Evaluation of inflammatory changes of maxillary sinus membrane pre sinus lift surgery using CBCT

A review article

Submitted to the collage of Dentistry ,Babylon University

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Certification of the Supervisor

I certify that this project entitled "evaluation of inflammatory changes of maxillary sinus membrane surgery (clinical and radiographical Review)"was prepared by the fifth-year student
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under my supervision at the College of Dentistry/University of Babylon in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

الاهداء

عليه من قال انا لها "خاليا"

وانا لها ان ابت رغما عنها أتيت بها

لم تكن الرحلة قصيرة ولا ينبغي لها ان تكون لم يكن الحلم قريبا ولا الطريق كان

محفوفا بالتسهيلات لكنني فعلتها ونلتها

الى من دعمني بلا حدود واعطاني بلا مقابل

،الى من علمني ان الدنيا كفاح وسلاحها العلم والمعرفة

داعمي الأول في مسيرتي وسندي

وقوتي بعد اللة .

والدي

الى من احتضنني قلبها قبل يدها وسهلت لي

الشدائد بدعائها ، الى القلب الحنون

والشمعة التي كانت لي في الليالي سر قوتي ونجاحي ومصباح

دربي الى وهج حياتي والدتي

الى ضلعي الثابت وامان ايامي الى ملهمي نجاحي الى من شددت عضدي بهم الى قره عيني

اخوتي

الى من اعطواواجزوا بعطائهم الى من روونا علما وثقافة ، الى من ضحوا بوقتهم و جهودهم ونالوا

ثمار تعبهم

الى دكاترتي المحترمين و بالأخص

د.هبة عزت و د.داليا محسن

.كل الشكر و التقدير ۶ جهودكم القيمة

اشكر كل من كان معنا في لحظاتنا الحزينة قبل السعيدة كل من قضينا

معهم احن اللحظات والطفها

اهديكم تخرجي واسعد لحظاتي

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Abstract

The maxillary sinuses are the largest of all paranasal sinuses and are located bilaterally within the maxilla bone, assuming a pyramidal shape. Maxillary sinus disease is common and numerous disorders can affect this anatomical area.

Abnormalities can be classified as:

- non neoplastic
- neoplastic benign
- neoplastic malignant.

The advances in craniofacial imaging have made it possible to obtain three dimensional (3D) representations of the craniofacial structures with cone-beam computed tomography (CBCT).

Aim of review :

is to provide clinicians with an overview of the role of three-dimensional (3D) CBCT imaging for:

- diagnostics
- treatment planning
- postoperative
- evaluation of inflammatory disease

in the maxillary sinus membrane pre sinus lift surgery.

In addition, it serves as a useful follow-up tool for assessing sinus and bone graft changes. Meanwhile, using CBCT imaging has to be standardized and justified based on the recognized diagnostic imaging guidelines, taking into account both the technical and clinical considerations.

Conclusion, CBCT machine relatively lower in cost than conventional CT scanner and very accurate in the diagnosis of different maxillary sinus diseases benign, malignant neoplasm and inflammatory pre, during and postoperatively

Introduction

The facial is region is formed in general, by oral cavity, jaw bones, nose and paranasal sinuses. Due to the wide anatomic proximity between the facial structures, diseases in one component can easily affect others . The maxillary sinuses are the largest of all paranasal sinuses and are located bilaterally within the maxilla bone, assuming a pyramidal shape . (**Oglo O E et al .,2012**)

Maxillary sinus disease is common and numerous disorders can affect this anatomical area . Abnormalities can be classified as :non neoplastic , neoplastic benign , neoplastic malignant . (**Stephens J C et al.,2013)**

Recent advances in craniofacial imaging have made it possible to obtain three dimensional (3D) representations of the craniofacial structures with cone_beam computed tomography (CBCT). CBCT was first introduced to dentistry in the United States in 2000 at Loma Linda University **.**The CBCT technique allows more rapid data acquisition than traditional CT. Sophisticated software is available for every unit, allowing image processing and measuring. With a versatile range of applications in the dental specialties, CBCT is becoming a valuable aid for diagnosis and treatment planning. (**Mah and Hatcher, 2004)**

The advantages of this technology are fairly low cost and convenient size compared with traditional computed tomography machines, 3D images of dentofacial regions, ease of operation, relatively quick scans, low radiation exposure, and the elimination of many X-rays to localize anatomic structures. CBCT technology is able to achieve radiation dose levels equivalent to a full-mouth series, and as low as two panoramic radiographs, depending on the setting in use **. (Mah et al., 2003; Ludlow et al., 2006)**

The recent accuracy studies involving CBCT scans have shown not only that 3D measurements are much more accurate than 2D measurements, but also that they are close to reality **. (Lascala et al., 2004; Hilgers et al., 2005)**

Aims of review

It design to clear the role of CBCT in evaluation of inflammatory disease in the maxillary sinus.

Radiographic evaluation of inflammatory change s of maxillary sinus membrane pre sinus lift surgery

1.1Maxillary sinus

1.1.1Maxillary Sinus Anatomy:

Maxillary sinuses are two spaces filled with air , located within the maxillary bones and can be of various shapes and sizes . Maxillary sinuses are bilaterally occupying the Maxillary bone . The maxillary sinuses are the largest one of the paranasal sinuses **as fig (1.1)**. The maxillary sinus is also named as the antrum of Highmore or the antrum . Antrum is a Greek word meaning cave from which its name is derived. An English physician named Dr. Nathaniel Highmore at 1600s described a sinus infection associated with a maxillary tooth ,and the name has been associated with sinus nomenclature **. (Hupp et al .,2008)**

The paired maxillary sinuses , occupying most of the bodies of the maxilla and they have a base formed by the lateral wall of the nasal cavity **. (Gray et al.,1995)**

The apex of the sinuses can extend into the maxilla within the zygomatic process . The roof of maxillary sinuses are formed by the orbital floor which passed by the course of the infraorbital nerve **. (Navarro, 2001,and hupp et al., 2008)**

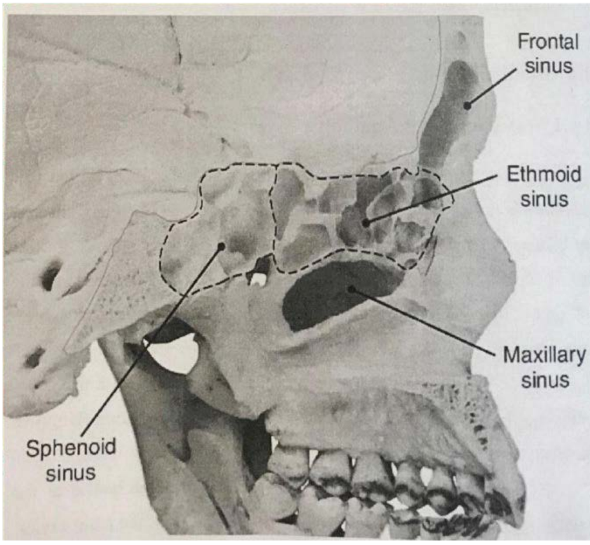
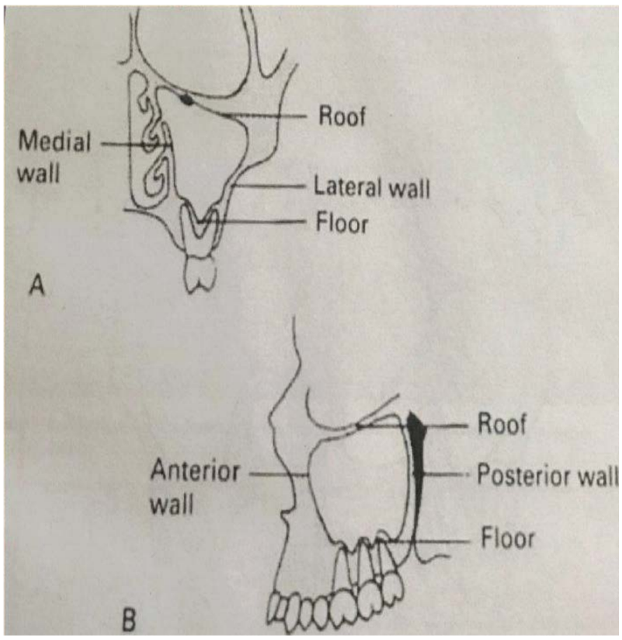


