant imaging (Phase2): The objectives of this phase are to evaluate the surgery sites during and immediately after surgery, assist in the optimal position and orientation of dental implants, evaluate the healing and integration phase of implant surgery,and ensure abutment position and prosthesis fabrication are correct.

3. Post prosthetic implant imaging (Phase 3): It commences just after the prosthesis placement and continues as long as implant remains in the jaws. The objectives of this phase are to evaluate the long-term maintenance of implant rigid fixation and function, including the crestal bone levels around each implant, and to evaluate the implant complex.

Imaging Modalities:

There are many imaging modalities that have been employed for implant imaging, including devices developed specifically for dental implant imaging. These modalities can be described as either analog or digital and two dimensional or three-dimensional. Analog imaging modalities are the periapical, occlusal, panoramic, lateral cephalometric radiographs which are two dimensional systems that employ X-rayfilm and/or intensifying screens as the image receptors These imaging modalities include conventional radiography like periapical, panaromic, occlusal and cephalometric ,substraction radiography, MRI, computed tomography, cone-beam CT,Denta Scan, linear , spiral , sectional , interactive tomography and various imaging softwares along with imaging stents used while implant placement .These create a three-dimensional image which is described not only by its width, height and pixels, but additionally by its depth and thickness.

The goal of modern dentistry is to restore the patient to normal contour, function, comfort, aesthetics, speech and health, whether by removing caries from a tooth or replacing several teeth. What makes implant dentistry unique is the improved ability to achieve this goal, regardless of the atrophy, disease or injury of the stomatognathic system (Miles DA 2008).[15] However, the more teeth a patient is missing, the more challenging this task may become. As a result of continued research, diagnostic tools, treatment planning, implant designs, materials and techniques, predictable success is now a reality for the rehabilitation of many challenging clinical situations.[16,17] Dental implantology has experienced explosive growth during last few years. Treatment planning for implants includes a radiographic examination that provides information about the location of anatomical structures, the quality and quantity of available bone, the presence of infrabony lesions, the occlusal pattern and the number and size of implants as well as prosthesis design, all which are essential for successful implant treatment.[18,19]

The imaging objectives are to provide the clinician with cross-sectional views of the dental arch for visualization of spatial relationship of internal structures of the maxilla and mandible. Minimal image distortion permits accurate measurement. Ideally, the images should allow evaluation of the density of trabecular bone and thickness of the cortical plates bone quality. Imaging studies should help to determine the optimum position of implant placement relative to occlusal loads. In addition, detection of the presence or absence of pathology and which is assessable at a reasonable cost to the patient are the desirable features [20] The decision of when to prescribe imaging depends upon the integration of these factors and can be organized into three phases. Those are: (1) Pre-surgical implant imaging, (2) surgical and interventional implant imaging. (3) Post prosthetic implant imaging. Although several image diagnostic methods are available to evaluate proposed sites for implants, currently, not a single technique is considered ideal for pre- and post-operative analyses. Therefore, few authors suggest a combination of various techniques to obtain reliable information (Frederiksen NL 1995, Silverstein et al 1994).[10,21] However, when weighing risk and cost against the benefit, excessive utilization of newer techniques should be avoided, especially when conventional methods are similarly efficient and adequate.

Intraoral periapical and occlusal radiography greatest details of any imaging techniques. The paralleling techniques with positioning images are of perhaps the instruments should be used to enable a reliable projection of the anatomic structures on plain views. Good quality intraoral radiographs help to reveal minute pathologic changes of the periodontium and the teeth, which can interfere with implant placement.. Alternatively, a positioning device connected to the implants has been proposed to guarantee parallelism between film and implant.[22] They are used in initial phase of patient evaluation to detect the presence of pathosis, the approximate location of anatomic structures such as maxillary sinus and also estimate the quality of the trabecular bone When periapical radiographs are used,it is important to ascertain certain guidelines. It is paramount that exposure be made using paralleling angle technique. However, because the film plane can rarely be placed parallel particularly in edentulous areas, the target film distance is difficult to standardize Hence,periapical radiographs do not provide an accurate assessment of vertical bone dimension or precise position of critical anatomic structures. As periapical radiographs are unable to provide a cross sectional information, occlusal radiographs are sometimes used to determine the facio-lingual dimensions of the mandibular alveolar ridge.Although somewhat useful, the occlusal image records only the widest portion of the mandible which is located inferior to the alveolar ridge. This may give the clinicianawrongimpressionthatmoreboneisavailableinthecross-sectionaldimensionthanthatactuallyexists.Theocclusaltechnique is not useful in maxillary arch because of anatomic limitations.

