ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at: www.ijmacr.com

Volume – 4, Issue – 5, September – October - 2021, Page No. : 143 – 159

Comparison of alveolar bone height and anatomic variations in maxillary sinus in patients willing for implant supported restorations in maxilla with panoramic imaging and CBCT

[1]Dr. Sushmitha Sakki, MDS, Assistant Professor, Tirumala Institute of Dental Sciences, Bardipur, Nizamabad.

[2]Dr. Parsa Arun, MDS, Reader, Meghna Institute of Dental Sciences, Nizamabad.

Corresponding Author: Dr. Sushmitha Sakki, MDS, Assistant Professor, Tirumala Institute of Dental Sciences, Bardipur, Nizamabad.

How to citation this article: Dr. Sushmitha Sakki, Dr. Parsa Arun, "Comparison of alveolar bone height and anatomic variations in maxillary sinus in patients willing for implant supported restorations in maxilla with panoramic imaging and CBCT ", IJMACR- September – October - 2021, Vol – 4, Issue - 5, P. No. 143 – 159.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Objective: Assessment of alveolar bone height in posterior maxilla, maxillary sinus anatomical variations and pathologies in patients willing for implant supported restorations in maxilla with panoramic imaging and Cone beam computed tomography.

Methods: 30 subjects were included in the study. Comparision of Panoramic and Cone beam computed tomography images were done for obtained along with anatomical variations and pathologies detected in maxillary sinus.

Results : Mean difference for the alveolar bone height measured at the implant site through Panoramic and Cone beam computed tomography is 1.34millimetre with a statistically significant difference ($p < 0.001$) .The percentage of septa detected , when observed for anatomical variations through Panoramic imaging is 0 percent, through Cone beam computed tomography is 26.7 percent with a statistically significant difference ($P = 0.002$).The percentage of Mucosal thickening detected when observed for pathologies through Panoramic imaging is 0 percent and through Cone beam computed tomography is 76.7 percent with a statistically significant difference ($P<0.001$).

Conclusion: Reliability based on Cone beam computed tomography image analysis seems to be more accurate than panoramic radiography for analysis of various parameters at implant site.

Keywords: Panoramic imaging, Cone beam computed tomography, implant site assessment.

Introduction

In persons with maxillary tooth loss, ridge atrophy sometimes combined with pneumatization of maxillary sinus (MS) leaving thin alveolar bone or only mucoperiosteum (Schneiderian membrane) between the sinus floor and oral cavity is seen. The placement of the dental implants in such patients requires pre-prosthetic surgical procedures such as alveolar bone grafting and sinus floor elevation (SFE) .

Augmentation of the MS floor is well-documented and considered as conventional procedure, which allows the rehabilitation of the atrophic posterior maxilla using osseointegrated dental implants. Anatomic variations within the sinus, such as septa and pathologies such as mucosal thickening (MT) of the sinus floor increase the risk of the sinus membrane perforation during pre- implant surgery in posterior maxilla [.1]

Perforation of the sinus membrane during SFE is the most common complication, which occurs in 10% to 60% of SFE procedures with incidence rate of approximately 30%. [1]

In MS floor elevation procedure, it is important to be acquainted with different anatomic and pathologic findings , to minimize the risk of postoperative complications .

Providing dental implants to patients who have lost upper posterior teeth and surrounding bone requires radiological assessment of the planned implant site.

Panoramic (PAN) radiographs are a more useful tool than perapical radiographs for complete visualization of the MS and evaluating the relationship between the level of the sinus floor and alveolar bone . However, they have a limitation for the three dimensional (3D) visualization of anatomical structures because of their two dimensional (2D) nature. In addition, soft tissues of the maxillary sinus cannot be effectively visualized on PAN radiographs and accurate measurements are difficult to obtain because PAN radiographs produce a variable inherent magnification distortion. [4]

Cone beam computed tomography (CBCT) is becoming the modality of choice for evaluating implant sites because of its 3D nature. Unlike traditional 2D radiography, CBCT avoids structural superimposition, magnification and distortion, thus allowing precise 3D visualization of dental and maxillofacial structures.[6]

Hence the present study was aimed at comparison of alveolar bone height and detection of MS anatomic variations and pathologies in patients willing for implant supported restorations in maxilla with PAN and CBCT imaging.

Aims & objectives of the study

1) To evaluate the available bone with respect to maxillary alveolus in the region of premolar and molar.
2) To confirm and compare the significant degree of anatomical variations and pathologies with respect to MS in the region of premolar and molar with PAN and CBCT imaging modalities.

Methodology

The study comprised of the subjects visiting the Department of Oral Medicine and Radiology, SVS Institute of Dental Sciences, Mahabubnagar, Telangana, INDIA. During time period between January 2015 to July 2016 with a chief complaint of missing teeth and willing for procedures for implant supported restorations in maxilla. An informed consent in their respective vernacular languages was obtained from the subjects enrolled in the study adhsering to the institutional ethical committee protocols.

Inclusion criteria

The subjects included in the present study are

1) Who are specifically referred for preoperative implant site assessment.

2) With no previous surgeries had been performed in the region of the MS and no history of previous ridge augmentation at the implant site.

3) With one or more edentulous areas in the posterior maxillary teeth region, with in an age group of 25-50 yrs with residual alveolar bone height greater than 4mm and less than 8mm detected on PAN radiographs and are willing for procedures for implant supported restorations in maxilla.

Exclusion criteria

1. Excluded subjects who are supposed to undergo implant supported restorations in maxilla with adequate bone height greater than 8 mm detected on PAN radiographs with no indication for SFE and 3D image exam.
2. Patients diagnosed for systemic conditions (like diabetes mellitus and patients under bisphosphonates therapy and other bony disorders) that may hamper the prognosis of implant placement.

A total of 30 subjects who met all inclusion criteria were included in the present study.

PAN radiographs were acquired using a Digital panoramic machine (figure 1), KODAK 8000C Carestream, operating at 60- 80 kVp , 4-12 mA and an exposure time of 16 seconds using the standard adult setting mode. Images were taken in the incisive occlusion position holding the head by an ear rod with the frankfort horizontal plane parallel to the ground. CBCT scans were obtained using a Newtom 3G machine (figure 2), operating at 90 kVp **,** 9 mA and exposure time of 3.6 seconds, using a 8 x 5 (medium) field of view (FOV) . Image analysis was performed on a multiplanar reconstruction window in which the axial, coronal, and sagittal planes could be visualized with a slice thickness of 0.3 mm of isotropic voxels and evaluated almost the same regions which were viewed on PAN radiographs.

