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Ministry of Higher Education and Scientific Research
University of Baghdad
College of Dentistry

Association of Degree of Nasal Septum Deviation to Maxillary Sinus Volume among adults using spiral CT.

A thesis submitted to the council of the College of Dentistry/University of Baghdad in partial fulfillment of the requirements for the Degree of Master of Science in Oral and maxillofacial radiology.

By

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2016 October ***1437 Muharam***

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا

إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ

الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

(البقرة ايه: 32)

Certification of the Supervisor

I certify that this thesis entitled "**Association of degree of nasal septum deviation to maxillary sinus volume among adults.**" was prepared by **Hamsa Jamal Mahdi** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the requirements for the degree of Master of Science in Oral and maxillofacial radiology.

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Certification of the examination committee and the dean

We, the members of the examining committee, certify that after reading the thesis and examining the student in its contents, it is adequate for the award of the Degree of Master of Science in Oral and maxillofacial radiology.

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Dedication

To my most precious

My parents

To my brother and sister

To the sun and moon of my life

My husband Ali and my lovely son Zaid

Without your love and support.

This would never be done...

Hamsa

Acknowledgement

In the name of Allah the most Merciful and Beneficent

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Abstract

Background: Maxillary sinus is one of four pairs of para nasal sinuses and they are located within the maxillary bone. They have several functions as reducing weight of head, warming and humidification of air, protection of vital structure in the head and resonance of voice. Their volume and integrity are affected by different anatomical variation. Deviated nasal septum is one of the most popular anatomical variation presented in population.

Aims of the study: To evaluate the accuracy of spiral CT in examining the nasal septum deviation and maxillary sinus, estimate the possible role of deviated nasal septum on the volume of maxillary sinus on both sides of deviation, ipsi and contra laterally and detect the relationship of presence of symptoms with changes on Maxillary sinus volume.

Subjects, material and methods: From Ghazi Al-Hariri hospital attendance, 45 patients (20 – 40) yrs. were examined between October 2015 to April 2016 by spiral CT. They had deviated nasal septum. Clinically, they were divided into two groups; symptomatic and asymptomatic while radio logically they were divided into three categories; Mild, moderate and sever deviation depending on the degree of angle in the radiological coronal section of computed tomography. The angle was obtained from two lines. The first one drown from the crista galli down to premaxilla and the second line from crista galli to the most prominent part of nasal septum. The volume of maxillary sinus was calculated from the sum of volumes of axial sections for each sinus. This obtained from multiplying the area of each section by its thickness.

Results: The mean volume of maxillary sinus at same side of deviation (ipsi lateral) was highest among those with mild deviation and lowest among those with sever deviation. However, the differences of mean volume between the three severity groups was not statistically significant (p.vlaue=0.1). Same was found for contralateral sinus volume. There was no significant difference (p.vlaue=0.88) between the three groups and no linear correlation between sinus volume and deviation severity. The mean difference between the contra lateral and ipsi lateral sinus volume was lowest among those with mild deviation and reach maximum value among those with sever deviation and statistical significant linear correlation between the contra and ipsi lateral sinus volume and degree of septum angle was found ($r=0.86$ $p<0.001$). When comparing the mean difference between two sided sinuses and having symptoms, the result showed a remarked difference. The mean of difference between the contra and ipsi lateral maxillary sinus volume of asymptomatic patients was a way lower than that of symptomatic group. Statistically, this was strongly significant ($p<0.001$)

Conclusion: Computed tomography is very accurate in evaluation of nasal septum deviation and maxillary sinus volume. The sinus volume at the same side of deviation (ipsi lateral) tends to be smaller than that on the opposite side of deviation (contralateral). The difference between the two sinuses volumes found to be more obvious with sever septum deviations. The mean difference between two sided sinuses is more and significant in symptomatic patients while those who were asymptomatic show no significant difference.

Key words: maxillary sinus volume, nasal septum deviation, spiral computed tomography.

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List of abbreviations

Symbol	Abbreviation
ANOVA	Analysis of variance
CBCT	Cone beam computed tomography.
cm	Centimetre.
CT	Computed tomography.
HRCT	High resolution computed tomography.
HU	Hounsfield unit.
Max.	Maxillary.
MDCT	Multi detector computed tomography.
ml	Millilitre.
MRI	Magnetic resonance image.
MS	Maxillary sinus.
NS	Non-significant.
NSD	Nasal septum deviation.
OMC	Osteomeatal complex
PA	Posterior anterior
PNS	Para nasal sinuses
P. value	Probability value.
ppb	Part per billion
SD	Standard deviation.
SE	Standard error.
SPSS	Statistical package for social variances.
WL	Window level.
WW	Window width.
%	Percentage.

Introduction

Introduction

The para nasal sinuses are four pairs of air-filled cavities located within the skull and facial bones and communicate with nasal lumen through ostiums. The maxillary sinus is the largest and the first to develop of paranasal sinuses. It's located within the maxillary bone below the eyes **(Ballenger, 2003).**

According to **Lawson in 2008**, the development of maxillary sinus takes place in two stages. The first stage occur in the first three years of life and the second one occur in the age of 6-12 years.

Several mechanisms have been proposed to explain the paranasal sinuses development as nasal air flow, brain growth, muscle mass traction and facial structures **(Shapiro, 1980).**

Anatomical variants are presented widely and commonly in sino nasal cavities and there about 15 anatomical variants have been described as nasal septum deviation, Haller cell and concha bullosa **(Lehmann et al, 2009).** These variation may cause obstruction of osteomeatal complex (OMC) channels which may hamper the normal airflow and\or mucocilliary clearance of sinuses. Some studies go to consider the anatomical variations as a factor that interfere with normal development of paranasal sinuses or risk factor for sinus diseases depending on its size, severity, location or amount of mucosal contact caused by variation **(Kennedy et al, 2001).**

Nasal septal deviation is presented commonly in population and associated with an increased prevalence of paranasal sinusitis, although the impact of this anatomic anomaly is limited. It appears to be one of many possible factors that might lead to the development of sinonasal pathologies (**Orlandi, 2010).**

Despite that the difference in maxillary sinus volume is related to sinusitis considered as common believe, there are only a few studies propose a role of deviated nasal septum in determine the sinus volume and etiology for sinusitis **(Fatua et al, 2006).**

Many surgical operations involving the maxillary sinus in the posterior maxillary region require good knowledge about any possible anatomical variations. Exact knowledge of the morphological conditions of patient allows accurate planning of invasive surgery and prevention of complications **(Velasquez-Plata *et al*, 2002; González-Santana *et al*, 2007).**

Evaluation of the anatomical structures and variations associated with maxillary sinus is crucial for the success of sinus surgical interventions. Therefore, an exact and precise radiological assessment is requisite **(Abrahams, 2001; Kim et al, 2006).**

Computed tomography considered as the method of choice for evaluation of different cases of sino nasal pathologies and variations that may not respond to medical therapy. Particularly in patients require surgical intervention **(Riello and Boasquevisque, 2008).**

This study try to evaluate the effect of deviated nasal septum on the volume and integrity of maxillary sinuses using spiral computed tomography.

Aims of the study

1. To evaluate the accuracy of spiral computed tomography in examining the nasal septum deviation and maxillary sinus volume.
2. To determine the possible role of nasal septal deviation on volume of maxillary sinuses.
3. To detect the relationship of presence of symptoms with changes on Maxillary sinus volume.

Chapter One

Review of Literature

Chapter one
Review of literature

1.1. Nasal septum:

Nasal septum is that part of nasal cavity which lies between the roof and floor of the cavity and composed of posterior part (thin sheet of bone) and anterior part (cartilage) **(Standring, 2008)**. It is composed by the quadrangular cartilage (anterior part), perpendicular plate of the ethmoid bone and the vomer posteriorly **(Keles, 2013).**

It is considered that until the age of 7 years the septum is a midline part but thereafter it deviates and the deviation occur mostly to the right **(Moore, 1994).** While other authors suggest that during development and growth, the nasal septum as a figure may represent the displacement of maxilla, however, this is not confirmed **(Enlow, 1992).**

1.1.1 Development of the Nasal septum:

It is thought that the nasal septum develops as a fold growing downward between the paired nasal cavities until it reaches the palatal shelves. From the nasofrontal prominence, this growth is thought to be in an inferior direction which continue to fuse with palatal shelves forming secondary palate **(Neskey et al, 2009).** This fusion separates the nasal cavity from the oral cavity and the fusion of the primary and secondary palate forms the incisive foramen **(Markus et al, 1992).** The function of nasal septum is to divide the nose into two chambers and it consists of the ethmoidal perpendicular plate, quadrangular cartilage, vomer, maxillary crest, the palatal crest and membranous septum. **(Neskey et al, 2009).** After the skeletal growth completes, Soft tissue nasal growth occurs. A systematic review provided more insight into the maturation of nasal structures in adolescents. It was stated that in females, the Maximum growth were at 11.7 years old, compared to that in males which was at 14.7 years old. Nasal maturation was found at 15.8 years old in more than 96% adolescent females while similar percentage were found in males who were nasally mature at 16.9 years of age **(Van der Heijden et al. 2008).**

1.1.2 Anatomy of nasal septum:

The nasal septum is composed of:

I. A small membranous part anteriorly.

II. A cartilaginous part which is quadrilateral cartilage that forms the anterior portion of nasal septum. The thickness of this cartilage is about 3 to 4 mm in its center but increases to about 4 to 8 mm anterioinferiorly and by collagenous fibers. It's bounded tightly to the bones of nasal cavity, vomer and the perpendicular plate of ethmoid. Inferiorly, it sets in the nasal crest of maxillary palatine process and at the inferior septal angle it abuts the maxillary spine. By the thin membranous septum it's attached to the medial crura of lower lateral cartilage anteriorly **(Lund, 1997).**