Figure 1: Sagittal view of the skull through the nasal cavity.The frontal, ethmoidal, and sphenoidal sinuses are located under the floor of the cranial cavity and the sinus of the maxillary bone is located between the orbit and oral cavity . (Weaker, 2014)

The floor of the maxillary sinus is formed by the alveolar process . The roots of the maxillary premolars , molars and occasionally canine teeth may project into the maxillary sinus . **(Waite , 1971; Lerno ,1983;Hauman et al., 2002 ;Tank ,2005)** The posterior wall of the sinus usually pass the whole maxilla and fall into the maxillary tuberosity . behind the posterior wall we found the pterygomaxillary fossa which is accompanied by the internal maxillary artery , sphenopalatine ganglion and the vidian canal , the foramen rotundum and the greater palatine nerve **. (Bailey ,2001;Hupp et al .,2008)**

Within lateral wall of the sinus there are canals for the blood vessels and the nerves supplying the upper posterior teeth **.** as shown in **figure (12)A and B.** (**Whaites ,2002)**

Figure 2 (A)and (B): Diagrams of a left antrum showing the basic shape and various walls and margins. (A) Front view (B) Side view . (Whaites, 2002)



The sinuses are lined primarily by respiratory epithelium , which is mucus – secreting , pseudostratified ciliated columnar .

The maxillary sinus opens into the inferior , or posterior end of the semilunar hiatus , which is located at the nasal cavity middle meatus , at the area between the inferior nasal conchae and middle nasal conchae . The mucus produced as a result of beating of the cilia will be moved by the lining epithelium and any foreign material contained within the sinus ,toward the ostium , then it will drains to the nasal cavity .

within the sinus there is a thin layer of mucus continuously moving and passed through the walls of the sinus , passing the ostium and into the nasopharynx **(Hupp et al .,2008)**

1.1.2 Histology of Maxillary sinus :

Each maxillary sinus is lined by a mucous membrane, also named as **(Schneiderian membrane)**that is composed of pseudostratified ciliated columnar epithilum rich in mucus –secreting goblet cells . Deep to this epithelium , within a lamina propria loose connective tissue , in which mucous , seromucous and serous glands lie **.** Normally the thickness of the schneiderian membrane varies from 0.13 mm to 0.5 mm . However , inflammation or allergic phenomena may cause it to thickness , either generally or locally (in steaks) . (**Coulthard et al.,2003;Testori , 2011)** As shown in **figures (1-3,1-4).**

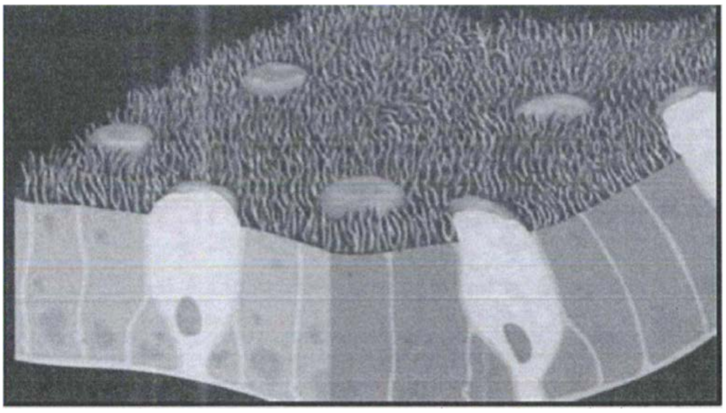


Figure 3:Diagram of the Schneiderian mucosa with various cellular Components . (Testori, 2011)

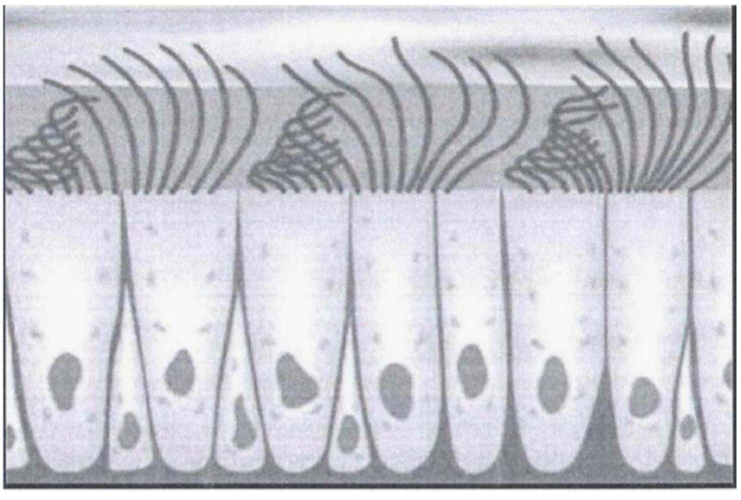


Figure (4)Diagram of the ciliated epithelium, propellant for sinus secretions . (Testori, 2011)

1.1.3 Nerve supply to the Maxillary Sinus :

The maxillary sinus is innervated by the infraorbital and superior alveolar **(posterior, middle and anterior)**branches of the maxillary nerve which is a division of the trigeminal nerve . These alveolar nerves run to the teeth in the walls of the sinus, and as they do so minute branches pierce the bone to supply the mucous membrane of the sinus **. (Sinnatamby ,2000)**

1.1.4 Blood supply to Maxillary Sinus :

Branches that supply the maxillary sinus are divisions of the internal maxillary artery which is in turn a branch form the external carotid artery . These divisions include infraorbital artery (which moves along with the infraorbital nerve), lateral divisions of the sphenopalatine artery , greater palatine artery . The venous drainage runs into the facial vein anteriorly and into the maxillary vein and jugular vein posteriorly **. (Anon et al., 1996)**

The Maxillary sinus is surrounded by highly vascular tissue that is ideal area for receiving a bone graft **. (Boyne and James , 1980;Tatum , 1986)**

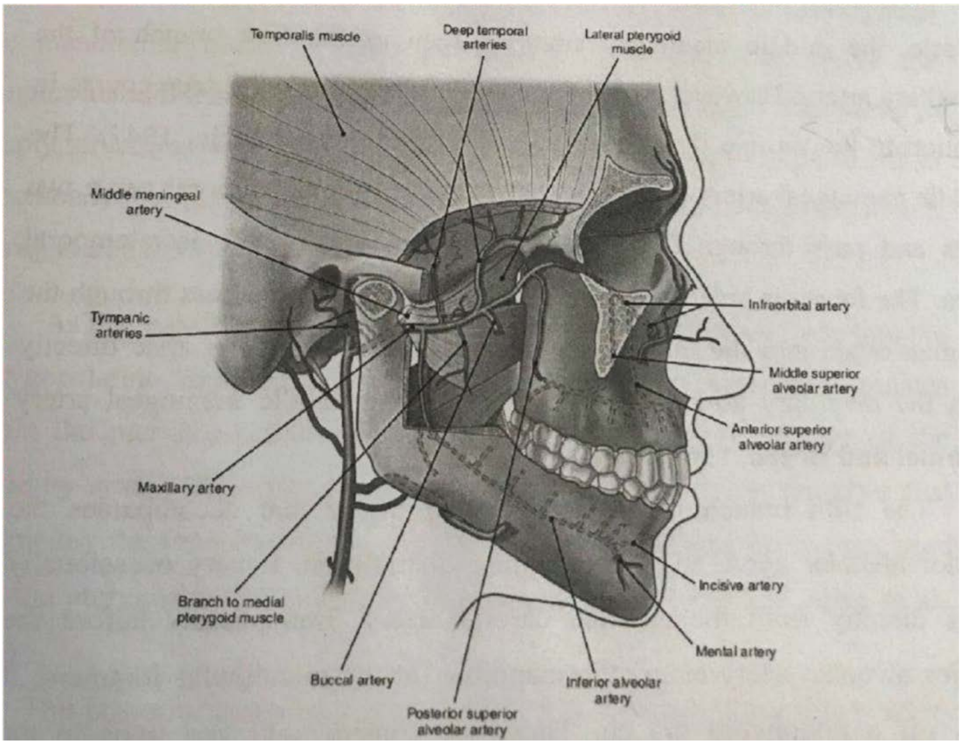
1.1.5 Nutrient Canal within Maxillary Sinus :

Nutrient canals are very small, passageways like tubes pass through the bone that contain blood vessels and nerve that supply the maxillary teeth and interdental areas . The lateral wall contains canals or grooves for the nerves and blood vessels supplying the upper posterior teeth .