i) **Periapical Radiography**:

Traditionally, conventional radiographic images e.g., periapical and panoramic images have been used to assist practitioners in planning implant treatment. Periapical radiographs commonly are used to evaluate the status of adjacent teeth and remaining alveolar bone in the mesiodistal dimension. In addition, they have been used for determining vertical height, architecture and bone quality (bone density, amount of cortical bone and amount of trabecular bone).Although readily available and relatively inexpensive, periapical radiography has geometric and anatomic limitations. If the paralleling technique is not used, periapical radiographs create an image with foreshortening and elongation.[3,23] When the x-ray beam is perpendicular to the film, but the object is not parallel to the film, foreshortening will occur. If the x-ray beam is oriented perpendicular to the object but not the film, elongation will occur. The most accurate intraoral radiographic technique used for implant planning is the paralleling technique. The long cone paralleling technique for exposing periapical radiographs is the technique of choice for the following reasons: Reduced skin dose; minimal magnification; a minimally distorted relationship between the bone height and adjacent teeth is demonstrated; and minimal superimposition of the zygomatic process of the maxilla over the upper molar region. It should be remembered that to get the most from the long cone paralleling technique, it should be performed using a long collimator with a film-focal distance of approximately 30 cm. (Tyndall et al 2000).[11] Therefore, standardized periapical radiographs with bite-blocks by using paralling technique should be perform to the longitudinal studies (Benson & Shetty, 2009; Resnik et al., 2008).[3,2]

Formoso et al analysed the precision of the modification of the long cone parallel technique that can be used with important anatomical limitations & checked the influence of the reference points definition of objects to be measured by using both the original and the modified radiographic techniques.[24] A total of 28 Straumann implants of bone level type were used measuring 4.1 mm in diameter with lengths of between 10 mm and 12 mm . 2 intraoral radiographs were taken of 28 implants with 2 different methods: a standard paralleling technique and a modified technique that used a smaller film and a silicone spacer to ensure parallelism. Measurements of peri-implant bone levels and implant width were made in triplicate on digitized film radiographs. The results of the peri-implant bone levels were that with the parallel method the mean was 0.44 mm and the precision was 0.43 mm, and with the modified method the mean was 0.73 mm and the precision was 0.66 mm. In addition to the correct localization of the point of reference in this study, the precision with the parallel method was 0.08 mm and with the modified method was 0.13 mm. Authors concluded that although it was greater with the gold standard technique than with the modified technique, precision was very high for both methods and accurate enough for clinical use.

Hansen et alcompared the Detailed Narrow Beam (DNB)radiographic technique with conventional intraoral radiography in the assessment of marginal bone loss around dental implants in the mandible and to evaluate observer agreement.[25] Forty patients were included in this study for the follow up examination after treatment with Branemark dental implants in lower jaw. Implants were randomly selected if same patient had more than one implant in the same region. Ten implants were selected from each of four dental regions(molars, incisors, canine, premolar) and no more than one implant was selected from same patient. Seven observers assessed all the radiographs and asked to assess the marginal bone level by counting the number of threads between implant- abutment connection and the level of marginal bone on the mesial and distal surfaces of the implant. Three of the observers made all the assessment twice and resulted that the seven observers agreed on the marginal bone level at only 12 of the 80 implant surfaces of these 12 cases, 10 were periapical, 2 were DNB radiographs. In these 12 cases, marginal bone level was assessed superior to thread 1. Inter observer agreement, expressed as the kappa value for 7 observers, was 0.33 for periapical radiograph & 0.27 for DNB radiography. Author concluded that Scanora multimodal radiography simplifies examination of implant in mandible & observers vitiations is comparable with that of IOPA.