III. A bony part. This part is formed by the perpendicular plate of the ethmoid, above and behind, while the posterior and inferior nasal septum formed by the vomer and by its two alae it articulates with the sphenoidal rostrum. The vomer's inferior border articulates with the nasal crest that is formed by the palatine bones and maxilla. The anterior border articulates with the perpendicular plate above and it articulates with quadrilateral cartilage inferiorly. Besides, the vomer posterior edge forms the free posterior edge of the septum. **(Lund, 1997). (fig.1-1)**

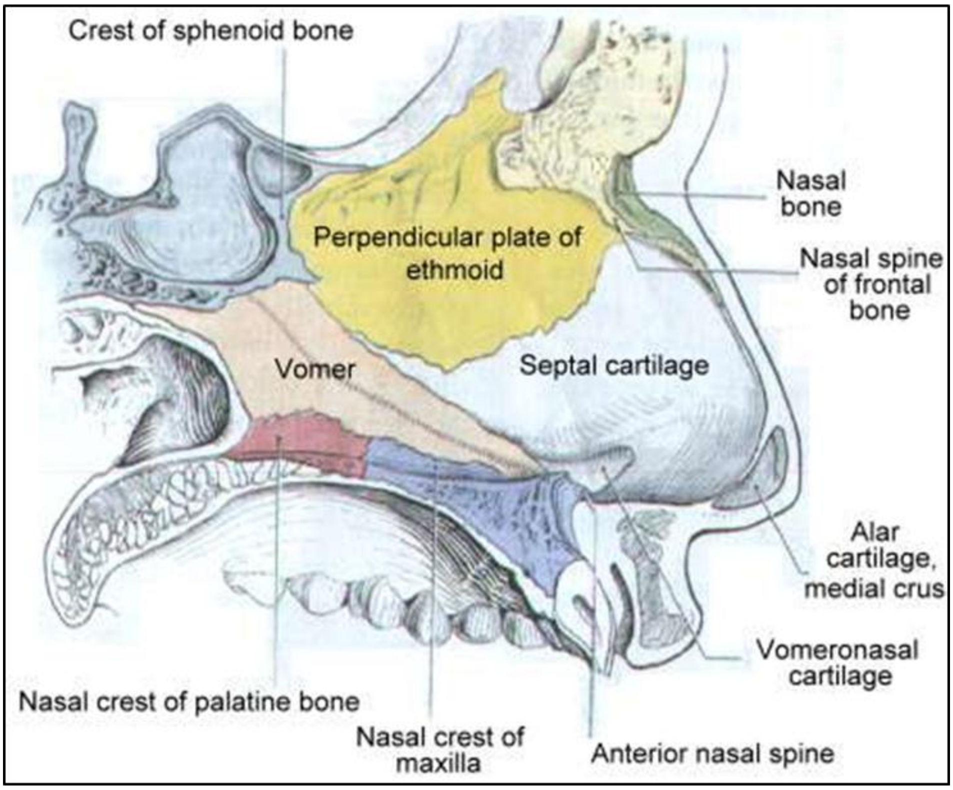

Figure 1-1*: Structural anatomy of the nasal septum* ***(Moore, 2014).***

1.1.3. Blood supply of nasal septum (Alan, 1997. Lund, 1997):

A. Arterial supply:

1. The internal carotid artery system:

“Supplies the superior part of the septum via anterior and posterior ethmoidal arteries

2. The external carotid artery system:

i. Sphenopalatine artery via sphenopalatine foramen supplies the posterioinferior septum.
ii. Incisive artery which is a branch of Greater palatine artery through incisive foramen in oral cavity supplies the anterioinferior septum.
iii. Superior labial artery of facial artery contributes to the anterior part of septum and collumella**. (fig.1-2)**

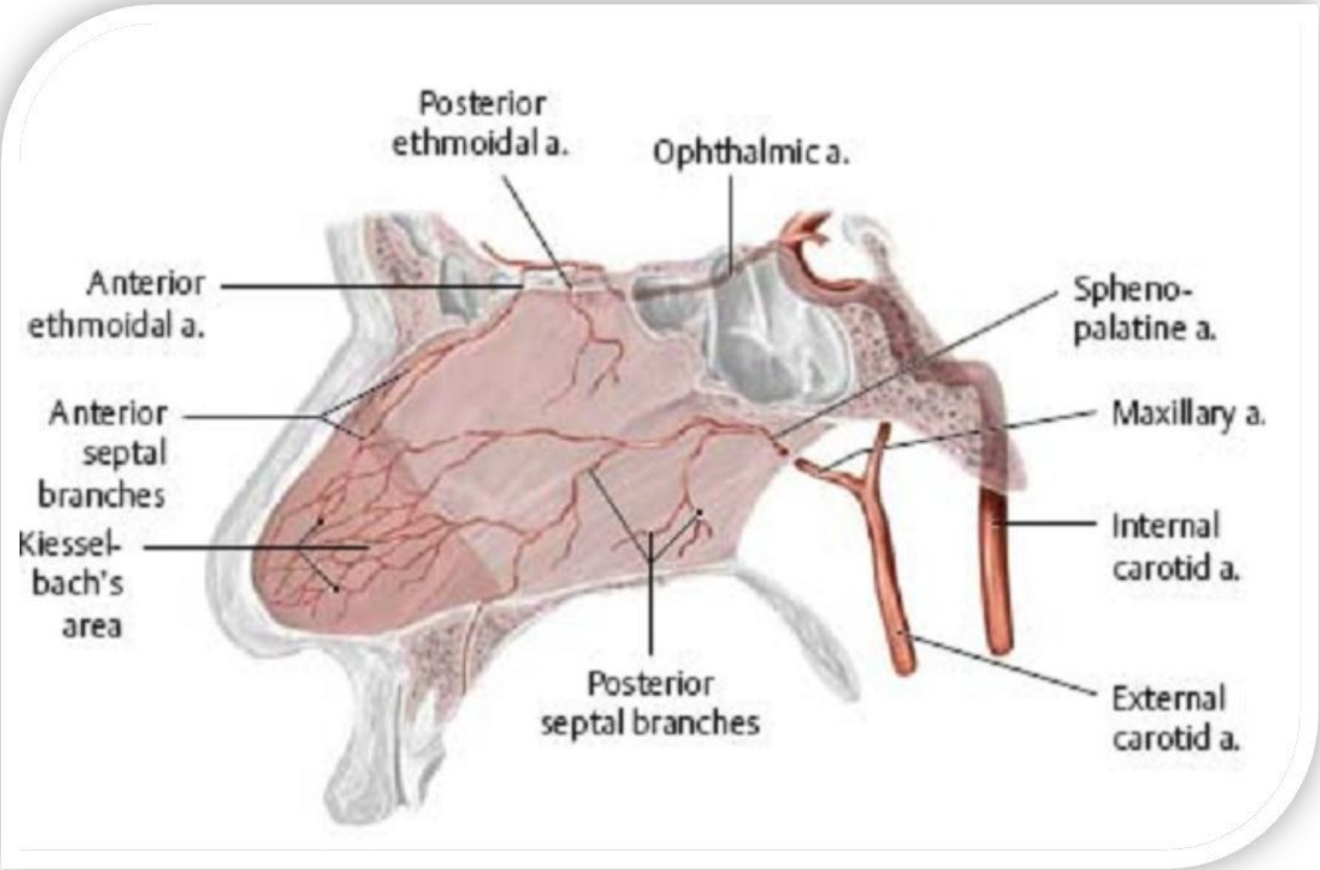

Figure 1-2: *Arterial blood supply of nasal septum* ***(Anne, 2008).***

B. Venous drainage:

Through the sphenopalatine vessels, the cavernous venous system drains posteriorly into the pterygoid plexus and anteriorly into the facial vein. The ethmoidal veins communicate superiorly with superior ophthalmic system and there may be direct intracranial connection into the superior sagittal sinus through the foramen caecum.

C. Lymphatic drainage:

The drainage of the anterior part of the septum is to the submandibular nodes with the external nose while posteriorly its drainage is into the retropharyngeal and anterior deep cervical nodes.

1.1.4. Nerve supply:

According to **Lund (1997)** the nasal mucosa innervation includes both sensory and autonomic components:

A. Sensory innervation:

I. The cribriform plate inferior surface is covered by the olfactory epithelium covers which spreads down to cover variable area of upper septum and adjacent lateral wall.
II. The second branch of the trigeminal nerve (maxillary nerve) gives sensory innervation that supplies the majority of nasal septum through nasopalatine nerve and also supplies the body of bony septum.
III. The lateral nasal wall and the anterosuperior part of the septum supplied by nasocilliary nerve through the anterior ethmoidal branch.
IV. A small area of the septum anteroinferiorly and the anterior portion of the inferior meatus supplied by the anterior superior alveolar nerve.
V. Branches from the pterygopalatine gangilia and anterior palatine nerve are received by the posteroinferior septum

B. The autonomic system:

It regulates the degree of vascular tone, turbinate congestion (sympathetic) and nasal secretion (parasympathetic). These fibers accompany the sensory nerves. Presynaptic parasympathetic fibers go side by side with the fifth cranial nerve (facial nerve) and keep on as the greater superficial petrosal nerve at the geniculate gangilion, then come along with the deep petrosal nerve so as the vidian nerve is formed, the fibers synaps at the sphenopalatine gangilion with post ganglionic neurons before innervating the nasal mucosa**. (Fig.1-3)**