Nutrient canals may be seen within the maxillary sinuses , radiographic appearance on a maxillary periapical radiograph, a nutrient canal usually seen as athin radiolucent band which is bounded by a couple of thin

Radioplaque lines . These radioplaque thin lins represents the cortical bone that forms the walls f the canal **. (Haring and lind ,1993 ;whaite , 2002)**

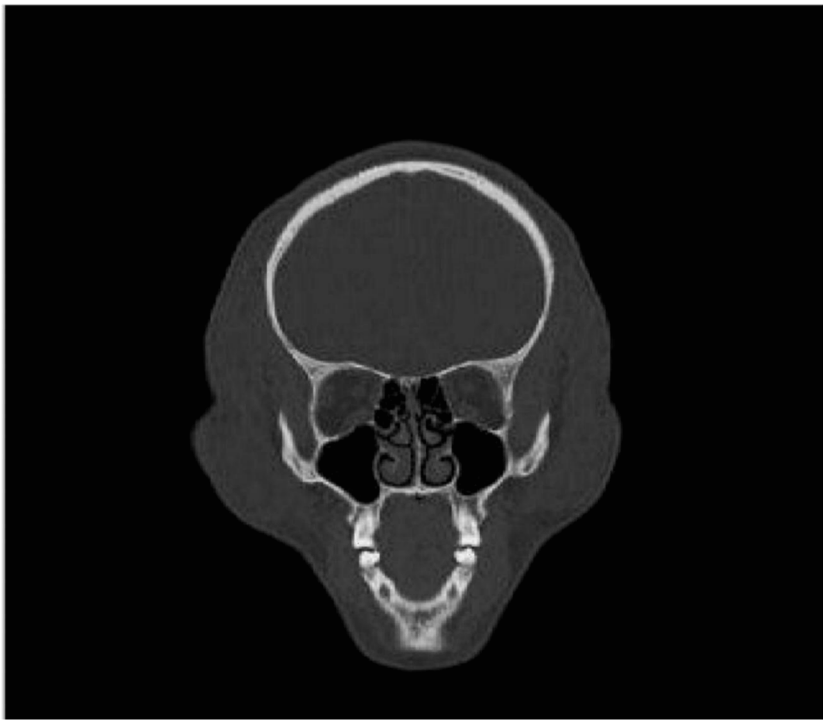
Figure (5): The branches of maxillary artery within the infratemporal fossa . (Weaker, 2014)



1.2 maxillary sinus disease :

The maxillary sinus disease is common and numerous disorders can affect this anatomical area. Abnormalities can be grouped as: non-neoplastic, neoplastic benign, and neoplastic malignant. Inflammatory processes, infections, cysts, polyps, and mucoceles are examples of non-neoplastic lesions. Papilloma, fibro-osseous, and mesenchymal tumors are benign neoplasms. The Squamous Cell Carcinoma, adenocystic carcinoma, adenocarcinoma, and sarcomas are some types of malignant tumors that affect the maxillary sinus**. (Stephens J C,et al.,2013)**

Figure (6): Normal maxillary sinus. [(oão et al., 2017)



1.2.1 Maxillary sinus diseases can be classified according to their nature

Types of maxillary sinus diseases depend on nature	diseases
congenital	aplasia and hypoplasia
neoplastic	benign or malignant
Dental conditions	benign dental tumor, odontogenic cyst or periapical inflammatory lesion
bone injury	ossifying fibroma, Fibrous Dysplasia, and Paget's Disease
traumatic bone injury; iatrogenic	related to previous surgical procedures
inflammatory	mucosal thickening, opacification, polyp, ,mucous retention cyst antrolith

(Lawson W,et al.,2008)(Mehra P,et al ., 2009)

A)Congenital

Maxillary sinus aplasia and hypoplasia are rare conditions that can cause symptoms such as headaches and voice alteration. The majority of patients are asymptomatic, but these conditions must be noticed for importance of differential diagnosis such as infection and neoplasms. Conventional radiographs could not differentiate between inflammatory mucosal thickening, neoplasm, and hypoplasia of the sinus. Computed tomography (CT) and also cone beam computed tomography (CBCT) are the proper modalities to detect these conditions. Endoscopic surgery has been recommended as an effective treatment for the sinus infection. (t.Louis: Mosby Elsevier; 2009)

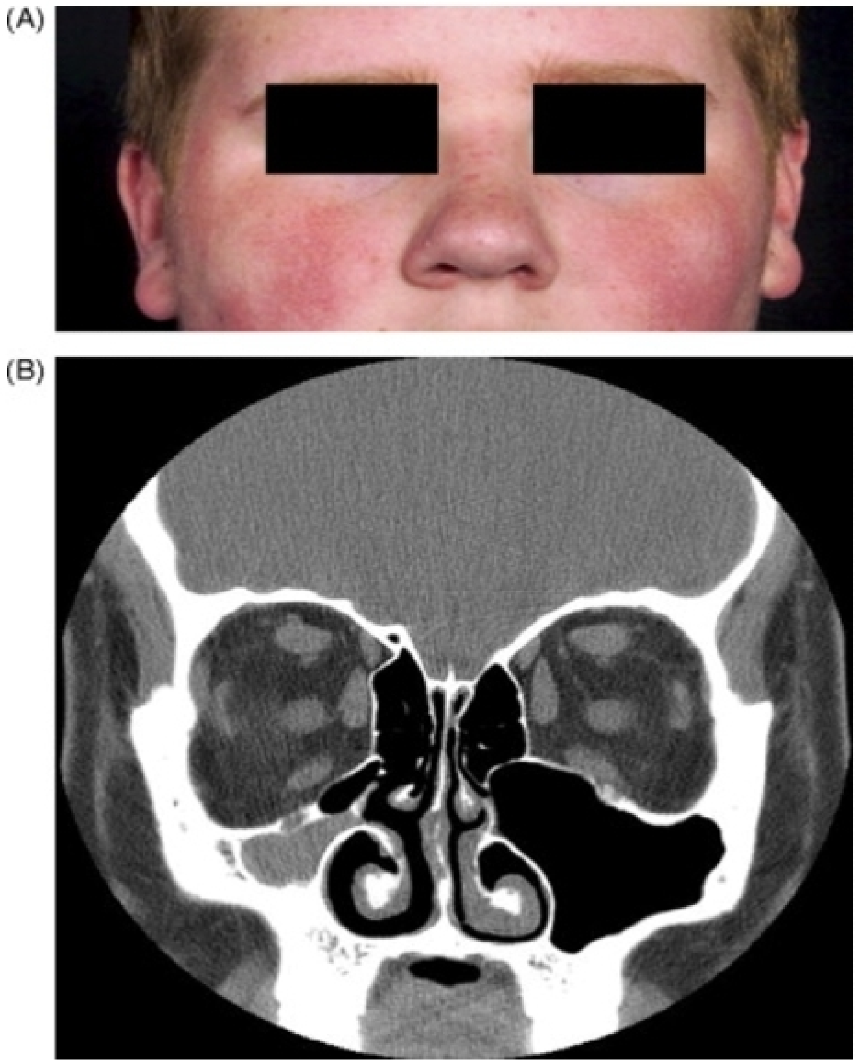


Figure 7: A)facial asymmetry in maxillary sinus hypoplasia. B)frontal section of cbct findings maxillary sinus hypoplasia

B)Dental

Maxillary cysts can proliferate in such a manner as to involve the antral or nasal mucosa; thus the inflamed cyst may be associated with upper respiratory mucosa.

Radiographically shows a round or flask-shaped radiolucency with prominent radiopaque margin .