Anil et al [26] described the use of radiographic imaging software to calibrate and measure anatomical landmarks to overcome inherent distortions associated with dental radiographs. Although technological advances have resulted in new imaging innovations for implant dentistry, dental radiography remains the most widely used tool for determining the quantity and quality of alveolar bone as it is a non-invasive procedure. However, the unreliable magnification factor associated with conventional radiographs remains a major problem when estimating the amount of bone available at the implant site. Authors concluded that the application of digital technology as well as the improvements in conventional radiographic techniques has facilitated the quality of radiographs and reduced the distortion in panoramic radiography.

ii) Occlusal Radiography:

Occlusal radiographs are planar radiographs produced by placing the film intra orally parallel to the occlusal plane with the central x-ray perpendicular to the film for the mandibular image and oblique (45°) to the film for maxillary image.periapical radiographs are unable to produce any cross sectional information occlusal radiographs are sometimes used to determine the bucco lingual dimensions of the mandibular alveolar ridge Cross-sectional occlusal radiographs of the mandible give some information about the buccolingual dimension of the mandible, but this information is only accurate with regard to the inferior aspect of the body and not the width of the alveolar ridge where the implant is to be placed. The use of cross-sectional occlusal radiographs can be helpful when assessing the position of the implant within the jaw following placement both in the mandible and maxilla.

Jameel et alevaluated the accuracy of longitudinal topographic occlusal view (LTO) in the measurement of alveolar bone thickness, and designing the beam aiming device to improve technical application of radiographic technique.[28] the alveolar bone thickness of 20 posterior edentulous sites (10 sites for each jaw) in the maxilla and mandible of three dry skulls measured directly by using digital caliper and radiographically by longitudinal topographic occlusal view with newly designed beam aiming device.Statistical analysis of the results with independent paired t-test showed no significant difference between the direct and radiographic bone thickness ($p \geq 0.05$). Authors concluded that the longitudinal topographic occlusal radiograph presents accurate measurements of alveolar bone thickness in the simple and uncomplicated implant cases of the proposed posterior implant sites to avoid the excessive radiation dose, cost and for time saving for patient and operator. The designed beam aiming device recommended using for standardization, and simplicity of technical application. Maxillary occlusal radiographs are inherently oblique and are so distorted that they are of little quantitative use for implant dentistry, for either determining the geometry or the degree of mineralization of the implant site. In addition, it shows the widest width of bone (i.e. the symphysis) versus the width at the crest, which is where diagnostic information is needed most.[27]

iii) Panoramic Radiographs

Assessment of available alveolar bone and bone morphology, with clinical examination and palpation of the bone ridge at the implant site, is essential in preoperative implant planning. Various presurgical imaging techniques, including conventional radiographs (intraoral and panoramic radiographs, occlusal , cephalometry) and computed tomography (CT), are proposed .But there are some limitations of intraoral and occlusal radiography like the periapical radiographs are unable to provide any cross-sectional information and cross sectional occlusal radiographs of mandible give some information about the buccolingual dimension of the mandible, but this information is only accurate with regard to the inferior aspect of the body, not the width of the alveolar ridge where the implant is to be placed. Panoramic radiographs are commonly used for diagnostic purposes in implantology.[29] Three types of shadows can be identified on pantomographs. Structures inside and outside the trough, whose long axis is parallel to the direction of the beam (i.e,structures near the midsagittal plane), form distinct images called primary shadows. Dense structures outside the focal trough, whose long axis is perpendicular to the direction of beam movement, form indistinct images called secondary shadows. Their appearance results from the beam passing the right and left jaw arches simultaneously, so that the jaw side nearest the film forms the primary shadows, while the jaw side nearest the x-ray source produces secondary shadows. The secondary shadows are reversed when the structures near the x-ray source are located behind the centre of the beam rotation. Superimposition of secondary and primary shadows can produce apparent radiolucencies caused by contrast. These images are called *false shadows* because they lack anatomic basis. Although the need for cross-sectional imaging has been strongly recommendedpanoramic radiography is considered to be the standard radiographic examination for implant treatment planning as it imparts a low radiation dose.[30,31,32,11,33]