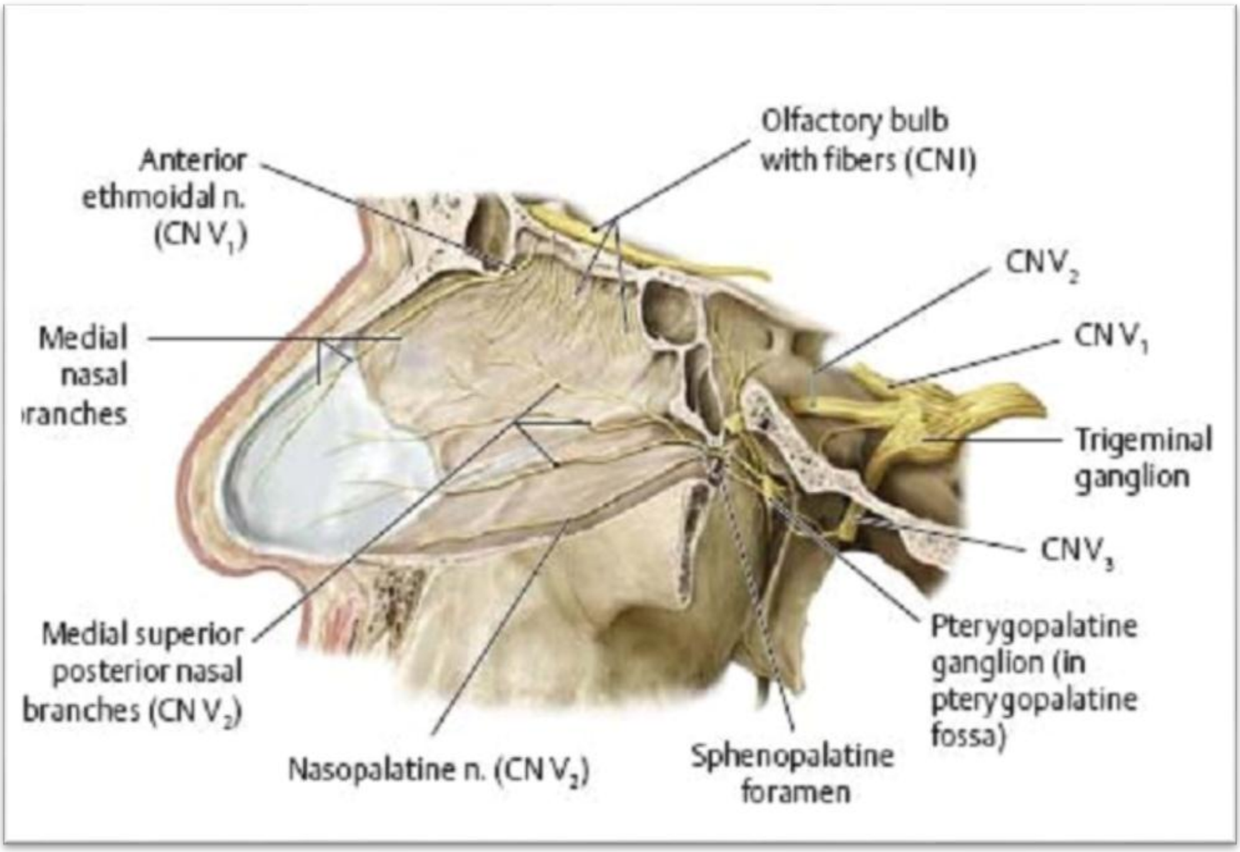

Figure 1-3: *innervation of nasal septum* ***(Anne, 2008).***

1.1.5 Nasal Septal Deviation:

Deviation is defined as "deviation of the bony and cartilaginous septum to one or both sides". As the deviation suggests some sort of growth disjunction, Septal deviation further complicates the growth theories of the septum, **(Gray, 1978).** The normal nasal septum is straight, symmetrical and meets the arched palate evenly in the midline **(Reitzen *et al*, 2011 and Mohebbi *et al*, 2012).** Deviated sptum considered as one of the common findings seen in Otorhino-laryngology daily practice. Some degree of NSD is found in 58% in newborn babies and less than 5% of these is also associated with external Nasal deformity **(Gray, 1985).**

1.1.5.1 Etiology of nasal septal deviation:

1. Trauma:

   i. Direct trauma: direct trauma can be the main cause for many septal deviations and this is associated frequently with destruction or damage of other parts of the nose as conditions of nasal bone fractures **(Bove, 1988).** minor trauma occurs early in life can be easy overlooked and micro fractures may result to the septal cartilages and healing of these micro fractures may cause cartilage bending away from the injury side which, when happens early in life, will lead to asymmetry of entire nasal structure as a result of the interruption of chondrocyte growth **(Russel *et al*, 2005).**

   ii. The birth moulding theory: the intrauterine pressures and trauma from birth considered as one of the major causes of septal deviation **(Gray, 1978**). Forceps delivery and passage of the fetal head through the narrow birth canal can lead to displacement of septum. However, normal vaginal delivery of neonates show a higher incidence of septal deviation compared to those delivered by caesarian section. Spontaneous straightening of the deviated septum was noticed in the first days of life **(Gray, 1978; Brain, 1998; Kawalski and Spiewak, 1998).**

2. Congenital malformations and developmental abnormalities:

Patients can still develop a deviated septum in the absence of trauma. The excess of growth which may occur and cause the septum to buckle or deviate due to the forces generated could be one of possible explanations.

Prevalence rates in children have been found to be about 1-20% and rates around 13% in teenagers **(Podoshin *et al*. 1991; Kawalski and Spiewak 1998; Song *et al*. 1999).** The pressure that occurs during the upward development of the maxillary crest along with the downward growth of the septum from the ossification centers of ethmoid all the way with the development of the premaxilla and vomer, all of these forces may result in DNS **(Blaugrund, 1989).** The sphenoidal process of the septal cartilage may show reduced ossification and this leads to greater overall septal length and increased nasal septal deviation **(Kim, 2012).**

1.1.6 Imaging of nasal septum

Although the use of plain images for nasal septum imaging is not suggested, the plain films are sometimes used. And in such cases the examinations of choice includes the Waters (occipitomental) and lateral nasal views acquisition. It should be noted that in most cases plain radiographs could be the cause of confusion regarding the clinical picture. Identification of cartilaginous disruptions, fractures, shearing, and injury in general cannot be distinguished in plain radiograph. They also do not provide sufficient information to evaluate injury severity and displacement **(Carter *et al*, 1988; Rodt *et al*, 2006).**

However, The Waters (occipitomental) view is believed to be the best overall view concerning observation of facial fractures in general. The radiologist should keep in mind the areas of relative weakness while looking for abnormalities of the nasal septum and arch. Different signs of possible fracture may be seen as marked deviation, displacement with sharp angulation, and soft-tissue swelling **(Mehra and Murad, 2004).** In Normal

Waters projection nasal septum is clearly seen **(fig.1-4).** Also the nasal septum and the nasal cavity floor are evident in PA projection (Occipito frontal or Caldwell projection) **(Hwang *et al*, 2006). Fig. 1-5**

Figure 1-4: *Water's view in which the nasal septum can be seen* ***(White& Pharaoh, 2014)***

Figure 1-5: *Caldwell projection which may show nasal septum* ***(White& Pharoah, 2014).***

Because of the poor sensitivity and specificity profile of other radiographic techniques including plain film radiography, they are of limited clinical advantage and these films are repeatedly misread as positive **(Hong *et al*, 2007; Mohammadi & Ghasemi, 2011).**

A study by **Hwang et al** in **2006** also suggested that plain radiography is not dependable for the diagnosis of fractures of nasal bone and that CT is better to be used in such diagnoses.

When children evaluation is demanded and limitation of exposure to radiation is required, ultrasonography has been beneficial to some in evaluating septal deviation, nasal fractures and comminution level which could be accomplished with a linear array transducer of 7-15 MHz **(Lee, 2015) Fig 1-6.**

Some limitations were found for providing detailed and clear information on the three-dimensional nasal septum structure in different studies which used X-ray while when magnetic resonance imaging (MRI) is used, specifically the sagittal plane, better identification could be confirmed for each structure. That’s why a wide range of researches on the development and structure of nasal septum have become prospective with the use MRI. However, no studies using the sagittal plane of MRI have been performed for determination of the development and structure of the nasal septum **(Kim *et al*, 2008). Fig.1-7**

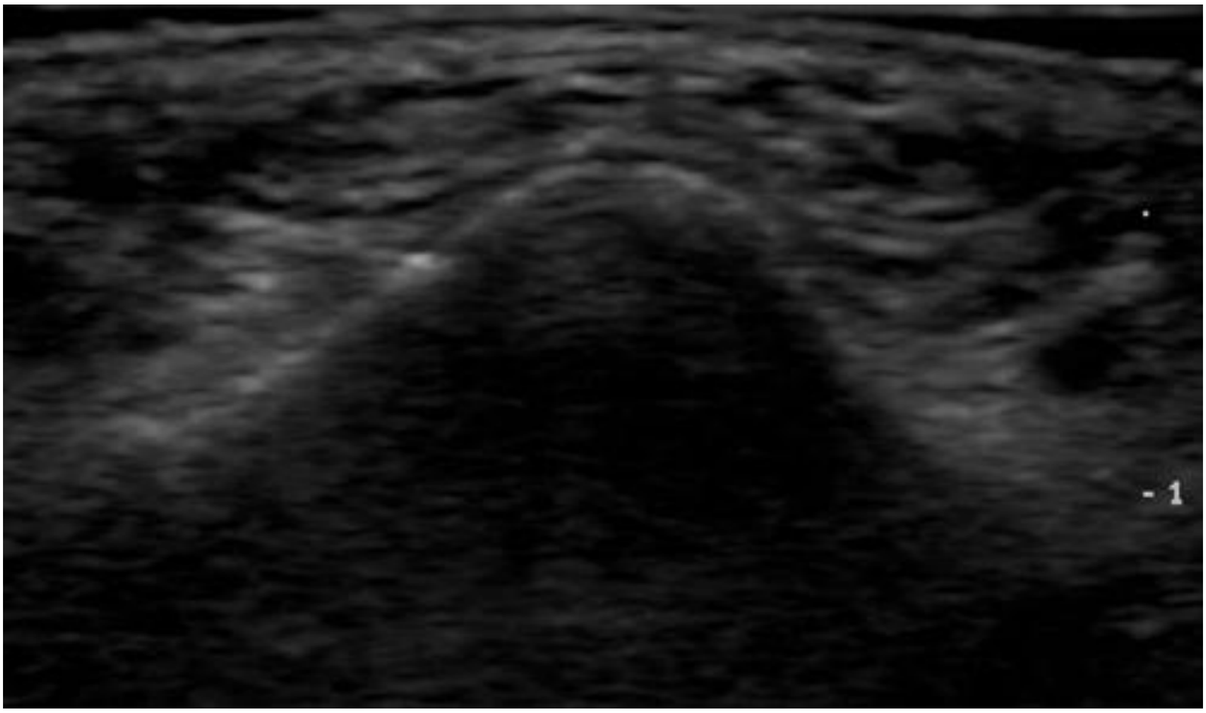

Figure 1-6*: Normal sonographic findings in 3-year-old girl with nasal contusion after falling down stairs. Axial sonograms show upper level of nose (Hong et al, 2007).*