It is generally accepted that periapical cysts will not resolve by endodontic fillings alone and must be surgically removed. The standard treatment for a DC in the maxillary region is enucleation and tooth extraction by using Caldwell-Luc antrostomy. (**Boston: Wright** 2007)

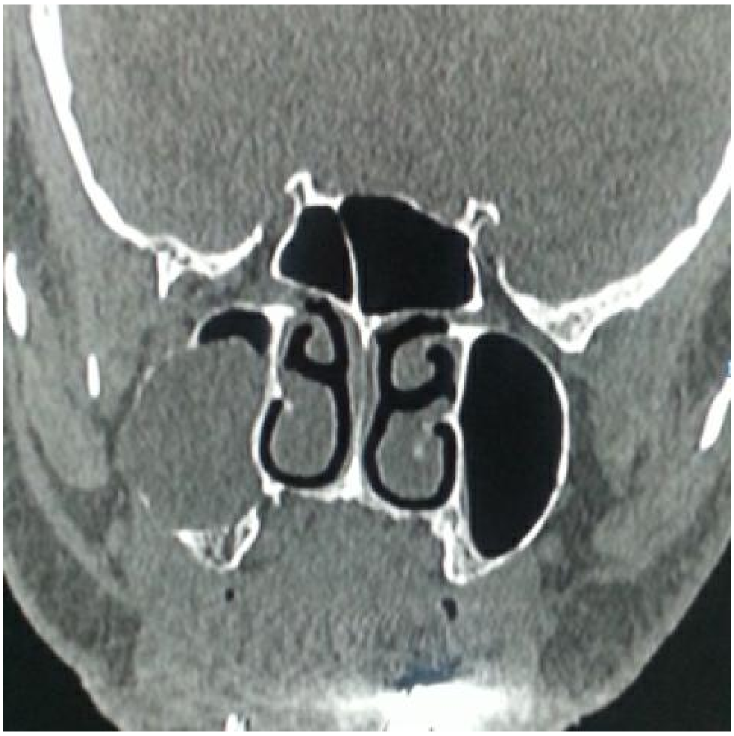


Figure 8: Giant dental radicular cyst with maxillary sinus involvement in frontal section of cbct

C)Bone injury

The fibrous dysplasia is a benign bone disease, of slow growth and unknown etiology. The involvement of the craniofacial skeleton is not uncommon and generally produces facial asymmetries. Presenting case series with fibrous dysplasia occupying the entire maxillary sinus confirmed with the radiological investigations . cystic, sclerotic and mixed. A typical FD lesion in the axial skeleton appear as an area of radiolucent ground glass matrix, which is usually smooth and homogeneous, not centrally located within medullary bone

Treatment may include surgery, medicines, pain management, or physical therapy . (Kelly MH, Brillante B, Collins MT 2008)

Figure 9: Fibrous dysplasia in the maxillary sinus in frontal section of cbct

D)Neoplastic

Benign tumer : Inverted Papilloma

Inverted papilloma is a benign but locally aggressive tumor that arises in the nasal cavity and paranasal sinuses. It is usually identified in patients with a history of sinonasal infections. Despite being a benign tumor, approximately 5-12 percent of tumors can convert into a malignant tumor, so inverted papillomas should be treated very aggressively. Symptoms in patients typically begin with complaints similar to chronic rhinosinusitis, including nasal congestion, drainage, headaches and postnasal drip.

Diagnosis of Inverted Papilloma

An inverted papilloma diagnosis is typically confirmed by a biopsy based on concerning features on CT, MRI or endoscopic appearance. Changes in bone that have been detected using cbct in patients with inverted papilloma include intratumoral calcification, thinning, bowing, erosion, and sclerosis. findings of bone thinning, bowing, and erosion might be due to an increase in the pressure exerted by the tumor as the tumor grows

Treatment

The mainstay of treatment for inverted papilloma is surgery. It is important to go to an experienced surgeon because if not removed completely, inverted papillomas have a high rate of recurrence. Surgical resection is typically performed endoscopically. If any concerning features arise after a surgical resection is performed, such as the development of a possible malignant tumor, patients may need a wider resection or additional treatments such as chemotherapy or radiation therapy

Figure 10: bilateral inverted papilloma of the maxillary and ethmoid sinuses in frontal section of cbct

E)Inflammatory

1)Silent sinus syndrome

Silent sinus syndrome or imploding antrum syndrome is a very rare condition, usually consisting of asymptomatic spontaneous collapse of the sinus walls and floor of the orbit Due to its rarity, the literature has often highlighted the confusion around its definition, diagnosis and proper management.

Analysis of the axial and coronal CBCT sections revealed characteristics including unilateral volume loss in the maxillary sinus, retracted sinus walls, partial to complete soft-tissue opacification of the maxillary sinus, and inferior bowing of the orbital floor.

Silent sinus syndrome is usually treated with surgery. The first stage involves restoring sinus function, most often by performing an endoscopic uncinectomy (removal of uncinate process) and maxillary antrostomy. The second stage, if needed, involves reconstruction of the orbital floor. (Sesenna E, Oretti G, Anghinoni ML, et al2010)

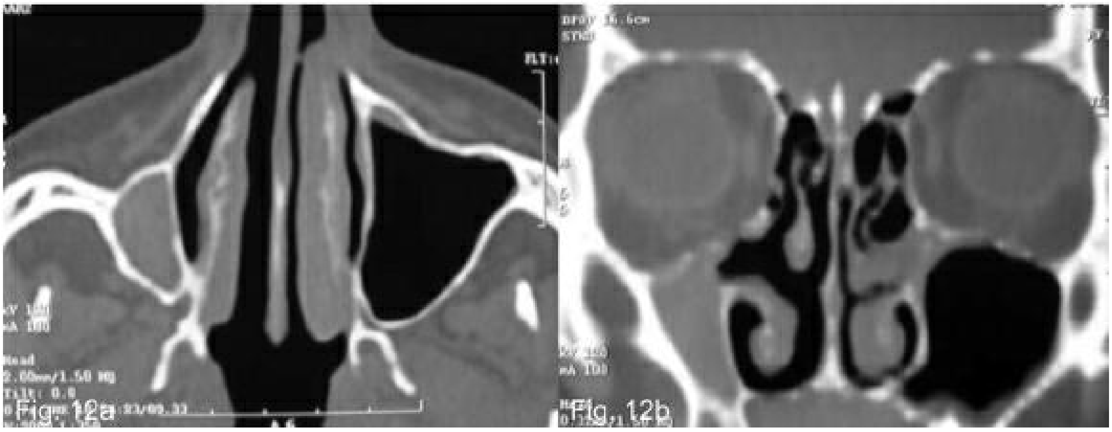


Figure 11: silent sinus syndrome in frontal and transverse section in cbct

2)Mucosal thickening:

Mucosal thickening is an inflammatory reaction with hyperplasia of the mucous lining of the maxillary sinus . This condition may result from harmful actions caused by trauma, infections, chemical agents, foreign body reaction, neoplasm, or airway conditions such as allergies, rhinitis, or asthma**.**The prevalence of allergic rhinitis in the world population is around 10.25%**..**Continuous exposure to inhaled allergens produces a chronic inflammation in the nasal-sinus mucosa, identified as mucosal thickening on Computed Tomography (CT) Mucosal thickening greater than 2 mm is considered a pathologic sinus membrane. The greatest thickness in the diseased population tends to be located in the midsagittal sinus region and adjacent to the maxillary first and second molars. (**Van Dis M L et al ., 1994 ⁄ White S C et al .,2009 ⁄ Brozek J L, et al ,m 2010**)

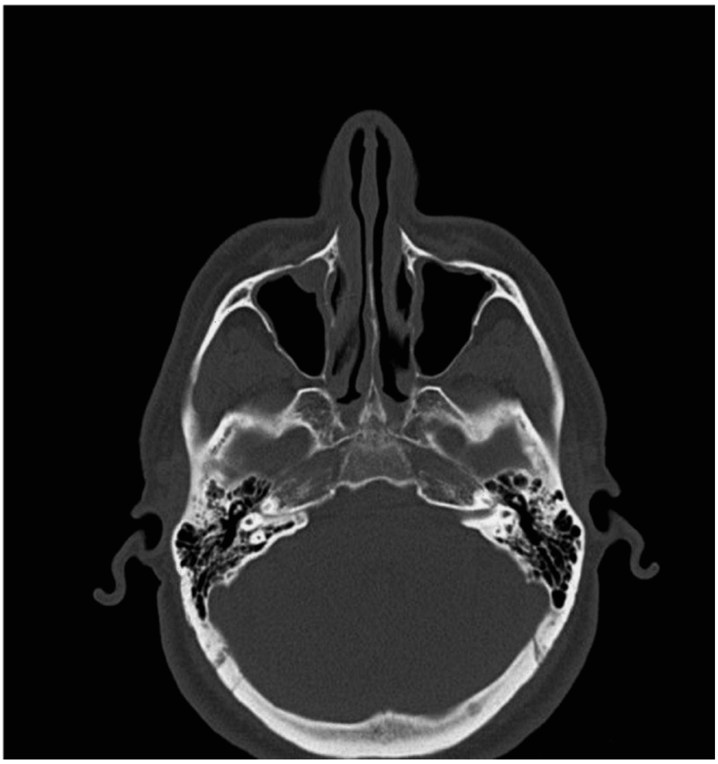


Figure (12) :mucosal thickening. (**João et al., 2017**)

