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Imaging Modalities in Dental Implantology: A Review

Abstract:
Replacement of missing teeth with dental implants has become an indispensable part of modern dental practice. The success of dental implants depends on meticulous treatment planning which depends on precision and accuracy of diagnostic information of the patient's anatomy at the proposed implant site. Various imaging modalities may assist in placing implants in an appropriate location with relative ease and obtain a predictable outcome. These include periapical, occlusal radiographs, panoramic and cephalometric, conventional and computed tomography (CT), cone-beam computed tomography (CBCT), and Magnetic Resonance Imaging (MRI). The present article focuses on various diagnostic imaging modalities available for dental implantology.

Keywords: Dental implants, Computed tomography, Treatment planning, Imaging modalities, Dental implantology

Introduction :

Implant dentistry has evolved to become an important part of modern dental practice.[1,2] Dental implants have grown in popularity and demonstrate high survival rates. This leads many clinicians to consider them the standard of care for the replacement of missing teeth.

Successful rehabilitation with implants is highly dependent on proper diagnosis and treatment planning which further depends on accurate imaging and skilful interpretation.[3] Diagnostic imaging techniques are an important tool for the treatment planning of implant prostheses. Imaging of implant site is required to identify underlying bony pathologies, undercuts, and concavities, to find out whether the patient can tolerate the surgical procedure, to assess bone density, to know the approximation of vital anatomical structures, and to estimate the number, dimensions, orientation, location, and prognosis of the implant to be inserted.[4]

The imaging modalities vary from standard projections routinely available in the dental office to more complex radiographic techniques. Standard projections include intra-oral (periapical, occlusal), extra-oral (panoramic, lateral cephalometric) radiographs. More complex imaging techniques include conventional X-rays, computed tomography (CT), cone-beam computed tomography (CBCT), and Magnetic Resonance Imaging (MRI).[5]

Multiple factors affect the selection of radiographic techniques for a particular case including cost, availability, radiation exposure, and patient's anatomy. The dentist aspires to find a balance between these factors to minimize the risk of any complications to the patient.[6]

This article focuses on imaging modalities that have a pivotal role in implant therapy and their applicability to facilitate the clinician's work in successful implant placement.

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Goals and Objectives of Imaging :

- To measure bone height and width (bone dimensions)
- To assess bone quality
- To determine the long axis of alveolar bone
- To identify and localize internal anatomy
- To establish jaw boundaries
- To detect any underlying pathology
- To predict implant prognosis and longevity[1, 6]

An important aspect of radiographic evaluation should be a qualitative description of the bone in the target is the most favourable Osseointegration is thought to occur only in certain types of bone.

Although there is no single universally accepted system for classifying bone quality in the maxilla and mandible, the Misch system based on the radiographic appearance of bone has been widely used by clinicians.
The Misch system divides bone into[4] subdivisions:-
The Misch system is widely used by clinicians and divides bone into four subdivisions based on the observed bone density (D-1 to D-4)
D-1 and D-2 bones generally have dense cortical plates with coarse trabeculae and small bone marrow spaces, D-1 (atrophic anterior mandible) being denser than D-2(anterior maxilla, anterior and posterior mandible)
D-3(anterior and posterior maxilla)
D-4 (posterior maxilla) bones range from poorly mineralized or thin trabeculae to complete paucity of mineralized trabeculae (D-3 being denser than D-4)7

Phases of Implant Imaging :
Imaging modalities are useful in three phases of treatment:

Phase 1: Pre prosthetic Implant Imaging:

In this phase, diagnosis and treatment planning for the dental implant is done. Evaluation of patient's edentulous site, soft tissue condition, bone mineralization and bone type, available bone in the edentulous area, number of dental implants required. Imaging in this phase determines the quantity, quality, and angulation of bone, the relationship of critical structures to prospective implant sites, and the presence or absence of disease at the proposed surgical sites.

Phase 2: Surgical and Interventional Implant Imaging:

Evaluation of surgical sites during and immediately after surgery can be done in this phase using imaging which would assist in the optimal positioning and orientation of dental implants and ascertains the healing and integration phase of implant surgery.