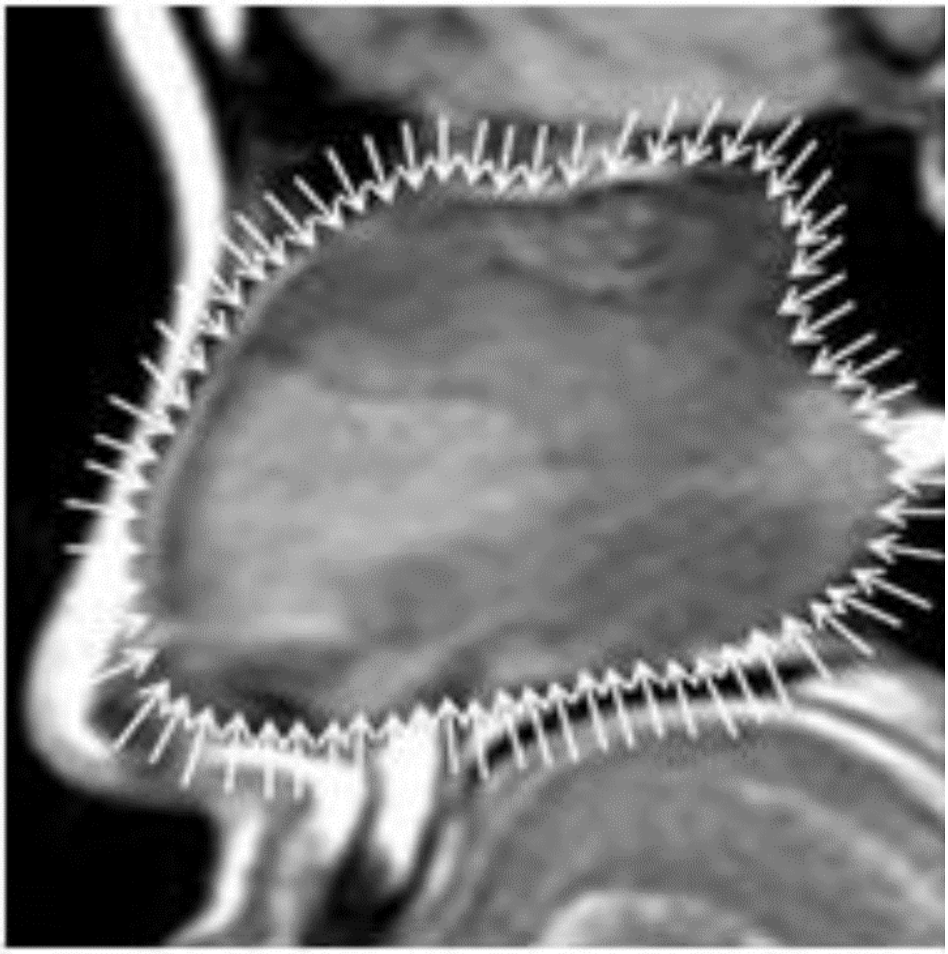

Figure 1-7: *Sagittal view of MRI showing the total septal area* ***(Kim et al, 2008).***

Nasal septum imaging has been enabled and improved by using Magnetic resonance imaging (MRI) and computed tomography (CT) scans. Using these technologies, septal deviation was found to occur in rates considered higher in adults and teenagers, compared to those patients who were under 4 years of age **(Reitzen et al, 2011). Fig.1-8a, b.**

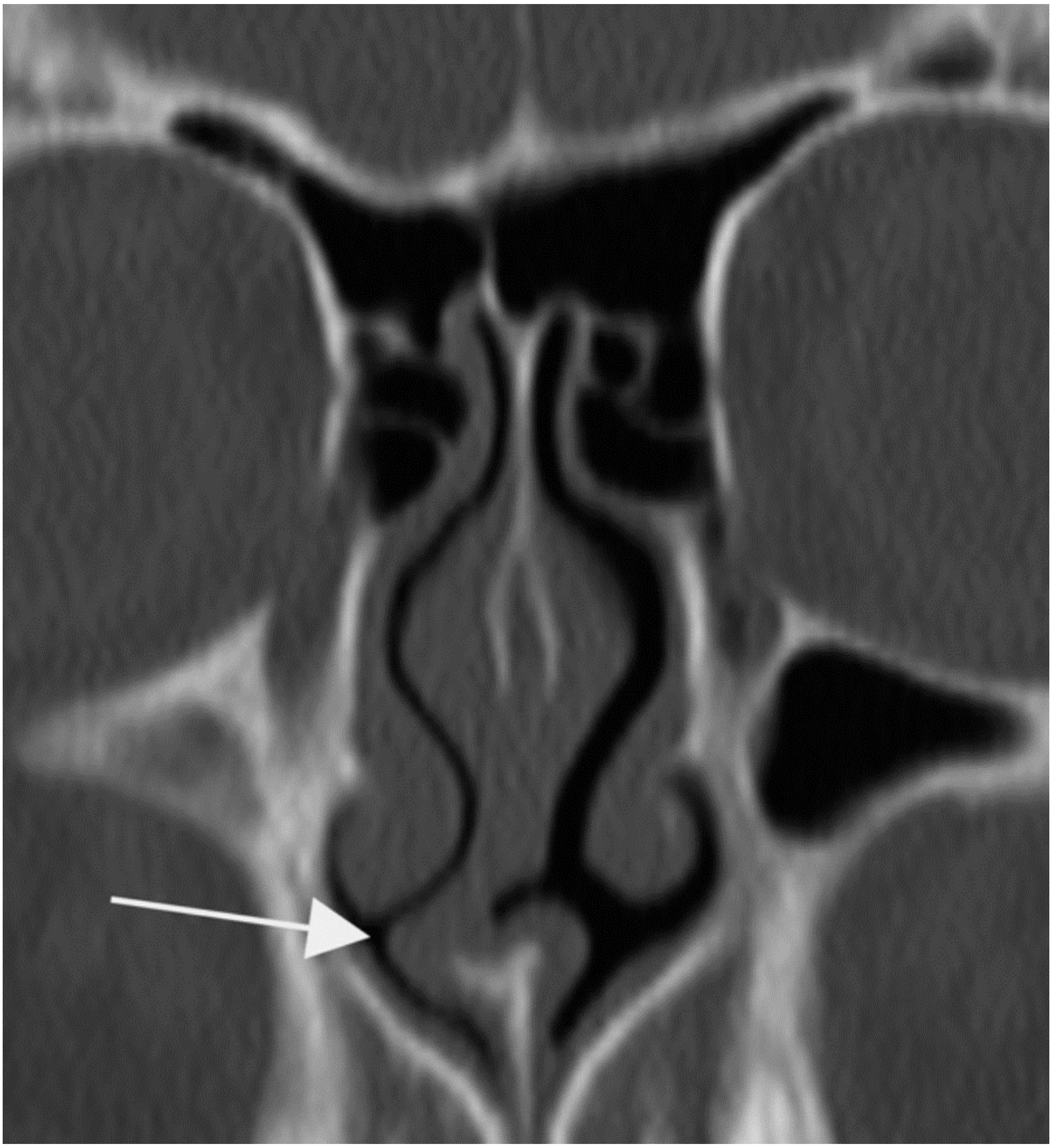

Figure 1-8a: *Coronal CT with deviation of the septum at the chondrovomeraljunction (white arrow)****. Beale et al, 2009.***