3) Sinusitis:

Sinusitis is the most common disease of the paranasal sinuses. Forms of acute or chronic presentation when hassle, do not require diagnostic imaging; but when the symptoms are recurrent or refractory, research with imaging is needed for a better diagnosis **(Okuyemi K S, et al ., 2002).** There is one different types of sinusitis acute and chronic and also odontogenic sinusitis. (**Okuyemi K S, et al ., 2002**)

1)acute sinusitis, liquid or fluid levels inside the maxillary sinus are isolated; but in

2)chronic sinusitis, there is a thickening of the bone sinus wall . (**Lana J P, et al ., 2012**)

3)The odontogenic maxillary sinusitis differs from rhinogenic for its pathophysiology, microbiology, and treatment. The odontogenic maxillary sinusitis is 10% to 40% of all maxillary sinusitis, and its incidence may be increasing. **.** (**Mehra P, et al ., 2004)**

Figure (13) Chronic sinusitis .
(João et al., 2017)

Figure (14) Odontogenic sinusitis. (João et al., 2017)

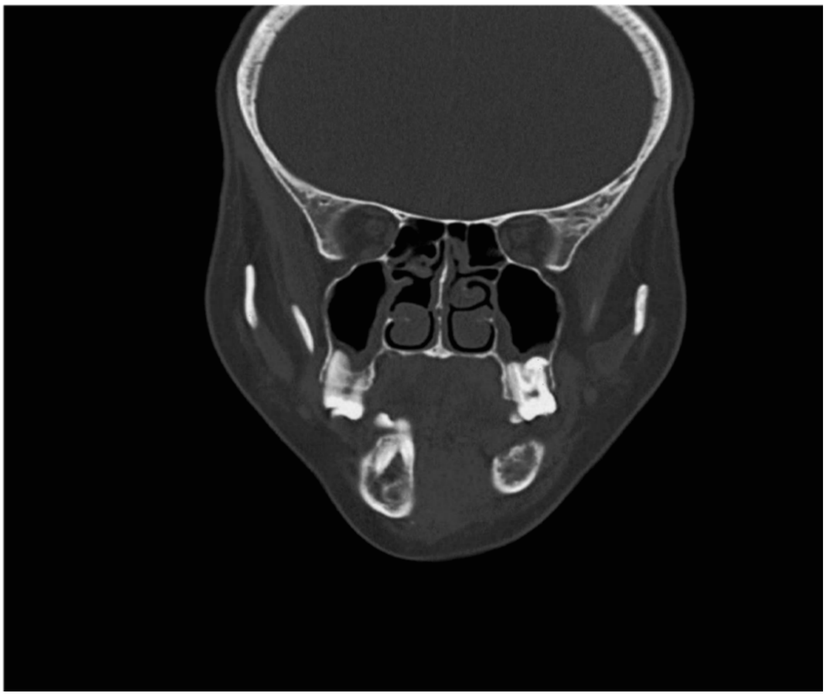
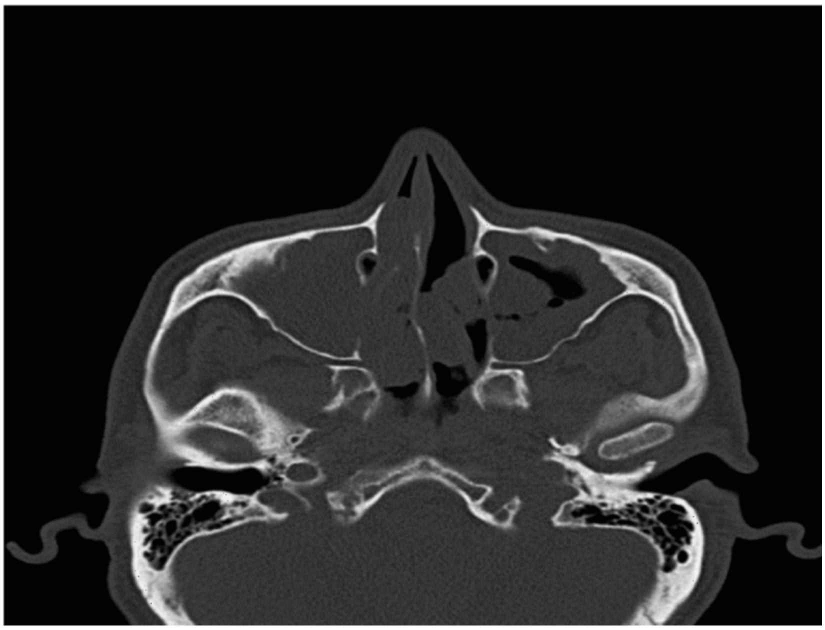


Figure (15) Acute rhinosinusitis. (João et al., 2017)



4) Mucosal cysts:

Mucosal cysts are a common incidental finding on imaging studies, with an incidence between 12.4 and 35.6% **.** They are typically spherical opacities on CT scanning, and are not associated with symptoms of chronic rhinosinusitis. (**Kanagalingam J, et al ., 2009 ⁄ Stephens J C et al ,m 2013**)

. Mucocele are pseudocysts expansive formations of the paranasal sinuses, whose wall consists of a modified sinus mucosa and the presence of cystic aseptic liquid inside, generally thick and viscous, and may be infected and became a mucopyocele **.** (**Almeida W LC, et al 2004**)

The accumulation of fluid increases intrasinusal pressure, resulting in expansion and bone destruction. Nasal polyps develop from the thickening of chronically inflamed mucosa, causing irregular mucosal folds. The polyposis can develop singly or in multiple forms within the maxillary sinus. (**White S C, et al .,2009**)

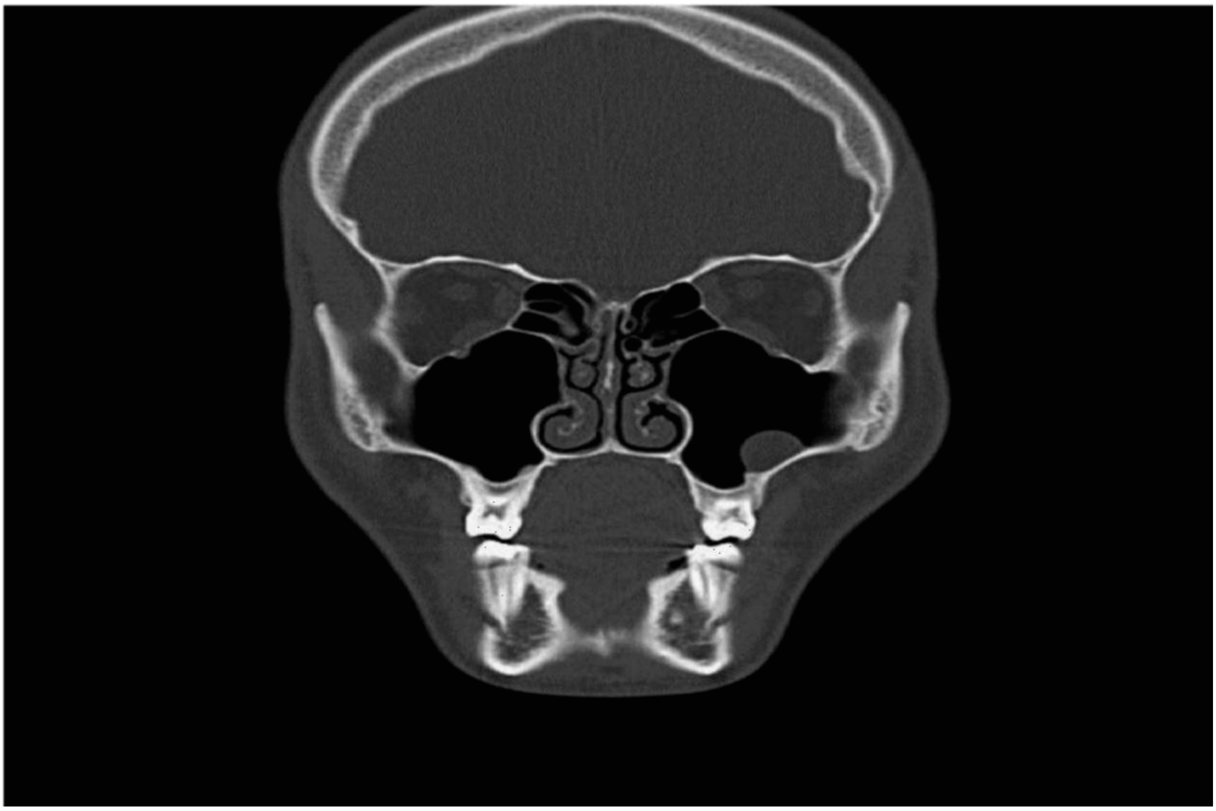


Figure (16) Polypoid lesion. (**João et al., 2017**)