All CBCT images were viewed as reconstructed images from the acquired volume in the DICOM format, and all PAN images were viewed as master view images. Vertical linear measurements were made directly on both the PAN and CBCT images using the linear measuring tool.

Specific data fields were exported from the records to a spreadsheet (Excel, Microsoft) which included comparison of alveolar bone height measured at the implant site (figure3) through PAN and CBCT, comparison of anatomical variations (figure 4) and pathologies (figure 5) in MS detected through PAN and CBCT.

Observations and Results

Data was analysed using software SPSS version 23. Descriptive statistics was done by performing unpaired T test for comparison of alveolar bone height measured through PAN and CBCT , Chi -square test for comparison of anatomical variations and pathologies detected through PAN and CBCT and P value < 0.05 , considered as statistically significant.

Comparison of mean of alveolar bone height at implant site measured through PAN and CBCT (Table 1 , figure 6) Mean of alveolar bone height measured at implant site through PAN is 6.6343 mm, through CBCT is 5.2900 mm, with a mean difference 1.34433 mm, with a statistically significant difference (P <0.001) for measurements obtained through PAN and CBCT **.**

Comparison of frequency and % of anatomical variations detected in MS through PAN and CBCT. (Table 2) When observed for anatomical variations**,** septa were not detected in 30 (100 %) PAN images. Septa was detected in 8 (26.7 %) CBCT images and were not detected in 22 (73.3 %) CBCT images.

Comparison of number and % of PAN and CBCT images which detected and which did not detect

septa for evaluation of statistical significance . (Table 3, Figure7)

In a total of 60 radiographs, Septa was not detected in 52 radiographs, when 52 radiographs are considered for 100 % included 30 PANS (57.7%) and 22 CBCTS (42.3%). In a total of 60 radiographs ,Septa was detected in 8 radiographs when considered for 100 % included 0 OPGS (0.0%) and 8 CBCTS (100 %). Difference in detection of septa through PAN and CBCT was significant (p = 0.002) **.**

Comparison of frequency and % of pathologies detected through PAN and CBCT (Table 4)

When observed for pathologies , MT was not detected in 30 (100 %) PAN images . MT was detected in 23 (76.7%) CBCT images and was not detected in 7 (23.3%) CBCT images.

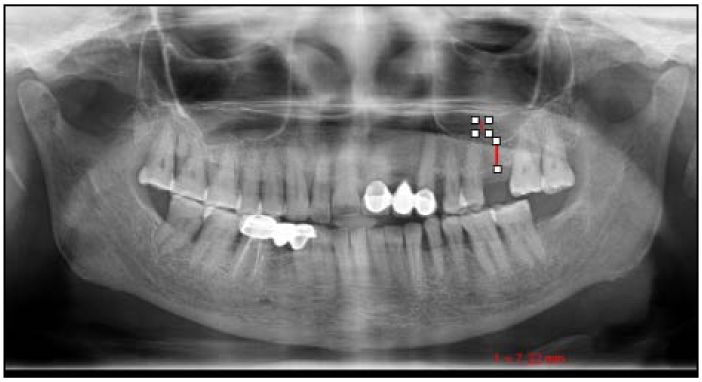
Comparison of number and % of PAN and CBCT images which detected and which did not detect MT for evaluating statistical significance. (Table 5 ,figure 8)

In a total of 60 radiographs , MT was not detected in 37 radiographs, when considered for 100 % , included 30 PANS (81.8 %) and 7 CBCTS (18.9 %). MT was detected in 23 radiographs when considered for 100 % included 0 PANS (0.0%) and 23 CBCTS (100 %). Difference in detection of MT through PAN and CBCT was significant ($p < 0.001$).

Figure 1: Panoramic machine

Figure 2: CBCT machine

Comparison of alveolar bone height measured at the implant site through PAN and CBCT