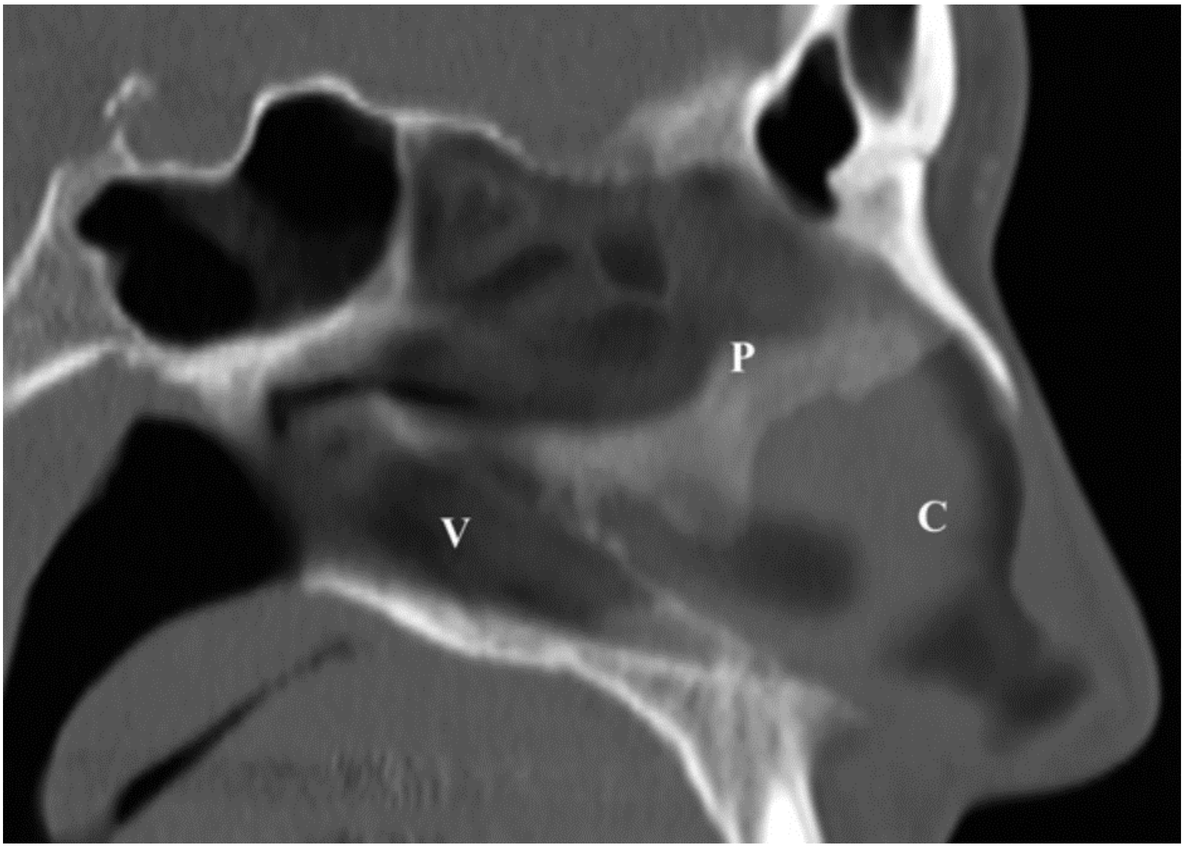

Figure 1-8 b*: sagittal CT highlighting the three components of the nasal septum: the perpendicular plate of the ethmoid (P), vomer (V) and the more anterior nasal cartilage (C).* ***Beale et al, 2009.***

Using CT, which was regarded as the optimal imaging modality for sinus disorders **(Bhattacharyya, 2010).** Coronal view of computed tomography scan of PNS is a complimentary and easy method for nasal septum and lateral nasal wall examination **(Mundra, 2014)**. Computed tomography (CT) is considered as the preferred modality for facial trauma evaluation because of its capability of the specific anatomical localization of fractures. CT dependably demonstrates the patterns of fracture and its level and severity **(Manson *et al,* 1990).** CT has become fundamental for estimation, evaluation and handling of midfacial fractures, nasoethmoidal orbital and orbital fractures **(Remmler, 2000; Sun and LeMay, 2002; Sargent, 2007; Escott and Branstetter, 2008; Kwon, 2009).**

1.2 Maxillary sinus

1.2.1 Maxillary sinus anatomy

The maxillary sinuses described as two spaces that are air filled and located within the maxillary bones. They can be of different sizes and shapes. The maxillary sinus take their places bilaterally in the maxillary bone. Among the paranasal sinuses, the maxillary sinus is the largest. It's named also as the antrum or the antrum of highmore. Antrum word has been taken from the Greek word which means cave. Dr. Nathaniel Highmore who was an English physician in the 1600 had a describtion for sinus infection associated with a maxillary teeth, and his name has long been associated with sinus nomenclature **(Plenk and Tschabitscher, 1986; Hupp *et al*, 2008).** With their bases which are formed by the lateral wall of nasal cavity, the paired sinuses occupy of the largest part of the bodies of the maxillae**. (Williams e*t al*, 1995).** The nasal surface of the body of the maxilla and parts of the palatine, lacrimal, ethmoid and inferior turbinate bones are the boundaries of medial wall of antrum. The presence of these bones decreases the size of the opening between the maxillary sinus and the nasal cavity during life in a remarkable way **(Dixon, 1986).** The zygomatic process of the maxilla contains the extension of the apex of the sinuses while the roof of sinuses are formed by the floor of orbit and through the latter there is the course of the infraorbital nerve **(Plenk and Tschabitscner, 1986; Navarro, 2001; Hupp *et al*, 2008). Fig. 1-9**

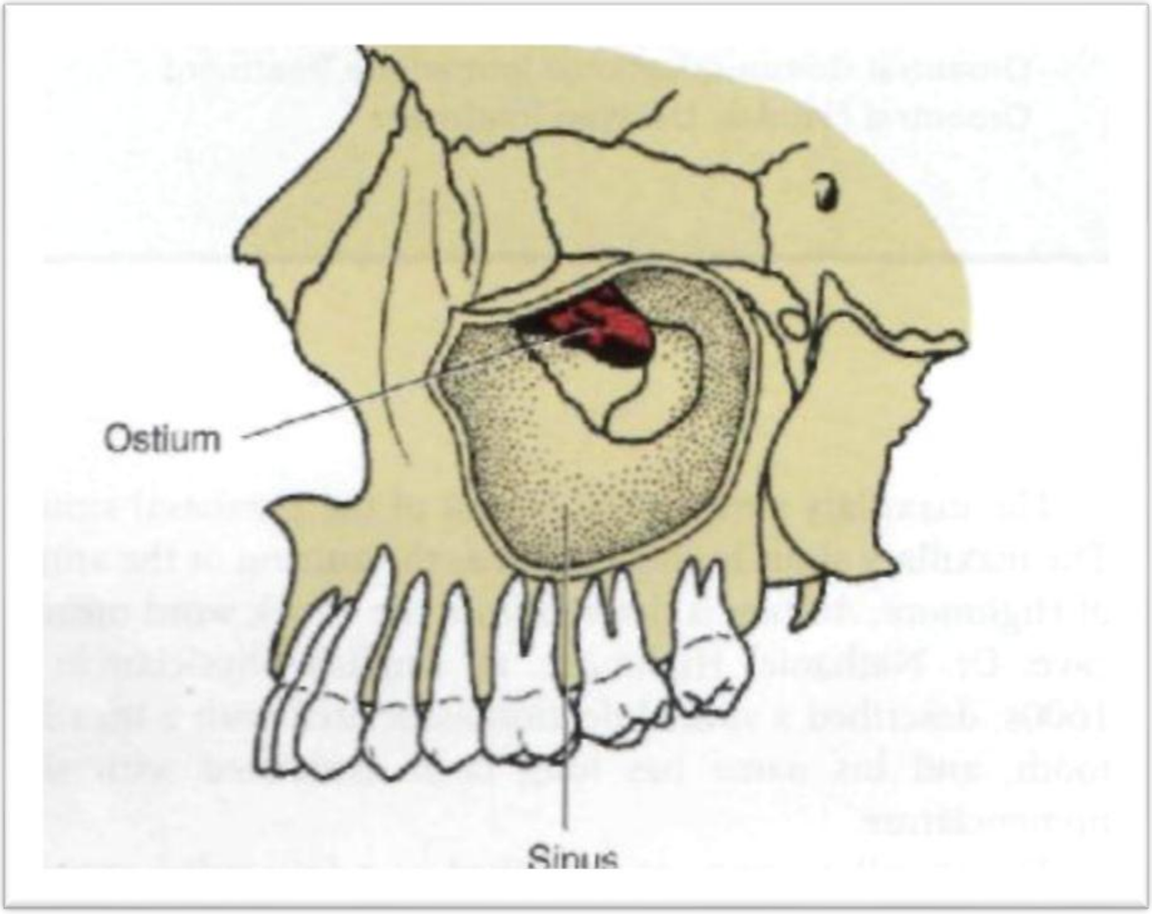

Figure 1-9: *diagram of lateral view for left maxillary sinus. What seen in depth is medial wall of sinus (which represents lateral nasal wall), also the ostium is seen. The sinus is pyramidal, with its apex directed into zygoma base* ***(Hupp, et al 2008).***

The alveolar process forms the floor of maxillary sinus. The roots of the maxillary bicuspid, molars teeth and sometimes cuspid teeth could project into the maxillary sinus **(Hauman *et al*, 2002; Tank, 2005).**

The posterior wall extends the length of the maxilla and be immersed into the maxillary tuberosity. Behind the posterior wall there is the pterygomaxillary fossa with the internal maxillary artery, sphenopalatine ganglion and the Vidian canal, the greater palatine nerve and the foramen rotundum**. (Bailey, 2001; Hupp *et al*, 2008).**

1.2.1.1 Blood Supply to Maxillary Sinus

The internal maxillary artery which is a branch of external carotid artery supply the maxillary sinus. These involve the infraorbital (it runs along with the infraorbital nerve), the sphenopalatine through its lateral branches, greater palatine and the alveolar arteries.