Dharmar et al in 1997determined whether it is possible to locate the anteroposterior course of the mandibular canal and the mental foramen more clearly on panoramic radiographs by tilting the patient's head downward approximately 5 degrees with reference to the Frankfort horizontal plane (FHP) of the Orthopantomogram (OPG) machine. One panoramic view would be taken with the standard setting as prescribed by the manufacturer, ie, the FHP of the patie patient's FHP would be kept at a 5-degree angle downward to the reference bar of the machine. The radiographs were read by the author for location of the mental foramen, mandibular foramen, and the entire course of the mandibular canal on both right and left sides. In 91% of the radiographs taken in this position, the mandibular foramen, mandibular canal, and mental foramen were visible. The angulation of the patient's head reduced the chances of superimposition on the contralateral sides, making these structures clearly visible. Authors concluded that by tilting the patient's head 5 degrees downward with reference to the Frankfort horizontal bar of the OPG machine, the mandibular canal can possibly be made more visible.[34]

Vazquez et al in 2011 estimate a panoramic unit's vertical magnification factor (MF) by measuring the length of dental implants used as radiopaque reference objects on postoperative panoramic radiographs.[35] Using a digital calliper, they measured the length of 32 implants on 17 postoperative panoramic radiographs taken with a Scanoras unit. The implants were 10mm-long placed in the posterior segments of mandibles. Author concluded that reliability of the MF confirms that a panoramic radiograph can be used for preoperative implant length evaluation in the posterior mandibular segments. MF stability should be verified with other panoramic units. In clinical practice, using the implant length as a reference object on postoperative panoramic radiographs is a simple and effective evaluation method to estimate a panoramic unit's MF.

Gijbels et al (2005)compared patient radiation doses generated by five different types of digital panoramic units.[36] An anthropomorphic phantom was filled with thermoluminescent dosemeters (TLD 100w) and exposed with five different digital panoramic units during ten consecutive exposures. Four machines were equipped with a direct digital CCD (charge coupled device) system, whereas one of the units used storage phosphophosphor plates (indirect digital technique).Salivary glands absorbed the most radiation for all panoramic units. When indirect and direct digital panoramic systems were compared, the effective dose of the indirect digital unit (8.1 mSv) could be found within the range of the effective doses for the direct digital units (4.7–14.9 mSv). Authors concluded that various digital panoramic machines can provide a rather broad range of effective radiation doses for the patient (4.7–14.9 mSv).

Kim et al (2011)evaluated the efficacy and accuracy of cases in which pre-implant diagnosis as well as treatment protocols were prepared through the application of the digital panoramic radiation system without performing CT and other expensive precision tests.[37]He selected 221implants (124 in males, 97 in females) were consecutively placed at the dental clinic in the Seoul National University Bundang Hospital. All of the patients enrolled in this study were partially edentulous or had single missing teeth.On all patients, digital panoramic radiographs were taken before the treatment and after implant surgery. For 10 of the 86 patients, CT was also performed before surgery (4 males, 6 females).They analysed the magnification rate and the difference between the actual inserted implant length and planned implant length according to the location of the implant placement and the clarity of anatomical structures seen in the panoramic radiographs .There was no significant difference between the planned implant length and actual inserted implant length (P . 0.05). The magnification rate of the width and length of the inserted implants, seen in the digital panoramic radiographs, was 127.28¡13.47% and 128.22¡4.17%, respectively. The magnification rate of the implant width was largest in the mandibular anterior part and there was a significant difference in the magnification rate of the length of implants between the maxilla and the mandible (P=0.05). When the clarity of anatomical structures seen in the panoramic radiographs is low, the magnification rate of the width of the inserted implants is significantly higher (P =0.05), but there is no significant difference between the planned implant length and actual inserted implant length according to the clarity of anatomical structures (P =0.05). Authors concluded that the digital panoramic radiography system is an effective method that is simple and inexpensive for pre-implant diagnosis and establishing treatment protocol, and it uses a relatively low radiation exposure.