Fiugre 3 a: 7.22 mm in PAN

Sagittal section

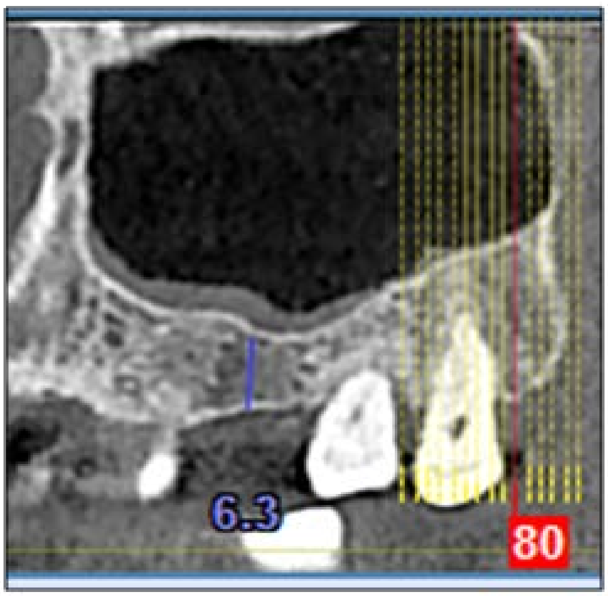


Figure 3 b: 6.3 mm in CBCT

Coronal section

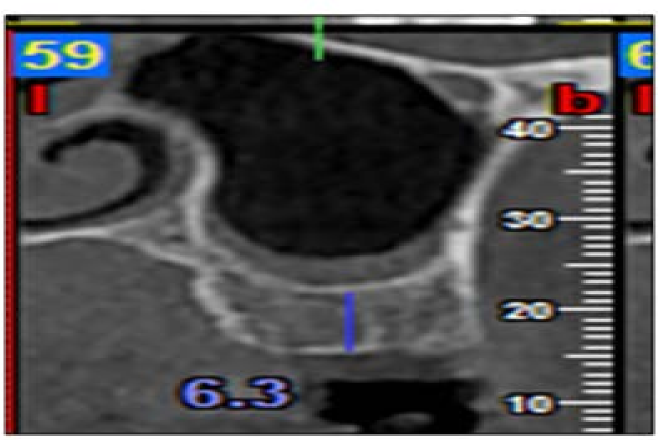


Figure 3c: 6.3 mm in CBCT

Comparison for detection of anatomical variations through PAN and CBCT

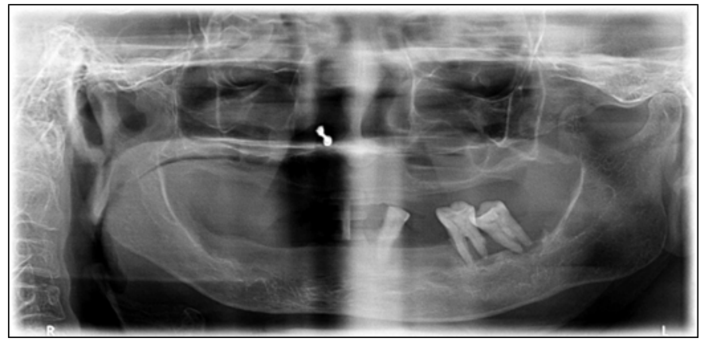


Figure 4 a: Septa not detected in right MS through PAN

Sagittal section

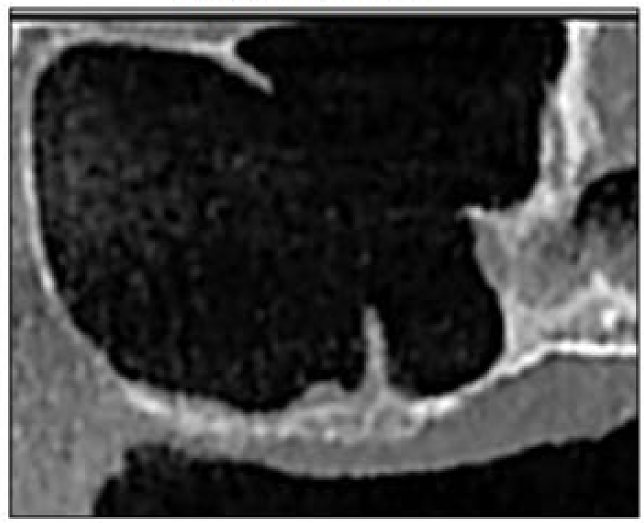


Figure 4 b: Multiple Septa detected in right MS CBCT image

Coronal section

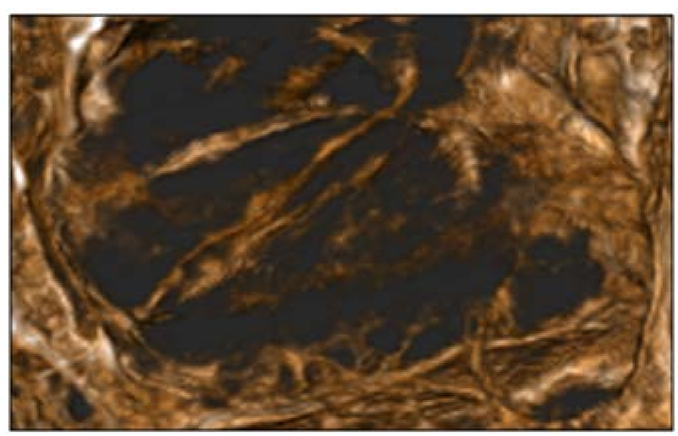


Figure 4 c: Multiple septa detected in 3D CBCT

Comparison for detection of pathologies through PAN and CBCT

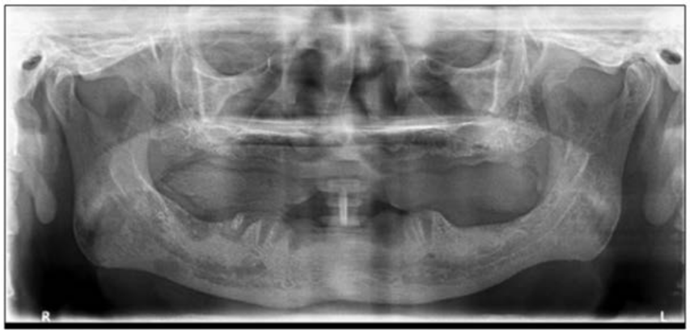


Figure 5 a: No MT detected in right MS through PAN

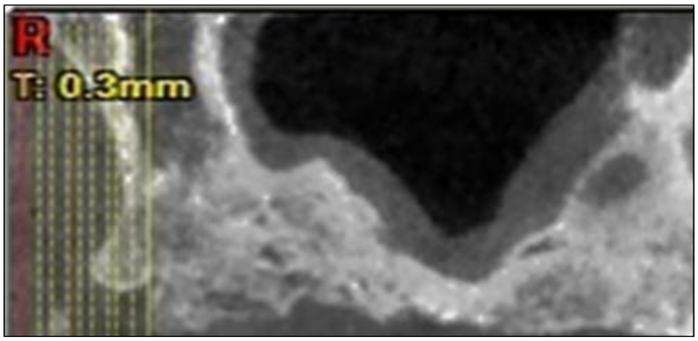


Figure 5 b : MT detected in right MS through CBCT

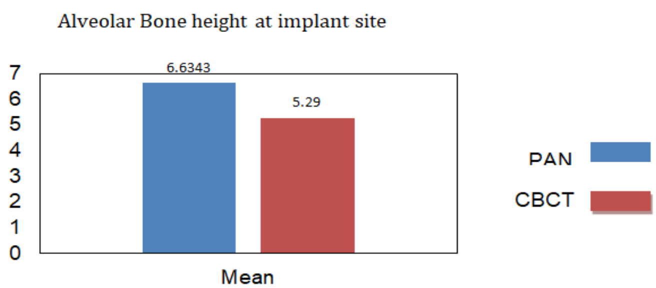


Figure 6: Simple bar diagram for comparison of alveolar bone height measured at implant site through PAN and CBCT

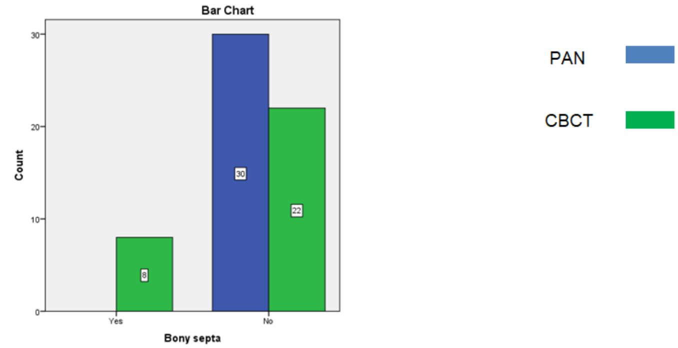


Figure 7 : Simple bar chart for comparison of PAN and CBCT images for detection of Bony Septa.