Phase 3: Post-prosthetic Implant Imaging:

This phase begins just after the placement of the prosthesis and continues as long as the implant remains in the jaw. Imaging evaluates any long-term change in the implant's fixed position and function, including the crestal bone levels around each implant. It can also evaluate the status and prognosis of the dental implant.[4, 8]

Ideal Imaging Modality Characteristics for Implant:
Ideal imaging modality characteristics for implant includes:

1. Cross-sectional views for the visualization of the spatial relationship of internal structures, such as the inferior alveolar canal, and as a means of obtaining accurate dimensions in both the vertical and the horizontal planes
2. Minimal image distortion to permit accurate measurements
3. Depiction of the density of the cancellous bone and thickness of the cortical plates of bone. This is of value if initial stabilization of the implant is required
4. Spatial relationship of the cross-sectional views of the mandible and maxilla to one another
5. A simple means of identifying the exact location of each cross-sectional image to the implant site that can be provided at the time of surgical placement
6. Ready availability and reasonable cost
7. Patient radiation dose should be small as possible
8. Imaging information should be balanced with the

radiation dose and cost to the patient. The ALARA (As low as reasonably achievable) principle should govern the selection of suitable technique[9, 10, 11]

Imaging Modalities in Implantology:

Imaging modalities employed for implant imaging include:

- Periapical Radiography
- Occlusal Radiography
- Panoramic Radiography
- Cephalometric Radiography
- Tomography
- Computed Tomography (CT)
- Dentascan
- Cone Beam Computed Tomography (CBCT)
- Interactive Computed Tomography
- Magnetic Resonance Imaging (MRI)

Periapical Radiography (Figure 1)

Periapical radiographs produce a high-resolution planar image. These may suffer from both distortion and magnification which is limited by using the long cone paralleling technique.7[] Digital periapical radiographs are captured electronically, loaded into, viewed and, stored in a digital format. The images obtained can be viewed in the dental operatory on a video monitor.[3] It allows rapid acquisition of intraoral images and their enhancement, storage, retrieval, and transmission to remote sites. It reduces exposure by almost up to 90% than conventional periapical imaging.

Uses:

1. Most often used for single tooth implants in regions of abundant bone width
2. For ruling out local bone or dental disease
3. It may be used during the initial stages of clinical examination to evaluate small edentulous spaces, identifying critical structures, and the status of teeth adjacent to the planned implant site
4. It is used post-implant surgery to check for the presence of any pathosis and/or prognosis during recall appointments7

Disadvantages:

1. It has limited value in determining bone quantity because the image is magnified, may be distorted, and does not depict the third dimension of bone width
2. It is of limited value in determining bone density or mineralization and in depicting the spatial relationship between the structures and the proposed implant site[7]

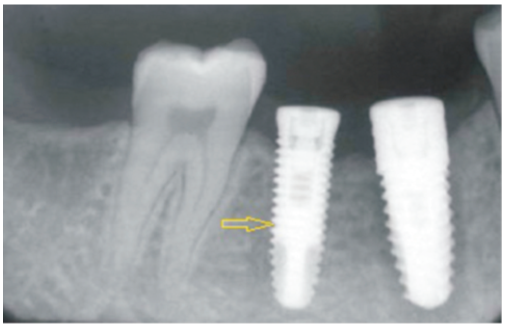

Figure 1: Periapical radiograph of the left mandibular posterior region shows the osseointegrated implant (arrows).[6]

Occlusal Radiography:

Occlusal radiographs are planar radiographs. It produces high-resolution images. Structures such as maxillary sinus, nasal cavity, and nasopalatine canal can be assessed through occlusal radiography.[1]

Uses:

1. It shows the widest width of bone vs the width at the crest, where diagnostic information is needed most
2. It provides generalized information about bone density and the width of the inferior border of the mandible; laterally exposed film shows the width of the bone in the midline
3. For the edentulous mandible/maxilla to obtain information regarding bucco-lingual width and contour7

Disadvantages:

1. It produces an oblique and distorted image of the mandible and maxilla, which is of little use.
2. The degree of mineralization of trabecular bone cannot be determined, and the spatial relationship between the critical structures and the proposed implant site is lost

Panoramic Radiography (Figure 2)

Panoramic radiography is a technique used to produce a single image of the maxilla and mandible and their supporting structures in a frontal plane. This radiographic technique is a part of the standard of care for pre-operative evaluation of an implant site and is the most utilized diagnostic element in implant dentistry today.[12]

Advantages:

1. Ease of identifying opposing landmarks
2. Ability to measure the vertical height of bone in the area of interest
3. Not time-consuming
4. Convenient and easy to use
5. Economical as compared to computed tomography
6. Gross anatomy of the jaws and any related pathologic findings can be evaluated[3,7]