Vazquez et al (2013) assessed the accuracy of the vertical height measurement on post-operative digital panoramic radiographs using implants in the posterior segment of the mandible as intrabony radio-opaque objects.[38] Direct digital panoramic radiographs, performed using a Kodak 8000C of 17 partially edentulous patients (10 females, 7 males, mean age 65 years) were selected from an X-ray database gathered during routine clinical evaluation of implant sites. Mean vertical DR was 0.99 for implants and 0.97 for balls, and was unrelated to mandibular sites, side, age, gender or observer. Inter- and intraobserver agreements were acceptable for both reference objects. Authors concluded that Vertical measurements had acceptable accuracy and reproducibility when a software-based calibrated measurement tool was used, confirming that digital panoramic radiography can be reliably utilized to determine the pre-operative implant length in premolar and molar mandibular segments.

Fortin et al (2011) compared clinically & radiographically panoramic images versus three-dimensional planning software for oral implant planning in atrophied posterior maxillary.[39] During a 2-year period, every patients who presented for the placement of implants in the posterior maxilla were included in this study. Primary planning was based on an intraoral or a panoramic radiograph. When indicated a sinus lift with creation of a lateral window, a CT scan was performed and examined using dedicated three-dimensional software by a clinician familiar with the Computer Assisted Design/ Computer Assisted Manufacturing (CAD/CAM) implant placement protocol. One hundred one patients were studied for the treatment of 135 edentulous spans accounting for 301 missing teeth.After examination of the CT data on the three-dimensional software, 202 teeth (67.1%) could be replaced using a CAD/CAM procedure; 60.7% of the edentulous spans could be completely repaired by a crown or bridge supported by implants. In addition, 67.3% of edentulism with no teeth posterior to the span could be completely repaired using a fixed prosthesis supported by implants. Authors concluded that the use of a panoramic radiological exam for oral implant planning in severely resorbed maxillae overestimates the need for a sinus augmentation procedure, when compared with the use of both three-dimensional planning software and strategic implant placement when there is little remaining bone volume.

Penarrocha et al (2004) compared extraoral panoramic with conventional and digital intraoral periapical radiography to quantify marginal bone loss.[40] A total of 108 implants were placed (59 in the maxilla and 49 in the mandible) in 42 patients (16 men and 26 women) with a mean age of 44.2 years (range 14 to 68 years). Orthopantomographic, conventional periapical, and digital radiographs were obtained at loading and again 1 year later. Bone loss was calculated from the difference between the initial and final measurements. Mean loss in alveolar bone height was determined to be 1.36 mm by extraoral panoramic radiography, 0.76 mm by intraoral periapical radiography, and 0.95 mm by digital radiography.Authors concluded conventional periapical films and digital radiographs were more accurate than orthopantomography in the assessment of peri-implant bone loss.

Takeshita et al (2014) compared diagnostic accuracy between conventional, digital periapical radiography, panoramic radiography and cone‐ beam computed tomography in the assessment of alveolar bone loss.[41] The sample consisted of 70 teeth from 10 macerated human mandibles of the university's Department of Morphophysiology Sciences, each mandible with varied number of teeth.Three programs were used to measure ABL on the images: Image tool 3.0 (University of Texas Health Sciences Center, San Antonio, Texas, USA), Kodak Imaging 6.1 (Kodak Dental Imaging 6.1, Carestream Health®, Rochester, NY, USA), and i‐ CAT vision 1.6.20. Statistical analysis used ANOVA and Tukey's test at 5% significance level. The tomographic images showed the highest means, whereas the lowest were found for periapical with Han‐ Shin. Controls differed from periapical with Han‐ Shin ($P < 0.0001$). CBCT differed from panoramic ($P = 0.0130$), periapical with Rinn XCP ($P = 0.0066$), periapical with Han‐ Shin ($P < 0.0001$), and digital periapical ($P = 0.0027$). Conventional periapicals with film holders differed from each other ($P = 0.0007$). Digital periapical differed from conventional periapical with Han‐ Shin ($P = 0.0004$). Authors concluded that conventional periapical with Han‐ Shin film holder was the only method that differed from the controls. CBCT had the closest means to the controls.