Venous drainage runs into the facial vein anteriorly and into the maxillary vein and jugular vein posteriorly **(Anon et al, 1996).** A highly vascular tissue surround the maxillary sinus and make it an ideal site to accommodate bone graft or, in the future, tissue-engineered constructs **(Boyne and James, 1980; Tatum, 1986).**

1.2.1.2. Nerve Supply to the Maxillary sinus

The innervation of maxillary sinus is by the infraorbital and superior alveolar (posterior, middle and anterior) which are branches of the maxillary nerve and the latter is a division of the fifth cranial (trigeminal) nerve. These alveolar nerves run to the teeth in the walls of the sinus, and as they do so tiny branches pass through the bone to supply the mucous membrane of the sinus **(Sinnatamby, 2000).**

1.2.1.3 Nutrient Canal within Maxillary Sinus

Nutrient canals are very delicate and small tube-like passageways within the bone and contain arteries, veins and nerves that supply the maxillary teeth and interdental areas. Canals or grooves for the nerves and vessels supplying the upper posterior teeth are contained in the lateral wall. These nutrient canals could be seen within the maxillary sinuses. Radiographically, on a maxillary periapical radiograph, a nutrient canal may be seen as a band that is narrow and radiolucent, bounded by two thin radiopaque lines which represent the cortical bone that makes up the walls of the canal **(Haring and lind, 1993; Whaites, 2003).fig. 1-10**

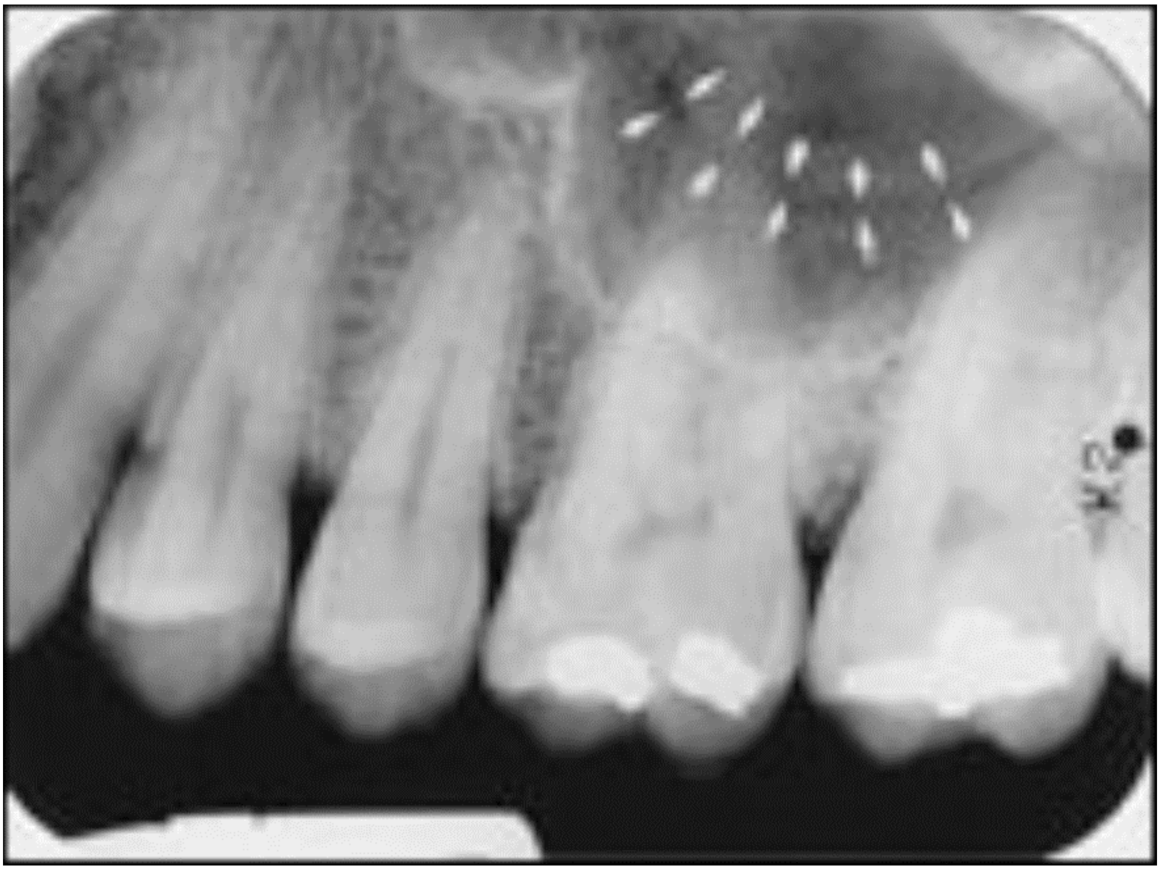

Figure 1-10: *Periapical radiograph showed nutrient canals in maxillary sinus appear as narrow radiolucent lines* ***(Haring and lind, 1993).***

1.2.2 Development and Growth of Maxillary Sinus

The paranasal sinuses development occur as invaginations from the nasal fossae into their respective bones with a continuous enlargement until maturity of skeletal system. The antra or maxillary sinuses are the first of paranasal sinuses to develop and this occur in the second month of gestation. An invagination grows in the lateral wall of the nasal fossa in the middle meatus, and this enlargement (sinus cavity) gets bigger into the body of the maxilla laterally. At birth, each sinus is presented as a thin and small slit that its length does not exceed 8 mm in its anteroposterior dimension. The maxilla gets more pneumatization progressively with time as the air cavity gains further development into the bone both laterally down to the orbits toward the zygomatic process and inferiorly into the alveolar process **(White &Pharaoh, 2014).** At birth, the primary sinus volume is not more than 8 cm3, with the anteroposterior direction show its maximal dimension. Although initially medial to the orbit, the lateral margin of the sinus by the end of the first year projects under the medial orbital wall. By age of 4 years the sinus extends laterally past the infraorbital canal. By age of 9 years it reaches the maxillary bone. Also by the age of 9 years the Inferior growth usually reaches the plane of the hard. Although, the development timing of these different stages is highly variable **(Scuderi *et al*, 1993)**. After birth the growth of the sinus goes into two phases, the first one shows rapid growth in the first 3 years, and then second rapid one from the age of 7 to 12. While growth between 3 and 7 years of age shows a slower growth phase, and then again after the age of 12 years, growth slows down until early adulthood **(Cummings *et al*, 1998)**. **White and Pharaoh (2014)** stated that final growth of the maxillary sinus occurs by 12 to 14 years of age and gets along with the eruption of permanent teeth and the alveolar process growth of the upper jaw, but **Misch (1999)** stated that growth of sinuses ends with the eruption of the wisdom teeth at approximately 20 years of age. **Fig. 1-11**

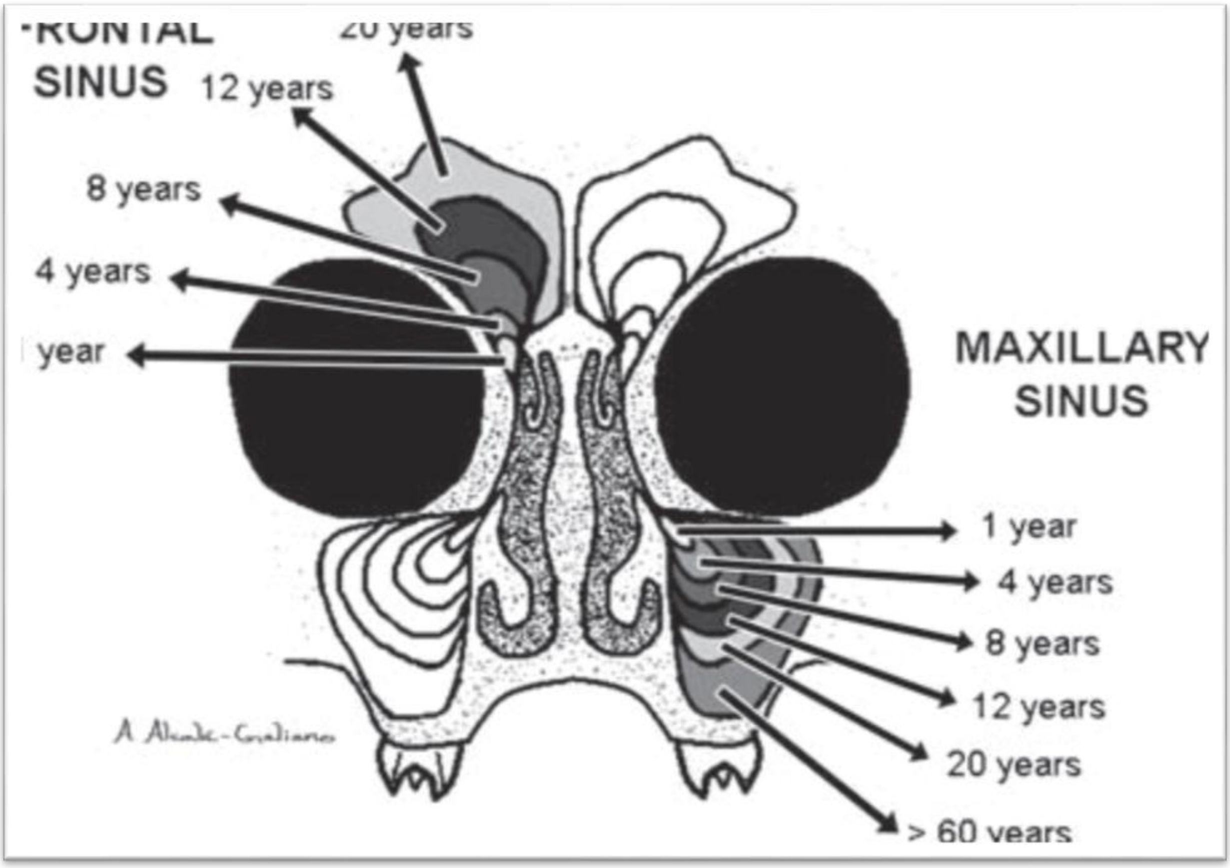

Figure 1-11: *Diagram showed the paranasal sinuses (frontal and maxillary) sinuses development according to age in years* ***(Shah et al, 2003).***

1.2.3. Maxillary Sinus Volume:

The maxillary sinuses have their size of maturation at the age of about 20 years, when the permanent teeth are fully developed. Their sizes and shapes change especially due to loss of teeth during adulthood. Then the volume of the maxillary sinuses reduce in both genders after the maximum growth period. This may be attributed to the loss of minerals in the bone matrix of the entire body structure that surrounds the maxillary sinuses in all directions, which constricts the maxillary sinuses and result in a reduction in the maxillary sinus volume **(Jovanic *et al*, 1984; Meier *et al*, 1987; Wishart *et al*, 1995).** The developed sinus average volume at maturity ranges between 15 and 20 ml which is about double its size at birth. Although these dimensions stays relatively steady once the permanent maxillary teeth have erupted and maxilla growth is complete, some patients show continuous pneumatization and expansion throughout life **(Mehra and Murad, 2004).**