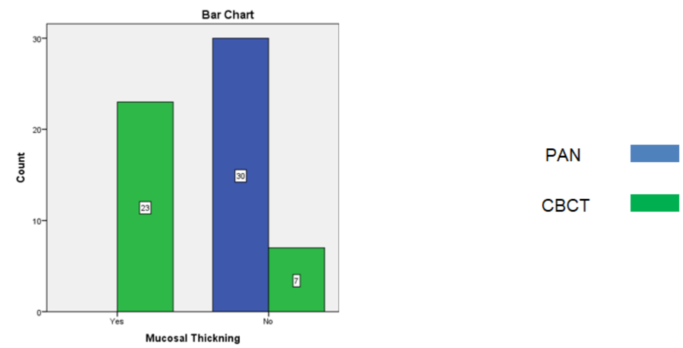


Figure 8: Simple bar chart for comparison of PAN and CBCT images for detection of MT

Table 1: Comparison of mean of alveolar bone height measured at implant site through PAN and CBCT

Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t value	Df	Sig.
PAN	30	6.6343	1.15008	.20997	1.34433	3.864	58	<0.001**
CBCT	30	5.2900	1.51938	.27740				

Table 2: Frequency and % of septa detected through PAN and CBCT

Septa			
Group		Frequency	%
PAN	Did not detect	30	100.0
CBCT	Detected	8	26.7
	Did not detect	22	73.3
	Total	30	100.0

Table 3 : Comparison of number and % of PAN and CBCT images which detected and which did not detect septa for evaluation of statistical significance

Septa		Group		Total
		PAN	CBCT	
Not detected	Count	30	22	52
	%	57.7%	42.3%	100.0%
Detected	Count	0	8	8
	%	0.0%	100.0%	100.0%
Total	Count	30	30	60
	%	50.0%	50.0%	100.0%
	Value	df		Asymptotic Significance (2-sided)
Pearson Chi-Square	9.231[a]	1		.002*

Table 4: Frequency and % of MT detected through PAN and CBCT

MT			
Group		Frequency	%
PAN	Did not detect	30	100.0
CBCT	Detected	23	76.7
	Did not detect	7	23.3
	Total	30	100.0

Table 5: Comparison of number and % of PAN and CBCT images which detected and which did not detect MT for evaluating statistical significance .

MT		Group		Total
		PAN	CBCT	
Not detected	Count	30	7	37
	%	81.1%	18.9%	100.0%
Detected	Count	0	23	23
	%	0.0%	100.0%	100.0%

Total	Count	30	30	60
	%	50.0%	50.0%	100.0%
	Value		Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	37.297[a]		1	<0.001**

Discussion

The maxillary posterior teeth have a higher morbidity rate than the rest of the teeth in the oral cavity. Replacement of these teeth is important to treat occlusion and to restore function. Traditionally, removable partial dentures and fixed bridges have been used as restorative options, but it has become increasingly common to replace missing teeth with dental implants. The long-term success of dental implants depends on the availability of bone in the proposed implant site.[31]

In some cases undergoing treatment planning for implant supported restorations in the maxilla, the bone quantity may be deficient for implantation because of resorption of alveolar bone and pneumatization of the MS. Relatively invasive techniques, such as SFE are required for these cases, and some complications have been reported with these techniques.[4] The most frequent surgical complication reported to occur during SFE is an accidental perforation of the Schneiderian membrane, occurring in 10–56% of the operated sinuses . Other postoperative complications include acute or chronic sinus infection, bleeding, wound dehiscence, exposure of the barrier membrane, and graft loss .[18]

The patency of the osteomeatal complex and the absence of any signs ofinflammation and infection are potential vital factors for the success of sinusaugmentation procedures .[21]

Therefore, diagnosis of lesions in the MS should be precisely and fully done to assess bone quality, bone quantity, and anatomical complexity before treatment planning. It is very important to pay attention to imaging of the MS. In fact, symptoms frequently do not appear at the outset of some lesions in the MS. Therefore, the diagnosis is often made accidentally when images of the area are obtained for other purposes .[4]In addition, a thickened mucosa or extensive mucosal cysts may increase the risk of ostium obstruction and development of sinusitis following SFE.[24]

Maxillary sinusitis of odontogenic origin has been reported to account for approximately 5% to 10%, or even up to 12% of all cases of sinusitis. Up to 25% of patients undergoing surgery for chronic maxillary rhino sinusitis had an odontogenic source of infection .[24]

The possible explanation for this finding may be that most patients whose maxillas need dental implant treatment have missing maxillary teeth because of inflammatory lesions such as pulpitis and periapical and/or periodontal inflammation(s).Thus, maxillary sinusitis may occur more commonly in such patients.[4]

The increased bacteria and toxins in apical lesions can infiltrate the sinuses directly or via the numerous vascular anastomoses, porous alveolar bone marrow, and lymphatic vessels, thereby increasing the likelihood of MT in MS.[24]

Thus, it can be hypothesized that by treating a dental infection, a dentist can prevent MT, thereby possibly prevent the development of maxillary sinusitis. It is therefore advisable to adequately examine the MS, treat any pathology that is found, and obtain desirable results before attempting any surgical augmentation.53

Currently, there is a lack of evidence to suggest that complete resolution of localized MT will occur after extraction or endodontic treatment of teeth with periapical disease. Studies have shown that MT may persist for more than 3 months postoperatively. [24]of course, the other causes of maxillary sinusitis other than odontogenic inflammation is rhinogenous and allergic inflammations.[4]

MS abnormalities were highly prevalent in the present study, 76 % of the subjects hoping to undergo implant-supported restorations of the maxilla had MT , and the lower sinus wall was the most affected location within the sinus, which would suggest a possible odontogenic involvement. The mucosa could be seen only at a thickness of 2mm or above, and therefore historically 2mm was considered a reliable threshold for pathological mucosal swelling.[18]