These are narrow beam rotational tomographs, which use two or more centers of rotation to produce an image, with a predefined focal trough, of both the upper and lower jaws. Panoramic radiography allows complete visualization of the relationship of the maxillofacial structures within the focal trough, and provides information on the relative position of the inferior alveolar canal and the maxillary sinuses in relation to the crest of the alveolar ridge. It provides an approximation of bone height and vital structures and any pathological conditions that may be present (Strid et al 1985).[42] A panoramic image cannot provide clinicians with information about the buccolingual cross-sectional dimension or the inclination of the alveolar ridge (Fredholmet et al 1993).[43] Angular measurements taken from panoramic radiographs tend to be accurate, but this is not true for linear measurement (Shetty and Benson 1999).[44] Assessments of mesiodistal distance can be very imprecise due to inappropriate patient positioning and/or individual variations in jaw curvature (Langland et al 1989).[45] The focal trough of panoramic radiography is relatively thick, approximately 20 mm in the posterior region and 6 mm in the anterior region . Moreover, the maxillary and mandibular anterior regions often appear blurred. Due to the use of an intensifying screen to reduce the radiation dosage, panoramic radiographs provide inferior images. Although panoramic radiographs may provide a useful overview and may be used in conjunction with ridge mapping or other diagnostic tools, they are unlikely to meet the strict criteria set for primary imaging tests for implant planning (Reiskin et al 1998).[46] In addition, panoramic image cannot provide clinicians with information about the buccolingual cross-sectional dimension or the inclination of the alveolar ridge. Assessments of mesiodistal distance can be very imprecise due to inappropriate patient positioning and/or individual variations in jaw curvature. Therefore, it is of limited value in demonstrating critical structures but is of very little use in depicting the spatial relationships between the structures and dimensional quantification of the implant site.

iv)Lateral Cephalogram

Lateral cephalometric radiographs are produced with the patient's midsagittal plane oriented parallel to the image receptor by using a cephalometer. The cephalometer physically fixes the position of the skull with projections into the external auditory canals. Lateral cephalometric radiographs have been recommended for evaluating the anterior maxilla and mandible for dental implant placement **.** They can accurately measure the height and width of the residual bone at the anterior midline of both the maxilla and mandible. Lateral cephalometric radiography also allows analysis of the quality of the bony host site (ratio of compact to cancellous bone), particularly that in the anterior region of the mandible (Lekholm et al 1985).[47] The soft tissue profile is also apparent on the radiographs and can be used to evaluate profile alterations after prosthodontic rehabilitation (Shetty et al 1999).[44] If a patient is already wearing a denture, a recording should be made with the denture in place in order to provide information about the preoperative relationships between the maxilla and mandible (Strid et al 1985).[42]

Beltrao et al (2007) presented an objective and simple technique that employs a lateral cephalometric radiograph for the preoperative planning of maxillary implant reconstruction with autogenous bone graft.[45] Lateral cephalometric radiographs were performed with a metallic marker placed inside an acrylic-coated model, followed by cephalometric studies, to predict the most adequate grafting method for maxillary reconstruction in 13 edentulous patients (2 males and 11 females) whose age ranged from 27 to 47 years (mean age 37.9 years). It was possible to predict the type of maxillary reconstruction in all patients. Onlay graft was used in 12 patients. One patient was submitted to LeFort I reconstruction with interpositional graft. After 8 months, the patients received a total of 95 standard implants. The success rate was 94.7% with loss of five implants. Rehabilitation was performed with protocol-type prostheses. All patients have been followed for more than 18 months since osseointegration. Authors concluded that this was a simple and objective method provided a useful contribution to maxillary reconstruction, and to the functional and aesthetic rehabilitation of the patients.