1.2.4. : Functions of the paranasal sinuses (Porter, 2002):

The function and physiology of the sinuses has been the discussed in many researches. However, it's still unsure about these air-filled spaces functions. Different theories concerning functions were discussed. These involve the act of humidification and warming of air, helping in regulation of internasal pressure and serum gas pressures, take part in immune defense, providing more mucosal surface area, lessen the weight of the skull, giving the voice its resonance, act as shock absorbers and have their role in facial growth. The nasal cavity considered an amazing warmer and humidifier of air. Even with seven liters/minute rate of air flow, the nose has not made its greater ability to perform the maximum of this function. It has been shown that the nasal humidification contributes to about 6.9 mm Hg on serum CO_2. Though the nasal mucosal lining shows best adaptation to accomplish such tasks, the sinuses also take part in increasing mucosal surface area and ability of warming. Some researchers have revealed that people with mouth breathing have increased serum CO_2 and sleep apnea which could be caused by their decreased end-tidal CO_2. Because of the sinuses' considerable production of mucous they play a serious role in nose performance in immune defense and air filtration. The mucosal lining of the nose and sinuses is ciliated and act to move out mucus to the choanae and the stomach thereafter. The thickening of nasal mucosal superficial layer take place in trapping microorganisms and particulate matter in a substance that is enriched with antibodies, antibacterial proteins and immune cells. The underlying layers are thinner and helps in providing a thinner part in which the cilia have capability of beating; their tips basically grab the upper layer and push it in the beat direction. Unless obstructed by anatomical variance or disease, the sinuses push mucous out from their cavities toward the choane through their ostia. The latest studies on sinus function has concentrated on the molecule Nitrous Oxide (NO). Such researches have revealed that the intranasal NO production is primarily in the sinuses and this one has been shown to be toxic to fungi, viruses and bacteria at levels as low as 100 ppb. Nasal concentrations of nitrous oxide may reach about 30,000 ppb which have been considered as the mechanism of sterilization of sinus by some researchers. Also NO has shown a role in raising ciliary motility.

The para nasal sinuses physiology and function is a matter that give reflection of the complication of their anatomy. Keeping research may probably reveal that many of such functions are just part of a bigger and more involved picture than is manifested now.

1.2.5. The Effects of Septal Deviations:

Deviated nasal septum may affect air flow and causes change in the nasal cavity pattern **(Mundra *et al*, 2014)**. Additionally, deviated nasal septum is also related to sinus infections and sleep apnea, repetitive sneezing, nose bleeds, and even difficulty with breathing **(Foda, 2005; Mundra *et al*, 2014; Lasters, 2014;)**.Adults with DNS can be presented with nasal obstruction history, headache and recurrent nasal discharge **(Mohebbi, 2012)**. **Danese (1997)** found that there was association between septal spurs and ridges with ipsilateral sinus disease as evaluated by CT scan. The nasal cavities imbalance associated with septum deviation represents a common etiological factor of nasal airway Obstruction **(Kim *et al*, 2014)**.Nasal obstruction is causative factor of snoring and sleeping with opened-mouth which may, at long term, result in dentofacial and orofacial changes **(Baumann and Plinkert, 1996)**. Palatal asymmetries, Dental malocclusions, ear disease and respiratory tract infections were found to be more common in patients with unilateral deviation of nasal septum **(Gray, 1983).**

Deviation of nasal septum may show association with considerable Sino nasal disease even in absence of any nasal symptoms **(Moorthy *et al*, 2014).**

1.2.6. Imaging of paranasal sinuses

1.2.6.1 Plain film radiography

Plain films have been used as they provide easy and fast method in evaluation of the maxillofacial structures since the beginning of the twentieth century. Most of surgeries that is related to sinus were aimed at the maxillary sinuses, since plain films show this area with ease and the modality was widely used. The standard projects used to show this morphologic area are four: the Waters', lateral, Towne's and submentovertex views. It is possible to evaluate the maxillary, frontal, sphenoidal and the posterior ethmoidal sinuses as well as the lower third of the nasal cavity with these views, however, the standard views are not sufficient for convenient evaluation of the ethmoidal air cells, upper two thirds of the nasal cavity and frontal recess .but since it provides a favorable demonstration of the lower one-third of the nasal cavity and maxillary sinuses, this modality kept to be widely used **(Hasaballa and Sharkaway, 1992; Zinreich, 1992; Kearney *et al*, 1997).**The occipito-mental technique, first described in **1915** by **Waters and Waldron,** obviously demonstrates the lateral margins with the superior and inferior ones of the maxillary sinuses while reflecting the petrous temporal bones shadow downwards below the sinuses inferior margin.

The occipito-mental view characterized also any soft fluid contents or soft tissue of the sinus; however, this one does not show the cortices of the posterior and anterior wall of the maxillary sinus **(Ohba and Katayama, 1976; Farman, 2007).** The Waters' view in general has limitations in the diagnosis of sinusitis of the maxillary sinuses and its role in diagnosing lesions in the other paranasal sinuses is considered very poor **(Konean *et al*, 2000).Fig. 1-12.**

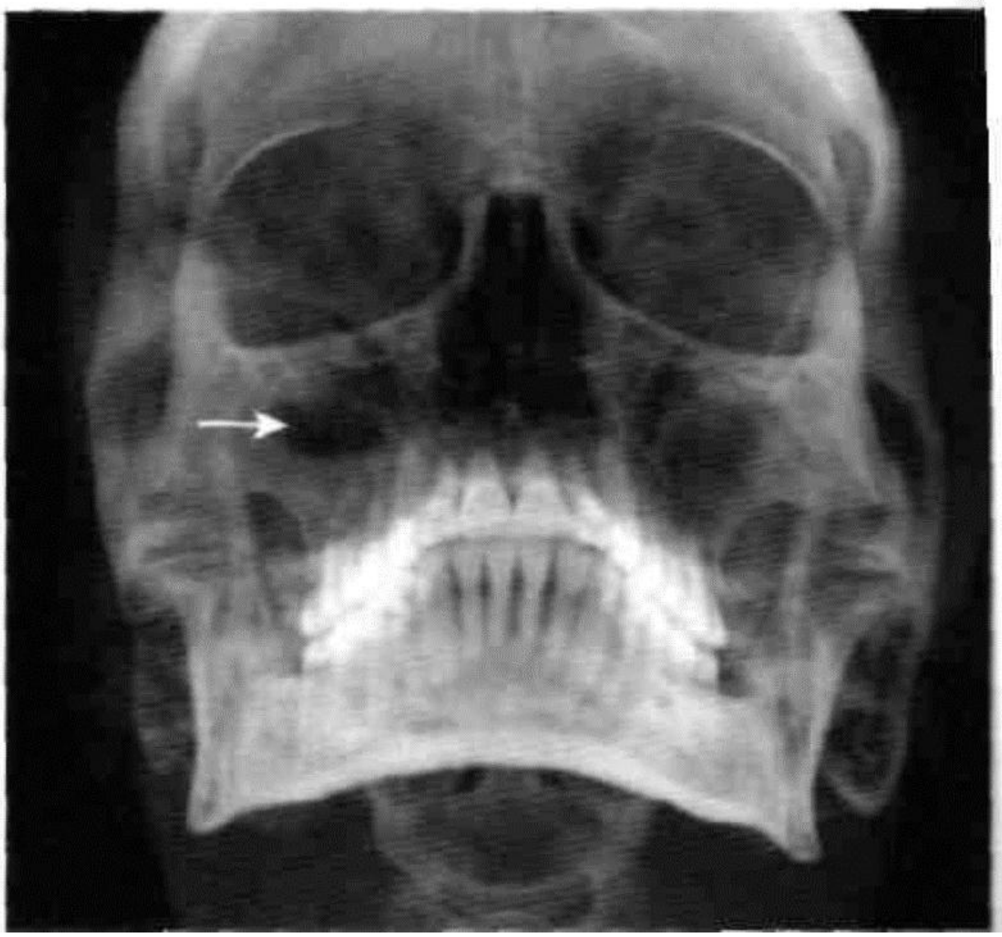

Figure 1-12: *Waters' view radiograph showing right max. sinus with air-fluid level (arrow), more opacity of the left one caused by significant mucosal thickening, fluid, or both* ***(White and Pharoah, 2014).***

1.2.6.2. Dental Panoramic Tomography

Panoramic radiography is one of the extra oral radiograph that provides a wide view of the mandible and maxilla as well as surrounding structures which includes the neck, tempromandibular joint, arches of zygoma, orbits, maxillary sinuses and nasal cavity. although it does so with less sharpness and detail, comparison between the two sides, right and left, is easier with a panoramic projection and this view helps in providing an suprior initial view of the osseous structures of the TMJ and the sinus floor integrity **(Greenberg and Glick, 2003).**

Dental panoramic radiographs are usually used as preoperatively giving image that helps in evaluation and planning for maxillary dental implants. For sure, this modality has been used clinically for patients with maxillary dental implants to evaluate the maxillary sinus. Comparing them to traditional dental radiograph, Dental panoramic radiographs are believed to be more useful technique because of their ability to show thorough visualization of the maxillary sinus and investigate the relationship between the sinus floor level and alveolar bone. Their nature of this modality is being two-dimensional. That is why they have a limitation for the three-dimensional (3D) visualization of anatomical structures. On the other hand, soft tissues of the maxillary sinus may not be effectively showed or demonstrated on panoramic radiographs. As yet there is no accurate and exact understanding of the limitations for the evaluation of anatomical variations and lesions of the maxillary sinus of panoramic radiographs **(Shiki *et al*, 2014). (Fig. 1-13).**