1.3Cone Beam Computed Tomography (CBCT):

explained that in order to imaging hard tissues of the maxillofacial region, cone-beam computed tomography (CBCT) systems have been designed for imaging hard tissues of the maxillofacial region. CBCT has ablility of supplying sub-millimetre resolution in images of high diagnostic quality, with little scanning times (10-70 seconds) and radiation dosages reportedly up to 15 times lower than those of conventional CT scans. Increasing accessibility of CBCT gives the dental clinician with an imaging modality able to supply a 3-dimensional representation of the maxillofacial skeleton with least distortion. (**Scarfe et al. (2006)**)

1.3.1 History of CBCT:

(Robb 1982) stated that in 1982 at the Mayo Clinic Biodynamics Research Laboratory, first generation CBCT first used to perform angiography.

Then, CBCT system was expanded to further medical sections, discovering that the application of CBCT is in dentistry and maxillofacial area.In 1995, CBCT technology used in dentistry. With the evolution of cheap x-ray tubes, high-quality detector systems and strong personal computers, reasonably priced systems have become commercially obtainable. (**Luminati and Eugenio, 2014**)

According to **Tyndall and Rathore (2008)** Italian inventors, Mozzo and Tacconi, developed a CBCT system (the NewTom DVT 9000) for the maxillofacial area that was designed and made by QR Srl of Verona, Italy.This unit, the NewTom QRDVT 9000, be the first merchant CBCT unit market placed specially to the dental market, and in 1999 it was firstly inserted in Europe.

1.3.2Technology of CBCT; Principles of Cone-Beam Computed Tomography:

By using a rotating gantry to which source of x-ray and detector are fixed, CBCT imaging is accomplished. A divergent pyramidal or cone-shaped source of ionizing radiation is directed through the middle of the area of interest onto an area x-ray detector on the opposite side. The detector and x-ray source rotate around a rotation fulcrum fixed within the center of the region of interest. Multiple (from 150 to more than 600) sequential planar projection images of the field of view (FOV) are obtained in a complete, or sometimes partial arc during the rotation. This procedure differs from conventional CT, which uses a fan- shaped x-ray beam in a helical progression to obtain individual image slices of the FOV and then heaps the slices to get a 3D image. Each slice needs a separate scan and separate 2D reconstruction.

Because CBCT exposure includes the whole FOV, just one rotational sequence of the gantry is essential to obtain sufficient data for image reconstruction as in (**Scarfe and Farman, 2008**)

The gantry carrying the x-ray source and detector revolves around the patient's head in full 360, or sometimes, partial 180- 270arcs. whilst rotating, the xray source sends out radiation in a continuous or pulsed mode permitting the detector to obtain single projection images called basis images. These image alike to lateral

cephalometric radiographic images, every a little offset from one another. The complete series of basis images is known as the projection data. Software programs incorporating sophisticated algorithms are applied to these projection data to make a 3D volumetric data set that can be used to give primary reconstruction images in three orthogonal planes (sagittal, axial and coronal**)** . (**Apinhasmit et al, 2006**) Geometry of cone beam captures volumetric data rapidly, and this configuration give to significant cost savings contrasted with conventional CT imaging as numerous patients can be imaged with CBCT imaging in the time taken for one patient to be imaged with conventional CT imaging. (**White and pharoah, 2014**)

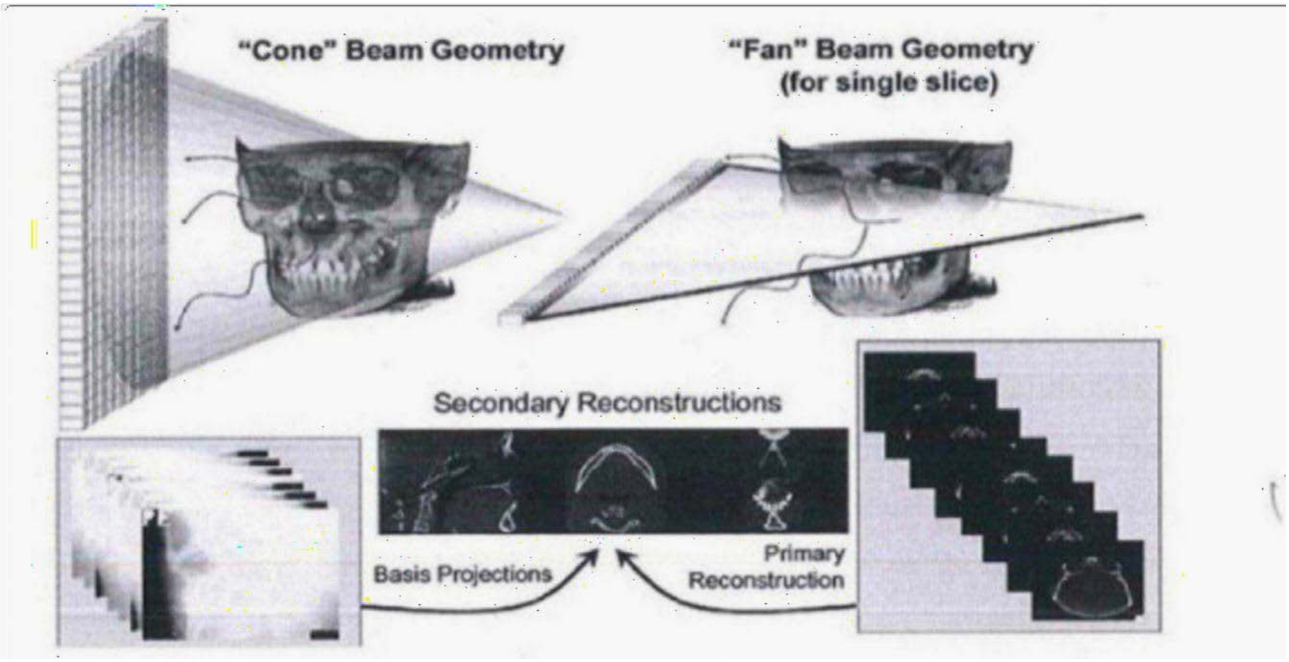


Figure (17) X-ray beam projection scheme comparing acquisition geometry of conventional or *fan" beam (right) "cone" bean imaging geometry and resultant image production .In cone-beam geometry (left), multiple basis projections form the projection data from which orthogonal planar images are secondarily reconstructed. In fan beam geometry, primary reconstruction of data produces axial slices from ۲ secondary reconstruction generates orthogonal images. The amount of scatter generated (sinusoidal lines) and recorded by cone-beam image acquisition is substantially higher, reducing image contrast and increasing image noise. (**Scarfe and Farman, 2008**)

1.3.3 CBCT Image production:

CBCT machines scan patients in 3 possible positions: (1) supine, (2) standing, and (3) sitting. Equipment that needs the patient to lie supine physically occupies a larger surface area may not be available for patients with physical disabilities. Standing units can not be capable to be adapted to a height to accommodate wheelchair- bound patients. Seated units are the most comfortable; however, fixed seats may not permit scanning of wheelchair- bound patients or physically disabled. Because of CBCT scan times often greater than that needed for panoramic imaging, restriction of movement of the patient's head is more important than patient orientation because any head movement degrades the final image. Prevent movement of the head is achieved by using a number of mixture of a bite fork, chin cup or other headrestraint mechanism **.** (**White and pharoah, 2014**)

1.3.4 Field of view (FOV) or scan volume:

Jacobsohn and Fedran (1995) said that the dimensions of the FOV scan volume capable of covering based mainly on shape and size of detector. geometry of the beam projection and the capability to collimate the beam The scan volume shape can be either spherical or cylindric. Collimation of the primary x-ray beam limits radiation exposure to the region of interest (ROI). Therefore field size limitation make sure that an timal FOV can be chosen for every patient, depend on disease presentation and the region designated to be imaged.