The absence of any radiographic pathology up to the presence of approximately2 mm of thickening of the sinus lining is consistent with safe surgical augmentation .Radiographic thickening of 2-5 mm is not an absolute contraindication for augmenting the sinus, but caution should be exercised in cases with that amount of radiographic thickening, especially if the numbers are in the higher end of the range. A comprehensive clinical examination along with a detailed history of the patient's allergies and previous episodes of headaches and/or other orofacial pain should be carefully recorded prior to attempting surgery. Radiographic thickening measuring 6-9mm, with or without partial obliteration of the sinus, is a contraindication for sinus augmentation. The presence of 6-9 mm of radiographic thickening is an indication of either inflammation or infection due to a variety of causes, ranging from odontogenic sinusitis to a mucocele.[21]

Entering the sinus in the presence of active disease of thattype will lead to potential complications. Referring patients with such findings to an ENT surgeon is indicated, to ensure that the pathology is addressed. Complete obliteration of the sinus is an obvious contraindication for sinus augmentation and puts the patient at high risk for complications. A referral to an ENT surgeon is recommended to diagnose, manage, and resolve the situation prior to attempting any surgical augmentation. [21]

Antral septa was defined as a pointed bone structure originating from MS wall.40 The presence of septa in the MS limits dental implant-related surgeries such as MS lift. The presence of septa has been related to an increased risk of perforation of the sinus membrane during SFE.[22]

In a study of 100 patients scheduled for SFE, Zijderveld and coworkers 30 reported 11 membrane perforations, 5 of which were directly related to the presence of septa. Von Arx et al observed a rate 42.9% of perforations in patients because of septa.[24]

The detection rates of septa in the MS in the present study was 26 % .The higher prevalence of septa in edentulous patients can be due to secondary septa formation in edentulous areas.57 An accidental perforation of the sinus mucosa can lead to the development of acute or chronic sinusitis, as well as subsequent bone resorption.[24]

Thus, detailed knowledge of the anatomic structures of the MS seems to be beneficial prior to SFE to avoid surgical complications .57

These conditions are frequently overlooked and technical difficulties such as the lack of soft tissue contrast in some radiographs, often lead to an inability to diagnose soft tissue abnormalities, thereby, increasing the vulnerability of oral-maxillofacialradiologists.[19]

Intra oral Peri-apical radiographs are used during the initial stages of clinical examination to evaluate small edentulous spaces, status of teeth adjacent to the planned implant site and/ or regions of single implants during surgery to determine implant alignment and placement. Vertical height, architecture and bone quality, bone density, amount of cortical bone and amount of trabecular bone can also be determined to some extent with the use of peri-apical radiographs. Some of the primary advantages of these radiographs are ease of availability, affordable cost and low radiation dose exposure to the patients.[2]

Intraoral periapical radiography is used in initial phase of patient evaluation to detect the presence of pathosis, the approximate location of anatomic structures such as MS and also estimation of the quality of the trabecular bone can be made. When periapical radiographs are used, it is important to ascertain certain guidelines. It is paramount that exposure is made using paralleling angle technique. Excessive base fog, improper exposure factor and poor processing should be avoided. 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 and also have the disadvantage of producing 2D images of 3D structures.[3] PAN produces a single image of the maxilla, mandible and its supporting structures in a frontal plane. It provides for better visualization of the jaws and anatomical structures. The advantages of this form of radiography includes ease of identifying opposing landmarks, ability to measure vertical height of bone in the area of interest, is not time consuming to capture, is convenient and easy to use. But this modality of imaging has highly variable magnification.[2] PAN radiographs are a more useful tool than periapical radiographs for complete visualization of the MS and evaluating the relationship between the level of the sinus floor and alveolar bone. However, they also have a limitation for 3D visualization of anatomical structures because of their 2D nature. In addition, soft tissues of the MS cannot be effectively visualized on PAN radiographs.[4]

As one of the important results of the present study, due to the magnification of depicted anatomic structures in the image layer, the alveolar bone height measurements in the sinus floor-alveolar ridge area are grossly misrepresented with PAN radiographs. This information could be pivotal in making a decision about the length and type of implant to use, as well as the need for sinus augmentation.

Another drawback of PAN radiographs is that , the respective walls of the MS not equal to the respective walls of MS on PAN radiographs, except for the floor. The respective walls of the MS except the sinus floor could not be expressed as a tangential line on PAN radiographs. The so-called anterior wall on PAN radiographs shows the transitional area from anterior to internal, and the so-called posterior wall shows that area from posterior to internal.3D evaluation of the MS , is helpful to analyze the MS in detail, since it provides an adequate depiction of the medial and lateral walls of the sinus along with the floor, thus showing all the anatomical boundaries of the sinus and reducing the risk of complications .[21]

With 3D imaging, the treatment plan can be modified and the outcome of preprosthetic surgery in posterior maxilla can become more predictable. In case of SFE; it ranges from modification in the surgical access strategy (or window design) to change in implant positions or even complete avoidance of bone graft surgery if diagnosed prior with 3D imaging. .[16]

In the last decade, a technique called CBCT was proposed for maxillocraniofacial imaging.[15] It has been widely recognized that the introduction of the CBCT was one of the greatest advances in recent years in terms of diagnostic imaging indentistry.[15] Unlike traditional 2D radiography, CBCT avoids structural superimposition and image enlargement and distortion, thus allowing precise 3D visualization of dental and maxillofacial structures[7] Location of anatomic structures such as the inferior alveolar nerve, MS, mental foramen, and adjacent roots are easily visible using CBCT. The CBCT image also allows for precise measurement of distance, area, and volume. Using these features, clinicians can feel confident in the treatment planning for sinus lifts, ridge augmentations, extractions, and implant placements.[6] The comparison of absorbed doses shows that the CBCT is similar to dental PAN, [15] with a reported radiation dose equivalent to that needed for 4–15 PAN radiographs .[25] CBCT is comparable in size to a conventional PAN machine.[26] and CBCT has short scan time. (10–70 s). [25]

The CBCT scanner provides sub millimeter resolution as small as 0.2 mm , in any directions for visualization of high- contrast morphology in sinus and maxillofacial bone imaging[1] its higher resolution in all dimensions and its ability to provide the finer details of small bony structures results in high diagnostic quality images which makes CBCT a more desirable imaging modality.[26]

Many dentists use PAN and other dental radiographs, but not CBCT, to plan for implant-supported restorations in the maxilla. In partially edentulous patients, it is claimed that in preoperative diagnosis and planning based on 2D imaging, can lead to implants be placed in areas with a potential risk of damage to vital structures.