Disadvantages:

1. The procedure cannot be performed in the dental operatory and requires additional set up
2. It has lesser resolution than periapical or digital periapical radiography and hence suffers from magnification and distortion
3. It does not demonstrate bone quality/ mineralization
4. Misleading quantitatively because of magnification and because of the third dimension, the cross-sectional view is not demonstrated
5. It is of some use in demonstrating critical structures but of little use in depicting the spatial relationships between the structures and dimensional quantification of the implant site shows 10% magnification7

Uses:

1. Panoramic radiographs are used for the longitudinal assessment of the success of the implant
2. To rule out gross pathoses within the jaw

Figure 2: Panoramic radiograph[3]

Cephalometric Radiography (Figure 3)

Cephalometric radiographs are oriented planar radiographs of the skull. A lateral cephalometric radiograph is produced with the patient's midsagittal plane oriented parallel to the image receptor. The magnification ranges from 6% to 15% and provides a more accurate representation than panoramic radiographs of vertical height, width, and angulation of bone at the midline.[12]

Uses:

1. A useful tool for the development of an implant treatment plan, especially for the edentulous patient
2. To evaluate the loss of vertical dimension and skeletal arch interrelationship
3. To measure anterior crown/implant ratio
4. To check soft tissue profile
5. To evaluate anterior tooth position in the prosthesis7, 12

Disadvantages: Not useful for demonstrating bone quality

Figure 3: Cephalometric radiograph[3]

Cross-sectional Imaging:

Tomography:

Tomography is a generic term formed from the Greek words Tomo (slice) and Graph (picture) that was adopted in 1962 by the International Commission on Radiological Units and Measurements to describe all forms of body section radiography.[7] Device used is called tomography and while the three-dimensional image produced is called Tomogram. It is accomplished by blurring the images of structures lying superficial and deep to the plane of interest through the process of motion "unsharpness".[12]

Various image slices obtained are 1 mm thick and suitable for both pre and post-implant placement assessment.13 Post imaging digitization of tomographic implant images enables the use of a digital ruler to aid in the determination of alveolar bone for implant placement. Image enhancement can aid in identifying critical structures such as the inferior alveolar canal.[12]

Conventional tomography:

Conventional Tomography is a method that obtains a clearer image of the structures lying within a plane of interest. The film and X-ray beam progress with respect to each other and consequently blurring out structures. The magnification factor of this imaging technique is stable in all directions.5 Conventional tomography is capable of resolving details as small as a few microns in size, even when imaging objects are made of high-density materials.

Uses:

1. It is used for accurate assessment of alveolar bone height, width, and inclination
2. It can assess both the quality and quantity of the bone
3. In dental implant patients it helps in determining the quantity of bone and proximity of critical structures to the implant site
4. It is useful for the planning of single implant sites or those within a single quadrant
5. It is used in multiple implants where bone densities or volumetric analysis are not required[13]

Advantages:

1. Minimal Superimposition
2. Facial-Lingual Dimension
3. Uniform Magnification
4. Measurements accurate within about 1mm
5. Moderate cost
6. Simulates placement with software[2, 10]

Disadvantages:

1. Bone quality can not be obtained
2. Less image definition than plain films
3. Somewhat limited availability
4. Special training for the interpretation
5. Sensitive to technical errors
6. Greater radiation exposure for multiple sites10

Computed Tomography (CT):

Computed tomography was invented in 1972 by British engineer Godfrey Hounsfield of EMI Laboratories, England, and by South Africa-born physicist Allan Cormack of Tufts University, Massachusetts.3 It is the most commonly used imaging modality for implant planning. CT provides a unique means of post-imaging analysis of proposed surgery or implant sites by reformatting the image data into any plane, such as axial, sagittal, or coronal thus gives the actual dimension of bone at the osteotomy site.[11]

Uses:

1. It is used for imaging, the temporomandibular joint, evaluating dental/ bone lesions, assessing maxillofacial deformities, and for pre and post-surgical evaluation of the maxillofacial region.
2. The information provided is a life-size image, which is highly desirable for ease of measurements7
3. It gives a correct picture of the proximity of vital structures at the site of implant placement so the proper orientation and position of the implant can be determined.
4. It helps in determining the bone quantity and quality.8

Disadvantages:

1. The high absorbed dose of radiation to the patient in comparison with the dose administered through panoramic and linear tomography.