As in fig (18) (**W hite and Pharoah,2014**) . CBCT systems can be classified according to the obtainable FOV or selected scan volume height into:

Localized region : about 5 cm or less (eg, temporomandibular joint, dentoalveolar)

Single arch: 5 cm to 7 cm (eg, mandible or maxilla)

Interarch: 7 cm to 10 cm (eg, mandible and superiorly to involve the inferior concha)
Maxillofacial: 10 cm to 15 cm (eg, mandible and extending to Nasion)

Craniofacial: more than 15 cm (eg, from the lower border of the mandible to the vertex of the head). (**Farman et al, 2007**)

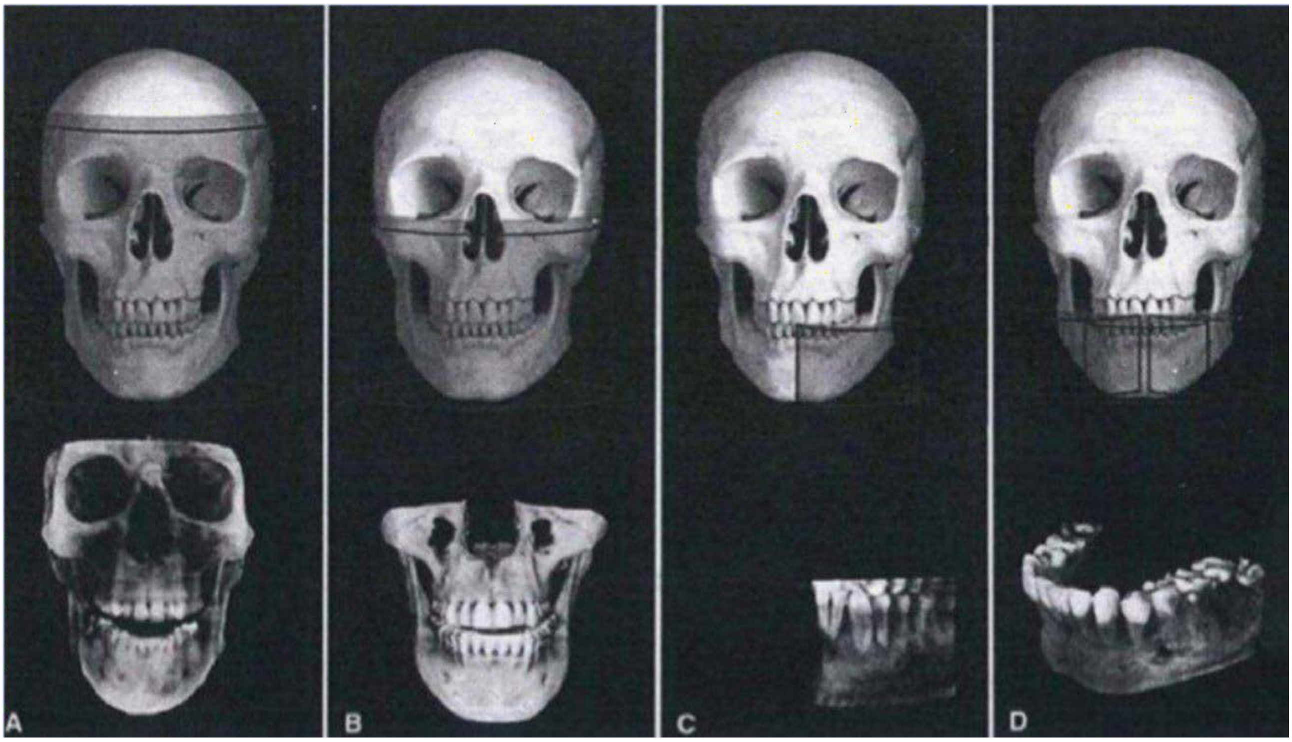


Figure (18) Classification of CBCT units according to the FOV. A, Large FOV scans provide images of the entire craniofacial skeleton, enabling cephalometric analysis. B, Medium FOV scans image the maxilla or mandible or both. C, Focused or restricted FOV scans provide high-resolution images of limited regions. D, Stitched scans from multiple focused FOV scans provide larger regions of interest to be imaged from superimposition of multiple scans **(White and Pharoah, 2014).**

1.3.5 Application of CBCT in dentistry :

Jaju and Jaju (2014)

Macleod and heath (2008)

1. CBCT in oral and maxillofacial surgery:

Found that main uses of CBCT in oral surgery practice involove surgical extraction of wisdom teeth and other impacted teeth , assessment of tumours and cysts ,diagnosis of maxillofacial fracture , drawing of the inferior alveolar canals , planning of orthognathic surgery and follow-up ,inflammatory conditionsof the jaws and the sinuses and also help in diagnosing unexplained symptoms of pain .

2.CBCT in dental implantology : CBCT scans help in the planning of oral implants; they enable measurement of the distance between the alveolar crest and mandibular canal to avoid impingement of inferior alveolar nerve, avoid perforation of the mandibular posterior lingual undercut, and assess the density and quality of bone.

3.cone beam CT in endodontics : CBCT is crucial in endodontics. Because of its ability to provide detailed information about root morphology, it contributes significantly to optimal diagnosis and treatment planning. CBCT is superior in evaluating root features, detecting complex morphologies, and assessing sex differences, thus making it a valuable tool for the diagnosis and treatment of root canal anomalies.

4.CBCT in orthodontics:BCT brings specific and unique diagnostic benefits in orthodontics . The most commonindication for CBCT in orthodontics is the 3D assessment of anomalies in dental position such as impactions and ectopic teeth . CBCT allows the visualization of impacted teeth in three dimensions, as well as the evaluation of roots of the impacted and adjacent teeth**.**

5.CBCT in periodontics : CBCT generates 3D images of anatomical structures necessary for the periodontal diagnosis of furcation involvement, intrabony defects, and implant placement. CBCT, thus, imparts various potential applications in the field of periodon- tics which serves to arrive at better diagnostic conclusions.

6.CBCT in operative dentistry : Perhaps the most important advantage of CBCT in Endodontics is that it demonstrates anatomic features in three dimensions that intraoral and panoramic images cannot. CBCT units reconstruct the projection data to provide inter relational images in three orthogonal planes (axial, sagittal and coronal).

7.application in forensic dentistry : Through CBCT radiology, evolutionary forensic odontology has been developed extensively in many applications, such as the estimation of age through teeth, the role of dentists in trials or forensic witnesses, analysis of bite marks, investigation of trauma cases, and determination of sex and race.
(**Whaites, E. (2002)**)

1.3.6 Advantages of CBCT in dentistry :

1.Dose reduction:

According **to Ludllow et al .,(2006):Schulze et al .,(2004) .** decresead patient radiation dose (29_477sv)as contrasted with conventional CT (nearly 2000sv

). Patient radiation dose is five times lesser than normal CT due to the exposure time is nearly 18 seconds, that is , one seventh the amount contrasted with the conventional medical CT.

2. Isotropic voxel :

[**Kau .et at. 2005**] Stated that CBCT produce isotropic volumetric image , which denotes the voxels generated have equal dimension in all three planes . CBCT can attain a voxel size as small as 0.125 mm .An isotropic feature together with small voxel size gives to high resolution , reproducibility and accuracy of CBCT images **.**

3.image accuracy :

Found that the volumetric data set includes a 3D block f smaller cuboid structure , called voxels , each representing a particular degree of x-ray absorption .