Thus, restricting preoperative diagnosis to 2D images in dental implant practice can potentially cause implant failures[4]

However, an interpretation of CBCT images requires familiarity with the anatomy of the area under investigation, an understanding of the spatial relationships of the image volume, a sound knowledge of the possible diseases, anatomical variations and abnormalities which affect the maxillofacial area and, finally, competence when formulating a differential diagnosis. [19]

Before CBCT was introduced to implant dentistry, the American Academy of Oral and Maxillofacial Radiology (AAOMR) provided the first professional recommendations for the use of cross-sectional imaging in implant dentistry. These stated that any prospective implant site should include cross-sectional imaging orthogonal to the site of interest. In 2012, the AAOMR published consensus-derived recommendations for imaging modalities in implant dentistry, with an emphasis on CBCT technology These guidelines stated that CBCT should be considered when clinical conditions indicate a need for bone augmentation or site development[27]

European Association for Osseo integration recommended cross-sectional imaging when clinical examination and conventional radiography fail to adequately demonstrate relevant anatomical boundaries or the location of important anatomical structures. More specifically, imaging was considered appropriate in cases when extensive bone augmentation is anticipated, for all SFE procedures and guided surgery cases, and in some instances for auto genous bone donor sites and special techniques (eg, zygomatic implants). Similar consensus findings were reported by a multidisciplinary international professional organization concerned with implant dentistry and by the International Team for Implantology.[27]

Patient risk from radiation has been a continuing concern in oral and maxillofacial imaging. As low as reasonably achievable (ALARA), is a fundamental principle for diagnostic radiology. Epidemiologists have suggested a link between self-reported dental x-ray exposure and an increased risk of intracranial meningioma. With the increased use of CBCT imaging in dental practice, clinicians must be made aware that patient radiation doses associated with CBCT imaging are higher than those of conventional radiographic techniques. Therefore, routine replacement of current radiographic techniques must be considered with great care.[27]

Nevertheless, dose reduction is always achieved by reducing the FOV of the CBCT examination to the actual region of interest, CBCT devices were grouped according to their FOV into three categories: CBCT devices with small (< 40cm2;visualizing two to four teeth), medium (40 to 100 cm2; visualizing a quadrant or an entire jaw), and large (> 100 cm2; craniofacial views) FOVs. The reported effective doses for all three groups encompass a wide range, ranging from 11 to 252 micro Sievert (Sv) for small, from 28 to 652 micro Sv for medium, and from 52 to 1,073 micro Sv for large. In an investigation, small FOVs of 4 X 4 cm and 6 X 6 cm were used most frequently, and only 329 of 1,479 additionally performed CBCT scans during the study period of 2008 to 2010 exhibited a dimension of 8 X 8 cm (medium FOV).This demonstrates that clinicians have adapted the FOV according to the indication for planned implant treatment and were trying to adhere to ALARA principles.62Regarding the frequency of 3D imaging, there was a significant increase in use of CBCT imaging during the study period from 2008 (52.4% of all patients) to 2010(65.9% of all patients). Interestingly, the use of FOVs of 4 X 4 and 8 X 8cm increased by100%, whereas the 6 X 6cm FOV became less popular in terms of the number of scans performed. On one hand, this demonstrates the effect of the growing popularity of this radiographic methodology and its acceptance by clinicians. On the other hand, this may also be a result of the lack of accepted evidence-based clinical practice guidelines for the use of CBCT in implant dentistry.[27]

Furthermore, a significant clinical benefit of CBCT imaging over conventional 2Dmethods, that is treatment plan alterations, improved implant success, survival rates, and reduced complications, has not been reported to date. Nevertheless, CBCT may be an appropriate primary imaging modality in specific circumstances (when multiple treatment needs are anticipated or when jawbone or sinus pathology is suspected).

Thus, the initial radiographic examination in selected cases would be a 3D low-dose CBCT scan with a dent alveolar FOV, with all other 2D diagnostic imaging steps and their related radiation doses skipped.[27]

Guidelines for the use of CBCT imaging are needed for implant treatment planning. Ideally, these should be based on proven clinical benefits from CBCT imaging, over conventional 2D methods.[S]

The outcomes of this study showed that there was significant difference for measurements of alveolar bone height, made through PAN and CBCT.

According to the present study. PAN radiographs clearly had limitations for detection of anatomic variations like septa and pathologies like MT . There was uncertainty regarding the presence of MT and septa more frequently to indicate the definitive presence or absence, underscoring the diagnostic unreliability of the PAN imaging modality, Since the PAN radiographs were unable to detect MT for when examined for pathologies in 76 % of the subjects and were unable to detect septa when examined for anatomic variations in 26 % of the subjects. These results were similar to those in previous reports, when comparison was made for detection of anatomical variations and pathologies with both radiological techniques, several authors have observed false-negative results with the PAN radiographs. Therefore the un detecteted pathological and anatomical entities through PAN can lead to the potential failure of the SFE procedure.

At the same time, the detection rate of septa and MT was high through imaging with CBCT. These results emphasized the importance of exploring the entire volume of the CBCT Image of MS and related areas, and how important it is to consider the whole clinical context when interpreting abnormalities. The results of this study were similar to the previously reported studies, that 3D imaging of the MS using CBCT proved to be significantly more reliable for detecting sinus anatomical variations and pathologies than PAN radiography. The opinion according to this study is that ,CBCT should be a prime imaging modality prior to implant therapy

Mean difference for the alveolar bone height measured at the implant site through PAN and CBCT is 1.34mm with a statistically significant difference (p < 0.001) for measurements obtained through PAN and CBCT.

The results of the present study are consistent with studies for comparison of alveolar bone height measured through PAN and CBCT by **Georgescu CE et al 2010 ,** found strong statistical significant difference (*p*<0.001) for measurements made through both modalities in 51 dental patients **.** [8] **Yim JH et al 2011** found a mean difference of 1.28 mm for measurements made through PAN and CBCT images, which is almost nearer to mean difference obtained for both modalities in the present study,[9] **Hu KS et al 2012** found strong statistical significant difference for measurements made through both modalities in 10 cadavers[10] **Pedroso LA et al 2014** found a statistical significanct difference (*p* <0.001) for measurements made at 95 sites with both modalities .[11] **Guerrero ME et al 2014** found a statistical significanct difference (P < 0.001) for measurements at 105 sites[5] **Correa LR et al 2014** found significant statistical difference between both modalities for measurements made at 103 sites.[12] **Takeshita WM et al 2016** found a statistical significant difference (*P* = 0.0130) for measurements at 70 sites on 10 macerated human mandibles. [14]

The results of the present study are contarary with the study by **Amarnath GS et al 2015** found no significant difference for measurements made with CBCT, PAN , as Digital calipers (*p*>0.001) in 15 human cadaveric mandibles .[13]**The % of septa detected , when observed for anatomical variations through PAN is 0 %, through CBCT is 26.7 % with a statistically significant difference for detection of septa through PAN and CBCT (P = 0.002)**. Results are contarary with the study conducted by **Shiki K et al et al 2014** found no difference for both the modalities for detection of septa (p = 0.383) in 61sinuses, [4] through PAN and CBCT, though the sample size was greater than the present study.