Simon et al (2013) highlighted a simple modification that was made to enhance a two-dimensional view provided by a lateral cephalogram to enable placement of a dental implant to replace the missing left maxillary lateral incisor, that was complicated by the presence of a narrow space.[46] An eighteen-year-old boy with a chief complaint to replace his missing left maxillary lateral incisor. The ridge mapping procedure revealed that there was adequate bone in the buccolingual dimension to accommodate a mini implant with a diameter of 3 mm. The modification was made possible by fabricating an occlusion rim in the region missing maxillary left lateral incisor region and placing a custom-made L shaped 21-gauge wire in the space of the missing teeth. The L shape of the wire was initially angulated using the long axis of the adjacent teeth and the inclination of the labial alveolar mucosa and the temporary splint was placed in the maxillary arch to facilitate a lateral Cephalometric radiograph. The resulting image was used to align the L shaped 21-gauge wire to make it lie parallel with the angle formed by the labial alveolar bone in the region of the maxillary left lateral incisor. A second image was then made to confirm that the angle formed by the L shaped wire was coinciding with the angle formed by labial surface of the alveolar bone in the region of the maxillary left lateral incisor. The occlusion rim was then converted to a surgical template with the final L shaped wire embedded into the labial surface adjacent to the missing maxillary lateral incisor. Authors concluded that the modified technique using the cephalogram in addition to the other diagnostic technique proved to be an approximate guide to the surgical procedure.

Lateral cephalometric radiographs offer limited information about the symphyseal area, and the inclination and buccolingual dimensions of the anterior jawbone region. They are not very useful when planning placement of implants lateral to the mid-sagittal plane. Moreover, due to the presence of genial tubercles, lateral cephalometric radiographs may create overly optimistic bone volume assessments (Jacobs et al 1998).[47] With a fixed relationship between focus-film and film-object distance, there is a uniform magnification of about 10% (7-12%) (Shetty et al 1999).[44]

II. Summary & Conclusion:

Coventional radiographs are traditionally used in many conditions in oral and maxillofacial arena as documented in the literature. It has been used for diagnosing the presence of alveolar bone and tooth and in cleft lip and palate cases, locating the displaced lower third molar in submandibular or lateral pharyngeal space by two x ray technique in different position technique , for detection of callus formation postoperatively in distraction osteogenesis, soft tissue analysis for the correction of mentolabial angle by either orthodontically , hard tissue surgery or a lip surgery (chelioplasty),for diagnosing a large odontogenic pathology or development anomalies like concrescence etc. Radiographs are also frequently used in trauma for diagnosing the fracture of mandibular and maxillary region, treatment by plates and screws and to compare pre and post orientation of hardwares and healing of the fracture sites. Also periodontal disease with significant bone loss that needs periodontal surgeries also needs radiographic evaluation.In the new era, conventional radiographs are widely used for implant pacement and their follow up.

The placement of dental implants requires meticulous planning and careful surgical procedures. A combination of a limited bone volume and poor bone quality may lead to less predictable bone apposition and early implant failures. A thorough radiographic assessment is paramount for evaluating these factors and informing patients of their prospects for successful rehabilitation with dental implants. A preoperative radiographic evaluation aims to identify pathological lesions, assess the quantity and quality of the alveolar bone, identify critical structures at the potential implant sites, and determine the orientation of the implants. Bone quantity and quality will influence the choice of implants with respect to their number, diameter, length and type. Preoperative radiographic assessment has assumed an increasingly important role in treatment planning for implant-supported prostheses. It often requires a more extensive radiographic examination than that used for other types of oral rehabilitation.

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