The voxels are size decides the resolution of the image . In conventional CT, the voxels are anisotropic –rectangular cubes where the axial slice thickness is the longest dimension of the voxel . In spite of CT voxel surface can be as small as 0.625 mm square ,their depth is typically 1-2 mm. Whole CBCT units give voxel resolutions that are isotropic-equal in all 3 dimensions.this generates sub millimeter resolution ranging from 0.4 mm to as low as 0.125mm **as in fig (1.14) .** (**Whait and Pharoah, 2014**)

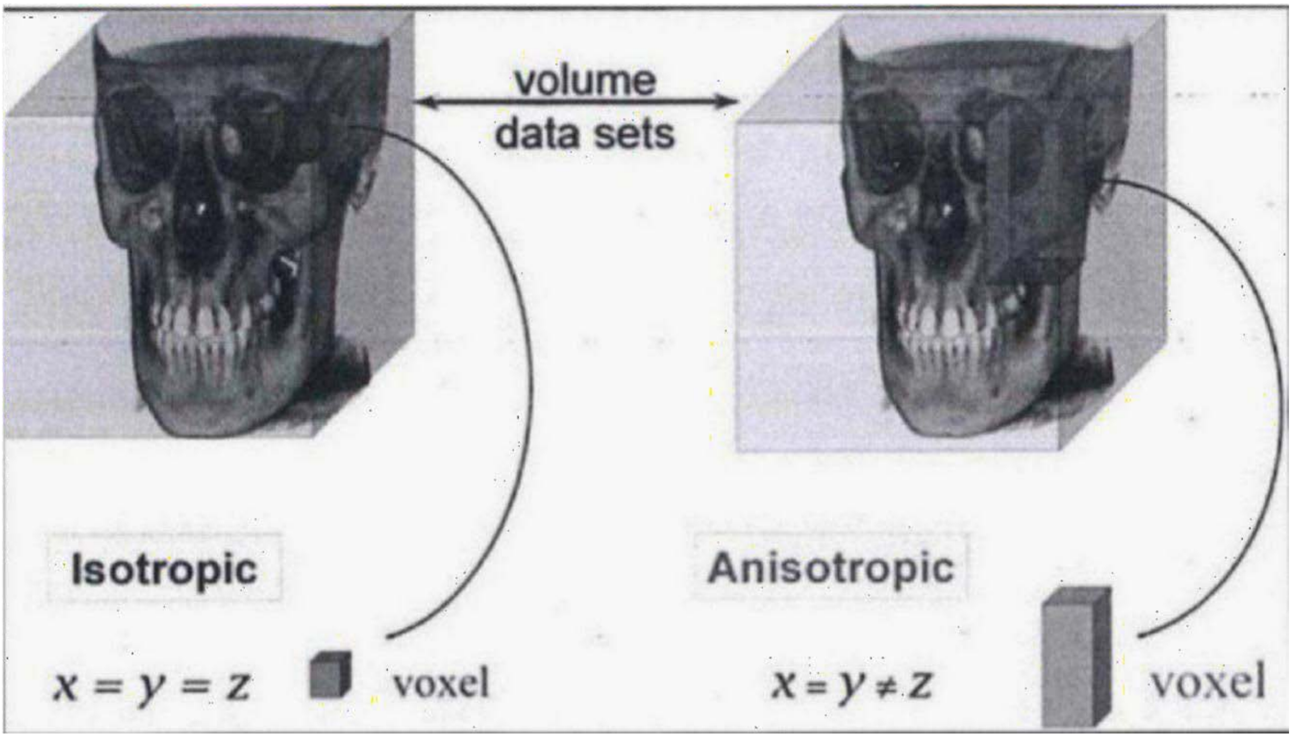


Figure (19)comparison of volume data sets obtained isotropiclly (left) and aniso tropically (right) **(whaite and pharaoh,2014).**

4. Beam limitation :

(**Scarfe et al .2006**) . Mentioned that collimation of the primary x-ray beam to the region of interest reducing the size of the irradiated area and reducing the radiation dose . The majority of CBCT units can be setted to scan small areas for particular diagnosis purposes . Others CBCT are able to scan the whole craniofacial complex when needed **.**

5. Rapid scan time :

(**Scarfe and Farman 2007**) . Stated that CBCT scan time is similar to panoramic radiography (approximated minute or less) because of CBCT obtain all projection images in one rotation . So that artifact due to subject motion is reduced .Computer time for dataset reconstruction however is considerably longer and varies based on FOV , resolution and the number of basis images acquired and may vary from nearly 1 to 20 minutes .

6. Variable FOV :

(**Adibi et al 2012**) . Explained that numerous CBCT unites have choices for selection of various fields of view , which reduce tissue irradiation through exposing only the certain region of interest . CBCT scan time is nearly a minute or less which permits for a rapid collection of data from the patient and so on decreases the chance of movement artifacts .

7. (**Palmo and Palmo 2009**)Suggested that CBCT consider to be suitable for the dental office setting due to its compact size and affordability . Furthermore , images of CBCT can be reconstructed into numerous formats that an oral care provider is familiar with . For example , a CBCT image can be reformatted to a panoramic , cephalometric or bilateral multiple cross-sectional view for valuation of type of oral &maxillofacial anomalies . These images , in turn , can be explained , assessed , and measured electronically **.**

8. Multiplanar reconstruction (MPR):

found that it is most common approach of showing information from a 3D dataset. Some anatomic structures are not specially good visualized and represented as demonstrated in the sagittal and/or coronal planes, and MPR can be helpfulin these conditions. (**Benavides et al., (2012)**)

9. Image display and enhancement:

(**Farman and Scarfe (2009)**) mentioned that initially, CBCT units reconstruct the projection data to give standard viewing designs in three orthogonal planes sagittal, coronal, and axial. Basal enhancements involve zoom or magnification, the ability to add notice, and measurement algorithms.

10. A more focused beam and much less radiation scatter produced by cone beam, compared with the conventional fan-shaped CT equipments. This considerably increases the X-ray utilization and decreases the X-ray tube capability needed for volumetric scanning**.** (**Scarfe and Farman (2008); Ahmad and Freymiller, 2010; Leung, 2010)**)

11.Cost:

(**Horner et al., (2008) ; Adibi et al., (2012)**) stated that CBCT machine relatively lower in cost than conventional CT scanner because of the x- ray source in CBCT is not much different from x-ray source used in conventional intraoral and panoramic tube heads. So that, CBCT suitable for dental hospitals or specialist dental practices.

12. Comfortable for patient because of there is no intraoral film or **sensor.** (**Farman and Scarfe (2008); Ahmad and Freymiller, 2010; Leung, 2010)**)

1.3.7 Disadvantages of CBCT technology:

The CBCT dynamic range for contrast resolution can just reach 14-bit maximally. To precisely read a soft tissue phenomenon, a 24-bit contrast resolution is required. So that, CBCT is not the greatest imaging modality to assess soft tissues, there are conditions that CBCT can assist, like analysis of soft tissue air way constrictions and obstructions for patient experiencing from sleep apnea, and other soft tissue assessment for orthodontic treatment. (**MacDonald-Jankowski and Orpe 2007; Palomo et al., 2007**)

Additionally, dissimilar MDCT, the Hounsfield units of tissue density are not calibrated on CBCT, which makes it undependable to compare tissue density depend on CT numbers generated from various CBCT units. (**Scarfe and Farman, 2009**)

Metal restorations cause streaking artifacts and motion artifacts due to patient movement stay present on CBCT images. (**Scarfe and Farman, 2009**)

Some published reports exhibit that the radiation effective dose of CBCT is within 36.950.3 microsievert, which is up to a 98% reduction as contrastd to MDCT systems . (**Cohnen et al., 2002; Schulze et al., 2004**)

Other study illustrates radiation effective dose of CBCT is amid 6 to 477 microsievert, basing on the parameters used(**Georgescu et al., 2010**). CBCT delivers a higher dose to the patient than a usual panoramic radiography by a factor of 5-16. Actually, CBCT dose is low contrasted to a MDCT, however is higher than the conventional dental radiograph techniques. (**Roberts et al., 2009**)

Ludlow et al. (2008) stated that the risk of deadly cancers per million tests of full month series with F speed film and round collimation is 9, for panoramic radiograph and for large field CBCT is 4-59. A number of CBCT systems have a similar deadly cancer risk the same as MDCT.

The choice of patient size, region of interest, field of view and resolution may have an effect on patient dose through an order of magnitude. (**Qu et al., 2010**)

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