The results are consistent with the studies conducted by **Malina-Altzinger J et al 2015** found significant difference between the two imaging methods for the detection of a septa (p = 0.004) in 54 sinuses, [23] **Alkurt MT 2016** in a retrospective study found septa in 29.8% of 104 sinuses with a statistically significant difference (p<0.001) , for PAN and CBCT images and the percentage of septa detected is almost near to the percentage of septa detected in the present study.[17]

Discrepancies indetection rates of septa may be due to several factors, such as dissimilarities in the sampling criteria, variations in image interpretation and diagnostic criteria, the resolution of CBCT units which were used, as well as the anatomic variations in different population.

The % of MT detected when observed for pathologies through PAN is 0 % and through CBCT is 76.7 % with a statistically significant difference for detection of MT through PAN and CBCT (P<0.001).

The results were consistent with the study conducted by **Baciut M et al 2013** found significantly higher detection rate of MT on CBCT when compared to PAN regarding preoperative implant planning in 16 sinuses,[20] with sample size less than the present study. Similarly results were consistent with the study conducted by **Shiki K et al 2014** found a statistically significant difference for the detection of MT with both modalities (p = 0.032) , in a retrospective analysis of 61 sinuses with higher detection rate through CBCT than PAN , [4] **Tadinada A et al 2015** found a very high detection capability of CBCT than PAN for pathologies in sinuses , where 72% out of 100 sinuses exhibited pathology , [21] with sample size of both studies greater than the present study.

Results were contarary with the study conducted by **Malina Altzinger J et al 2015** found the difference between the two imaging methods was not significant for the detection of polypoid MT (p = 0.123) in 54 sinuses with a sample size greater than the present study.[23] Discrepancies in detection rates of MT may be due to several factors, such as dissimilarities in the sampling criteria, variations in image interpretation and diagnostic criteria and influence of the climate among differences geographical areas gender gingival biotype and the months during which CBCT were taken and the resolution of CBCT units which were used.

Conclusion

There was statistically significant difference for mean of measurements made for alveolar bone height at the implant site obtained through PAN and CBCT and statistically significant difference for detection of MS anatomic variations like septa and pathologies like MT with both modalities.

Based on the finding of the present study, CBCT should be required in treatment planning for implant-supported restorations of the maxilla as it allows precise measurement of distance, area, volume when compared to PAN and allows for proper detection of anatomical variations and pathologies in MS , as they have a low detection rate on PAN radiographs, the reliability based on CBCT image analysis seems to be more accurate than PAN radiography for analysis of various parameters at implant site and PAN radiograph is not a reliable radiographic technique for evaluation of implant site because of its inherent magnification for the measurements made at implant site, overlapping of the anatomical structures , and for the poor soft tissue contrast seen on PAN images.

Thus it can be concluded that obtaining exact dimensions of alveolar bone height for the size of the implant to be planned, evaluation of sinus anatomical variations and pathologies through CBCT imaging leads to modifications of dental implant treatment plan and may be beneficial prior to SFE to avoid surgical complications. CBCT with low-dose and dentoalveolar FOV may be an appropriate primary imaging modality with all other 2D diagnostic imaging steps and their related radiation doses skipped in specific circumstances ,where multiple treatment needs are anticipated or sinus pathology is suspected .

Strengths of the study

Many dentists use PAN imaging, but not CBCT for evaluation of implant site including MS, particularly when implants are planned in maxillary posterior edentulous area. In the present study evaluation of implant site was done with CBCT imaging after initial evaluation with PAN imaging. Most of the studies have compared PAN and CBCT for measuring alveolar bone height at the implant site, and many studies have compared PAN and CBCT for evaluation of MS prior to SFE, but alveolar bone height and MS were not combinely evaluated in the prior studies. In the present study comparison of PAN and CBCT imaging was done not only for measuring alveolar bone height at the implant site , but also for evaluation of MS prior to SFE.

Limitations of the study

- Other findings in MS like polypoid MT , sinus opacification, foreign bodies, antroliths sinus perforations, exostoses and tumours were not detected in the present study due to limited sample size and association of periodontal pathology and periapical pathology in relation to MT detected in the present study was not evaluated.
- A final diagnosis of sinusitis may also be considered when clinical signs and symptoms are present and such factors were not evaluated in the present study.

Recommendations

1. Further studies should be aimed at analyzing a larger sample for better validation of the results in evaluation of sinus findings.
2. Further studies should be aimed at reporting of modifications in dental implant treatment plan made with CBCT.

References

1. Dobele I, Kise L, Apse P, Kragis G, Bigestans A. Radiographic assessment of findings in the maxillary sinus using cone-beam computed tomography. Stomatologija. 2013;15(4):119-22.
2. Dattatreya S, Vaishali K, Vibha Shetty S. Imaging modalities in implant dentistry. J Dent Oro Fac Res. 2016; 12 (1) : 22- 965.
3. Lingeshwar D, Dhanasekar B, Aparna . Diagnostic imaging in implant dentistry. Int J Oral Implant Clin Res 2010 Dec 25;1(3):147-153.
4. Shiki K, Tanaka T, Kito S, Wakasugi-Sato N, Matsumoto-Takeda S, Oda M, Nishimura S, Morimoto Y. The significance of cone beam computed tomography for the visualization of anatomical variations and lesions in the maxillary sinus for patients hoping to have dental implant-supported maxillary restorations in a private dental office in Japan. Head Face Med. 2014 May 28;10: (1) 1-13.
5. Guerrero ME, Noriega J, Castro C, Jacobs R. Does cone-beam CT alter treatment plans? Comparison of preoperative implant planning using panoramic versus cone-beam CT images. Imaging Sci Dent 2014 Jun 1;44(2):121-8.
6. Panicker KG, Nair AP, Reddy BC. Versatility of the cone beam computed tomography in oral surgery: an overview. Surg Tech Dev. 2011 Nov 9;1(2):31.76- 81
7. Gracco A, Incerti Parenti S, Ioele C, Alessandri Bonetti G, Stellini E. Prevalence of incidental maxillary sinus findings in Italian orthodontic patients: a retrospective cone-beam computed tomography study. Korean J Orthod 2012 Dec 1;42(6):329-34.
8. Georgescu CE, Mihai A, Didilescu AC, Moraru RU, Nimigean V, Nimigean VR, Tanase GA. Cone beam computed tomography as a method of quantitative and qualitative analysis of alveolar crest in the frontal mandibular area. Rom J Morphol Embryol. 2010 Jan 1;51(4):713-717.