2. Limited availability of reconstructive software
3. Expensive[3, 14]

Denta-Scan Imaging (Figure 4):

Dentascan is a commercially available desktop interactive software program that permits imaging of the mandible and maxilla in three planes i.e. cross-sectional, axial, and panoramic. These 3D Images allow accurate pre-surgical treatment planning. [5]

Advantages:

- Assess radiographs in two or three dimensions
- Assess bone volumes and density
- Manipulate the images to simulate implant placement or bone grafting procedures,
- Evaluation of bone height and width
- Identification of soft and hard tissue pathology
- Location of anatomical structures
- Measuring vital qualitative dimensions necessary for implant placement[8]

The disadvantage of Dentascan is radiation exposure, increased cost and image magnification because the images produced are not of the true size and require compensation for magnification.(2)

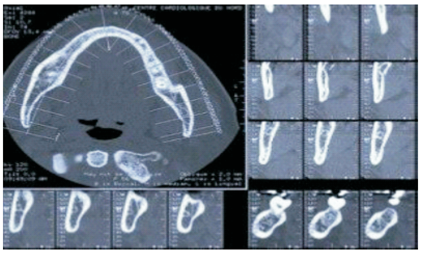

Figure 4: Dentascan(3)

Recent advances in computed tomography:

Cone Beam Computed Tomography (CBCT) (Figure 5)

CBCT is a highly advanced imaging modality. It produces a 3D image that too with high resolution. Image data obtained can be reformatted using software for customized visualization of the anatomy.[13]

Cone-beam tomography has a wide range of applications in dentistry such as dental traumatology, apical surgery, challenging periodontal bone defects, endodontics, orthodontics, preoperative planning of periodontal surgery, forensic odontology, and dental implant surgery.[2]

According to the American Association of Oral and Maxillofacial Radiology, cross-sectional views should be used for planning dental implants. Therefore, with the CBCT thickness of the bone, bone width and height at the implant site can be measured with a high degree of accuracy.

- CBCT scanners are specifically designed to diagnose and plan for implant placements.
- Multiple views of the area of interest are obtained in a single scan. This allows the dentist to perform minimally invasive surgery without lifting the flap, ultimately reducing surgery time, post-surgery pain, and swelling
- The master cast can be made before surgery using data stored on the software and a temporary restoration can be fabricated and placed immediately after surgery
- During the scanning process, radiographic markers may be inserted which indicate the exact location of the proposed implant. Stents help recognize radiographic landmarks that can be used to connect proposed implant position and angulations within the accessible alveolar bone
- Digital Imaging and Communications in Medicine data can be used to produce computer-generated surgical guides (Stereo lithographic models) from the CBCT data Figure [6]
- The surgical guide is used to help the surgeon in placing the implant in its best location. A specific surgical design that replicates the patient's alveolar structure can be developed from a model

The template helps in determining position and orientation of proposed implants.[13]

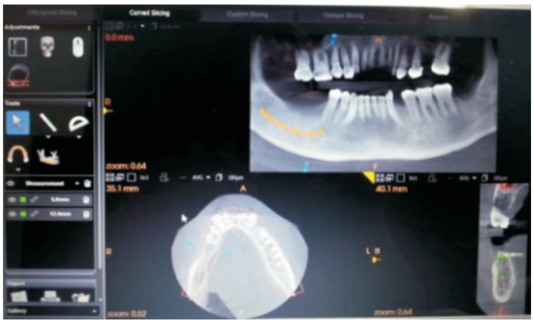

Figure 5 Cone-beam computed tomography (CBCT) [3]

Figure 6: Stereo lithographic Model6

Advantages of CBCT:

1. Because of quick acquisition, the majority of the CBCT scans is completed in 30 seconds
2. CBCT has less image blur and magnification as opposed to periapical radiography and panoramic radiography
3. It is possible to specifically evaluate bone density, cortical plate thickness, trabecular pattern, and the relationship of any important structure such as the lower alveolar nerve with CBCT
4. It increases the clarity (improves resolution) of the image in comparison to dental CT
5. This technology yields images with isotropic submillimeter spatial resolution. As a result, its use is suited perfectly for dental and maxillofacial cases3
6. More compact equipment
7. Small footprint for the clinic
8. High degree of accuracy in all 3D
9. Cost Effective
10. Low radiation dose

Disadvantages of CBCT:

1. Small degree of contrast
2. Restricted field of view
3. Due to the small detector size, scanned volume is decreased
4. Gives less information about inner soft tissue
5. Increased noise from radiation scatter and artefacts
6. Radiation propagation
7. Prolonged scan time
8. The Dynamic range of x-ray detector[13]

CBCT versus CT:

- CBCT equipment takes less area in the clinic due to its smaller size and lighter weight than medical CT, so CBCT can be easily installed in dental clinics.
- CBCT equipment is less technique sensitive to operate and much economical as compared to medical CT.
- In CBCT, the image is made in a sitting position rather than the conventional lying position of medical CT.
- The patient is more comfortable with CBCT than medical CT as it eliminates the claustrophobic feel.
- CBCT imaging is more conservative in terms of radiation and the picture quality (high resolution) is much higher than medical CT.[11]

Limitations of CBCT:

Despite several advantages, CBCT has some limitations like less soft-tissue contrast, image noise, and some artefacts (streaking, shading, rings, and distortion) which reduce the diagnostic value of the reformatted image to some extent for implant planning.[11]

Interactive Computed Tomography (ICT):

In Interactive Computed Tomography, a tomographic image is taken by the radiologist and is transferred to the practitioner in form of a computer file. It helps the clinician in measuring the length and the width of the alveolus and also bone quality. An important aspect of interactive computed tomography is that the clinician and radiologist can together perform "electronic surgery."1Various softwares are available for reformatted Interactive computed tomography like SIM-Plant (Materialise Medical, Glen Burnie, Md.), dental scan plus, tooth pix (Cemax Inc., Fremont, Calif.).11 This enables a 3D treatment plan that is integrated with the patient's anatomy and can be visualized before the implant surgery by the clinician and the patient. It provides the ability to measure bone density, identify and measure the proximity of the implant to vital structures, estimate the volume needed for a sinus graft, visualization of implants from a 3D perspective allowing verification of parallelism, thus reducing offset loading of implants.3

Magnetic resonance imaging (MRI) (Figure 7):

Magnetic resonance imaging (MRI) was first discovered by Lauterbur.6 Magnetic resonance imaging (MRI) is based on the phenomenon of nuclear magnetic resonance (NMRI). It was first described in 1946, however its application in Implantology is of recent origin.[9] Magnetic fields and radio frequencies are used by electromagnetic detectors to provide electronic images of the body. However, there is no exposure to radiation.[4]

Magnetic resonance imaging or MRI is of recent origin in the field of dental implantology.

Uses:

1. It is used in implant imaging as a secondary imaging technique when primary imaging techniques fail
2. MRI visualizes the fat in trabecular bone and differentiates the inferior alveolar canal and neurovascular bundle from the adjacent trabecular bone.
3. Oriented MRI imaging of the posterior mandible is dimensionally quantitative and enables spatial differentiation between critical structures and the proposed implant site.[3, 9]

Advantages:

1. Sharply delineate soft and hard tissues
2. Differentiate between cortical and cancellous bones
3. Zero radiation doses
4. Flexibility of plane acquisition
5. Gives good soft tissue details and fewer artefacts

Disadvantages:

1. Expensive
2. No special software is available for specific use in Implantology, an expert radiologist is required to interpret and its application in Implantology is still in its experimental phase.
3. Not useful in characterizing bone mineralization or a high-yield technique for identifying bone or dental disease[2, 3]
4. Ferromagnetism is the phenomenon related to MRI which results in the production of artefacts in the image thus limits the use of MRI as an imaging modality after implant placement.
5. Exposure of dental implant to MRI may result in heating of implant which may interfere with osseointegration.[2]

Figure 7: A transaxial image showing the marker indicating the potential implant site (arrow).The lines show the planned position of a set of images at right-angles to the maxilla at the site7

Guided image planning:

It is a highly precise implant positioning which can be obtained along with information regarding bone quantity for minimally invasive surgery. Four kinds of templates can be used as tools with CT during implant planning, including vertical lead strip guides, circumference lead strip guides, gutta-percha guides, or guides with a system of disks. With the help of templates, it is easier to place implants during a one-step surgery, especially in areas of anatomic limitations. Not only does it help in implant placement, but it also allows for the visualization of the bone in each area to choose the ideal donor site for osseous grafts.[8]

Guided Surgical Planning:

CT or Remote Neural Monitoring (RNM) images are used as maps to represent surgical instruments in relation to patient images. During surgery, this allows for the visualization of the instrument position. Computer-assisted surgery not only helps in implant placement, but is also useful in arthroscopy of the TMJ, osteogenic distraction, biopsies, tumour treatment, deformities, and foreign body extirpation. Sensors are attached to the rotatory instruments, surgical template, and patient's head cap. It is possible to see the real situation through data obtained from this navigation. The only disadvantage associated with this is the use of CT, leading to greater radiation exposure.[8]

Conclusion:

Medical images can be assessed for their technical quality and diagnostic value. The clinician has to carefully weigh the pros and cons of each modality and choose a particular technique accordingly. Various radiographic methods have their unique characteristics and each of these applied judiciously, where required, will help the diagnostician as well as the clinician to accurately plan, execute, and evaluate implant treatment. There are various imaging options available in the present day scenario; however, the choice of modality should be based on the individual requirements of a particular case. The skill, knowledge, and ability of the clinician to interpret obtained data also plays a crucial role in the selection of the imaging modality. The cost of the procedure and radiation dose should also be weighed to the benefit of anticipated information. Selection of the type of modality should be made keeping in mind the type and number of implants, location, and surrounding anatomy. The evaluation of CT and CBCT changes the era of implant practice as these provide precise information of bone quality, bone quantity, maxillary sinus, inferior alveolar canal, mental foramen, and adjacent root with low radiation.

References:

1. Bagchi S. Different Imaging Techniques for Dental Implants. Int J Prev Clin Dent Res 2018;5(2) :S49-51
2. Hussain MW, Chaudhary MAG, Ahmed AR, et al. Latest trends in imaging techniques for dental implant: a literature review. Int J Radiol Radiat Ther. 2017; 3(5):288-290. DOI: 10.15406/ijrrt.2017.03.00076
3. Dattatreya S, Vaishali K, Shetty V, Suma. Imaging modalities in implant dentistry. Journal of Dental & Orofacial Research. 2016; 12:22-9
4. Aravind K., Dhanraj M., Ashish R Jain. A review on imaging modalities for dental implants. Drug Invention Today Vol 10 Issue 7 2018
5. Alasmari DS, Riyaz MA. Role of Imaging Modalities in Dental Implantology. International Journal of Contemporary Medical Research. Volume 3 Issue 11 November 2016 ICV (2015): 77.83 ISSN (Online): 2393-915X; (Print): 2454-7379
6. Nagarajan A., Perumalsamy R., Thyagarajan R., Namasivayam A. Diagnostic Imaging for Dental Implant Therapy. J Clin Imaging Sci. 2014; 4(Suppl 2): 4.doi:10.4103/2156-7514.143440
7. Manisundar N., Saravanakumar B., Hemalatha V.T., Manigandan T., and Amudhan A. Implant Imaging- A Literature Review Biosciences Biotechnology Research Asia, April 2014. Vol. 11(1), 179-187
8. Gupta S, Patil N, Solanki J, Singh R, Laller S. Oral Implant Imaging: A Review. Malays J Med Sci. 2015 May-Jun; 22(3):7-17. PMID: 26715891; PMCID: PMC4681716
9. Jayadevappa BS, Kodhandarama GS, Santosh SV, Rashid WT. Imaging of dental implants. J Oral Health Res. 2010;1:50–61
10. Sharda N., Kant P. Dental Implant Imaging: An Overview. 4th Anniversary Issue Health Talk September-October 2012 Volume 5 Issue 1
11. Pandey K. K., Gaur A., Katiyar P., Bashir T., Srivastava P., Srivastava M., Rai A. (2016). Imaging Techniques for Dental Implants: Review Article. Journal of Advances in Medicine and Medical Research, 18(7), 1-8. https://doi.org/10.9734/BJMMR/2016/28115
12. Ahmed S.S., Kumar M.R. Hashmi G.S. Radiological aspects of dental implants: A Narrative Review Asian Pacific journal of Health Sciences Vol.7 Issue 4 October-December 2020
13. Bawa SKS., Sharma P., Jindal V., Malhotra D., Bansal R., Chauhan P. A comprehensive review of new innovations in dental implant imaging techniques. Int J Contemp Dent Med Rev, Vol.2020. Article ID: 020520, 2020. Doi: 10.15713/ins.ijcdmr.146
14. Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R. Cone beam computed tomography in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks. Int J Oral Maxillofac Implants. 2014; 29 Suppl: 55-77. Doi: 10.11607/jomi.2014 suppl.g1.4. PMID: 24660190