9. Yim JH, Ryu DM, Lee BS, Kwon YD. Analysis of digitalized panorama and cone beam computed tomographic image distortion for the diagnosis of dental implant surgery. J Craniofac Surg. 2011 Mar 1;22(2):669-73.
10. Hu KS, Choi DY, Lee WJ, Kim HJ, Jung UW, Kim S. Reliability of two different presurgical preparation methods for implant dentistry based on panoramic radiography and cone-beam computed tomography in cadavers. J Periodontal Implant Sci. 2012 Apr 1;42(2):39-44 .
11. 1ss1. Pedroso LA, Garcia RR, Leles JL, Leles CR, Silva MA. Impact of cone-beam computed tomography on implant planning and on prediction of implant size. Braz Oral Res 2014;28(1):46-53.
12. Correa LR, Spin-Neto R, Stavropoulos A, Schropp L, da Silveira HE, Wenzel A. Planning of dental implant size with digital panoramic radiographs, CBCT-generated panoramic images, and CBCT cross-sectional images. Clin Oral Implants Res.2014 Jun 1;25(6):690-5.
13. Amarnath GS, Kumar U, Hilal M, Muddugangadhar BC, Anshuraj K, Shruthi CS. Comparison of Cone Beam Computed Tomography, Orthopantomography with Direct Ridge Mapping for Pre-Surgical Planning to Place Implants in Cadaveric Mandibles: An Ex-Vivo Study. Journal of international oral health: J Int *Oral* Health. 2015;7(1):38-42 .
14. Takeshita WM, Iwaki LC, Da Silva MC, Tonin RH. Evaluation of diagnostic accuracy of conventional and digital periapical radiography, panoramic radiography, and cone-beam computed tomography in the assessment of alveolar bone loss. Contemp Clin Dent. 2014 Jul;5(3):318 -323.
15. Orhan K, Kusakci Seker B, Aksoy S, Bayindir H, Berberoğlu A, Seker E. Cone beam CT evaluation of maxillary sinus septa prevalence, height, location and morphology in children and an adult population. Med Princ Pract. 2012 Jul 24;22(1):47-53.
16. Shahidi S, Zamiri B, Danaei SM, Salehi S, Hamedani S .Evaluation of Anatomic Variations inMaxillary Sinus with the Aid of Cone Beam Computed Tomography (CBCT) in a Population in South of Iran. J Dent Shiraz Univ Med Sci. 2016 March; 17(1): 7-15.
17. Alkurt Mt, Peker I, Degerli S, Cebeci Ar, Sadik E. Comparison of cone beam computed tomography and panoramic radiographs in detecting maxillary sinus septa. J Istanbul Univ Fac Dent 2016;50(3):8-14.
18. Janner SF, Caversaccio MD, Dubach P, Sendi P, Buser D, Bornstein MM. Characteristics and dimensions of the Schneiderian membrane: a radiographic analysis using cone beam computed tomography in patients referred for dental implant surgery in the posterior maxilla. Clin Oral Impl Res . 2011 Dec 1;22(12):1446-53.
19. Rege IC, Sousa TO, Leles CR, Mendonça EF. Occurrence of maxillary sinus abnormalities detected by cone beam CT in asymptomatic patients. BMC oral health. 2012 Aug 10;12(1):1- 8.
20. Baciut M, Hedesiu M, Bran S, Jacobs R, Nackaerts O, Baciut G. Pre-and postoperative assessment of sinus grafting procedures using cone-beam computed tomography compared with panoramic radiographs. Clin Oral Implants Res. 2013 May 1;24(5):512-6.
21. Tadinada A, Fung K, Thacker S, Mahdian M, Jadhav A, Schincaglia GP. Radiographic evaluation of the maxillary sinus prior to dental implant therapy: A comparison between two-dimensional and three-

dimensional radiographic imaging. Imaging Sci Dent 2015 Sep 1;45(3):169-74.

22. Bornstein MM, Seiffert C, Maestre-Ferrin L, Fodich I, Jacobs R, Buser D, von Arx T. An Analysis of Frequency, Morphology, and Locations of Maxillary Sinus Septa Using Cone Beam Computed Tomography. Int J Oral Maxillofac Implants . 2016 Mar 1;31(2). 280 -287
23. Malina-Altzinger J, Damerau G, Gratz KW, Stadlinger PB. Evaluation of the maxillary sinus in panoramic radiography—a comparative study. Int J of Implant Dent. 2015 Jul 10;1(1):1-7.
24. Vogiatzi T, Kloukos D, Scarfe WC, Bornstein MM. Incidence of anatomical variations and disease of the maxillary sinuses as identified by cone beam computed tomography: a systematic review. Int J Oral Maxillofac Implants 2014 Nov 1;29(6):1301-14.
25. John GP, Joy TE, Mathew J, Kumar VR. Fundamentals of cone beam computed tomography for a prosthodontist. J Indian Prosthodont Soc 2015 Jan;15(1):8-1.
26. Shankar MS, Bhupinder P, Nitesh R, Digvijaya PP. CBCT as an Emerging Gold Standard for Presurgical Planning in Implant Restorations. J. Indian Acad. Oral Med. Radiol. 2013 Jan;25:66-70.
27. Bornstein MM**,** Brugger OE, Janner SF, Kuchler U, Chappuis V, Jacobs R, Buser D. Indications and Frequency for the Use of Cone Beam Computed Tomography for Implant Treatment Planning in a Specialty Clinic. Int J Oral Maxillofac Implants. 2015 Sep 1;30(5):1076-1083.