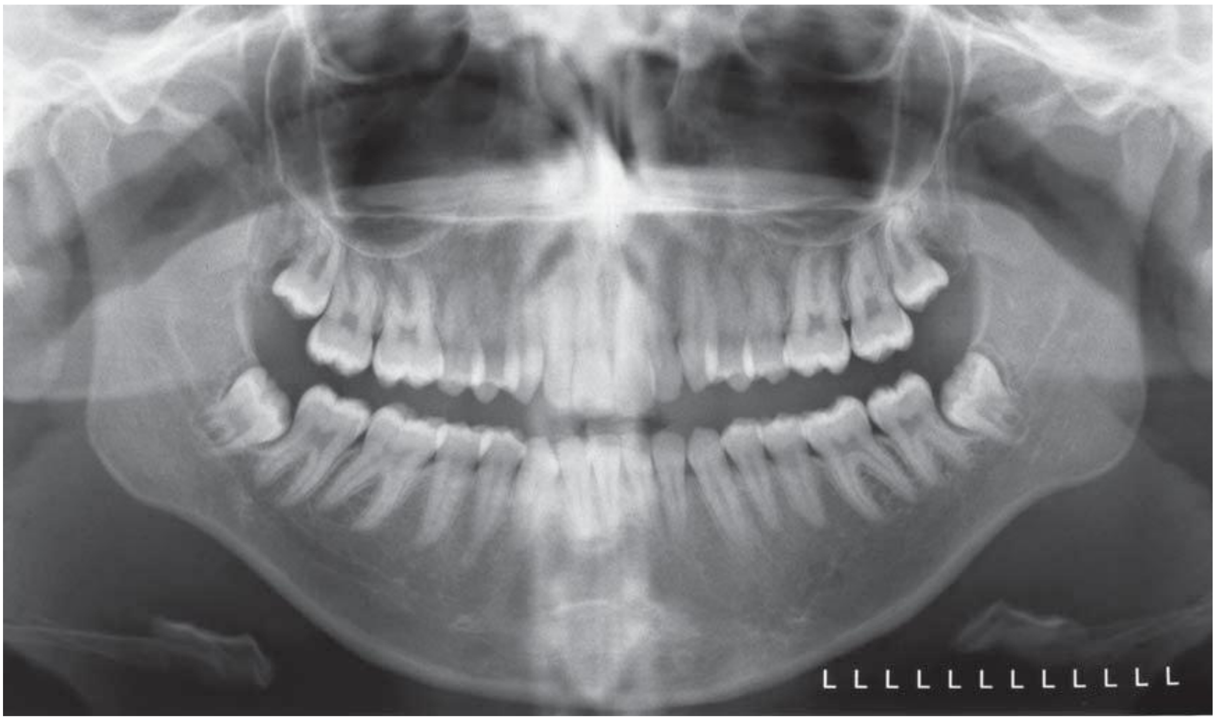

Figure 1-13: *Panoramic image of an adult patient* ***(White and Pharoah, 2009).***

1.2.6.3. Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is much less commonly performed than CT scanning of the sinuses which is mostly because this modality does not provide well imaging for bone, even so, MRI can usually differentiate mucus retention from masses of soft tissue based on characteristic of signal intensity which have an corresponding appearance on computed tomographic scans; therefore, MRI can be very useful and beneficial in differentiating a sinus that is fully filled with tumor from one partly filled with retained secretions. This modality is also helpful with suspected intracranial or orbital extension **(Lalwani, 2007). Fig.1-14**

With standard MRI of the sinuses ,which could be with or without contrast using, axial and coronal planes of imaging MRI provides multiplanar capabilities.

T1- and T2-weighted sequencing performance occurs due to the variability and differences in signal intensity of sinonasal secretions that result from concentration of protein. Fat-suppressed T1-weighted post-contrast sequence is obtained in both coronal and axial plane for the visualization and evaluation of extra sinus spreading of inflammation/infection but for the assessment of masses or malignancies and their extent in sinonasal cavities and this includes exploration of perineural spread, T2-weighted fat suppressed sequences are used for better investigation of disease extent and extra sinus involvement. Imaging with high-resolution for paranasal sinuses provides exquisite spatial in combination with contrast resolution. MRI is useful in differentiation between sinonasal masses and inflammatory diseases and also in case of tumors MRI illustrates the tumor boundaries and extent **(Mossa-Basha *et al*, 2013).**

MRI presentation of cortical bone is poor despite the fact that its soft-tissue resolution is good. Since it is unable to show the fine anatomy of the sinus bones, and therefore cannot show the convoluted physiologic and anatomic relationships between the sinuses and their drainage portals, besides, its cost is higher, acquisition time is longer and poor description for bony anatomy **(Zinreich *et al*, 1987; Batra, 2004).**

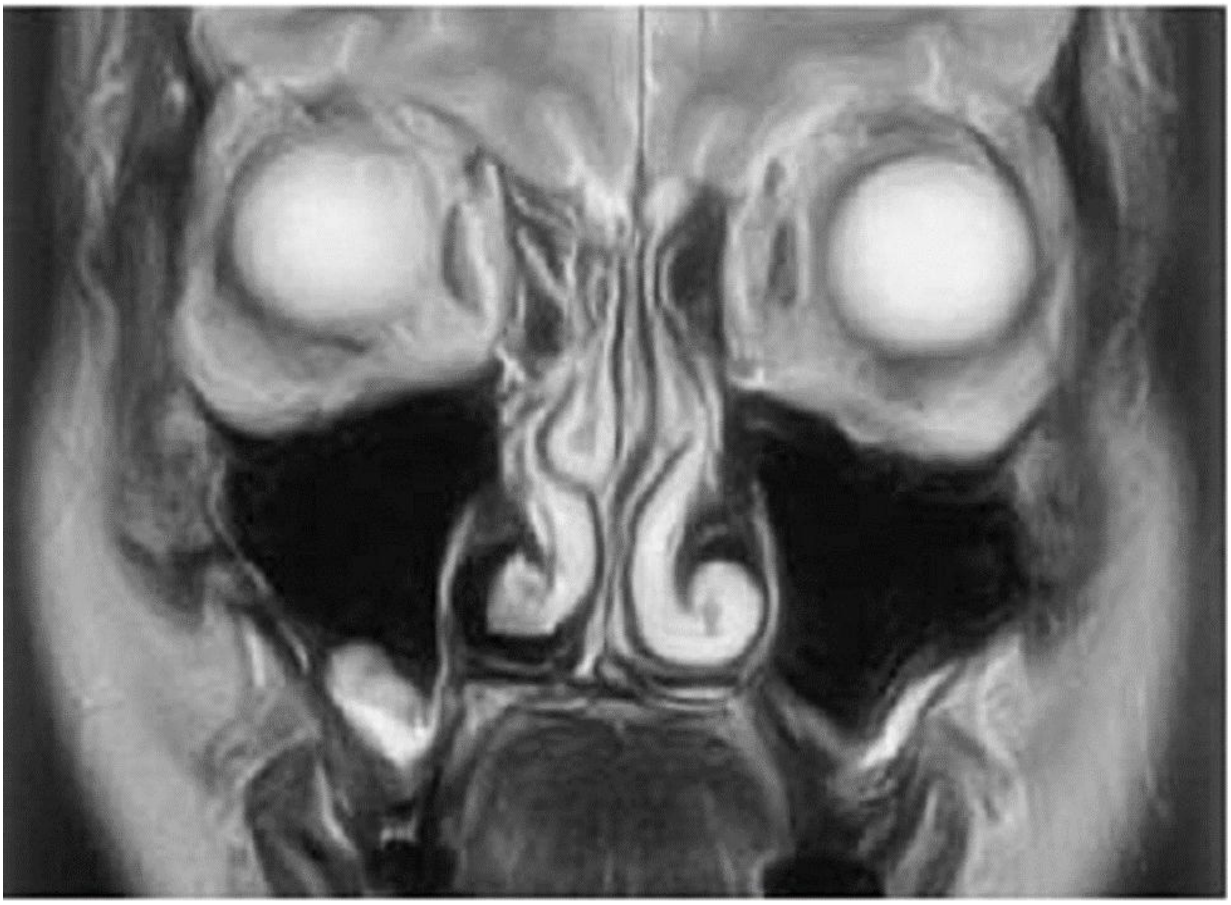

Figure 1-14: *MRI through paranasal sinuses.* ***(Anne, 2008).***

1.2.6.4. Computed tomography

1.2.6.4.1. History of computed tomography

Since 1972, when x-ray pictures converted into digital signals by the first computerized scanner, major changes have occurred in imaging. First, CT used the technology of computer to present images with surprising enhanced detail. Not as those conventional techniques used for diagnosis which provide images with less than 30 differences of gray, CT techniques produce images with shades that may exceed 200 shades of gray. The higher CT scale of grayness display the superfine differences in tissue densities. Second, special software programs designed for dental processing are capable of additional enhancing for the images of CT to show three-dimensional views and one–to-one stratification were produced in1987. **(McGivney *et al*, 1989; Kraut, 1991 and Maher, 1991).**

Such programs can help in providing cross-sectional and panoramic images of either the maxilla or mandible in addition to the three dimensional images **(Michael et al, 1997).**

X-ray computed tomography (CT) is a medical technique of imaging that can produce images of trans-axial planes through the body. The conventional radiograph can produce an image of many planes superimposed on each other and when compare them with CT, a CT image shows considerably developed contrast although that it is at the expense of decreased spatial resolution. A CT image is mathematically reproduced from a large number of one-dimensional projections of the specific plane. These projections are obtained electronically using a linear array of solid-state detectors with the patient is still and the source of x-ray rotates around him **(Michael, 2001).**

Conventional tomography is known as axial tomography which is because that the imaging plane is parallel to the long axis of the body and results in coronal and sagittal images. A computed tomography image is a transverse or trans axial image. The image is perpendicular to the long axis of the body **(Stewart and Bushong, 2004). Fig.1-15.**

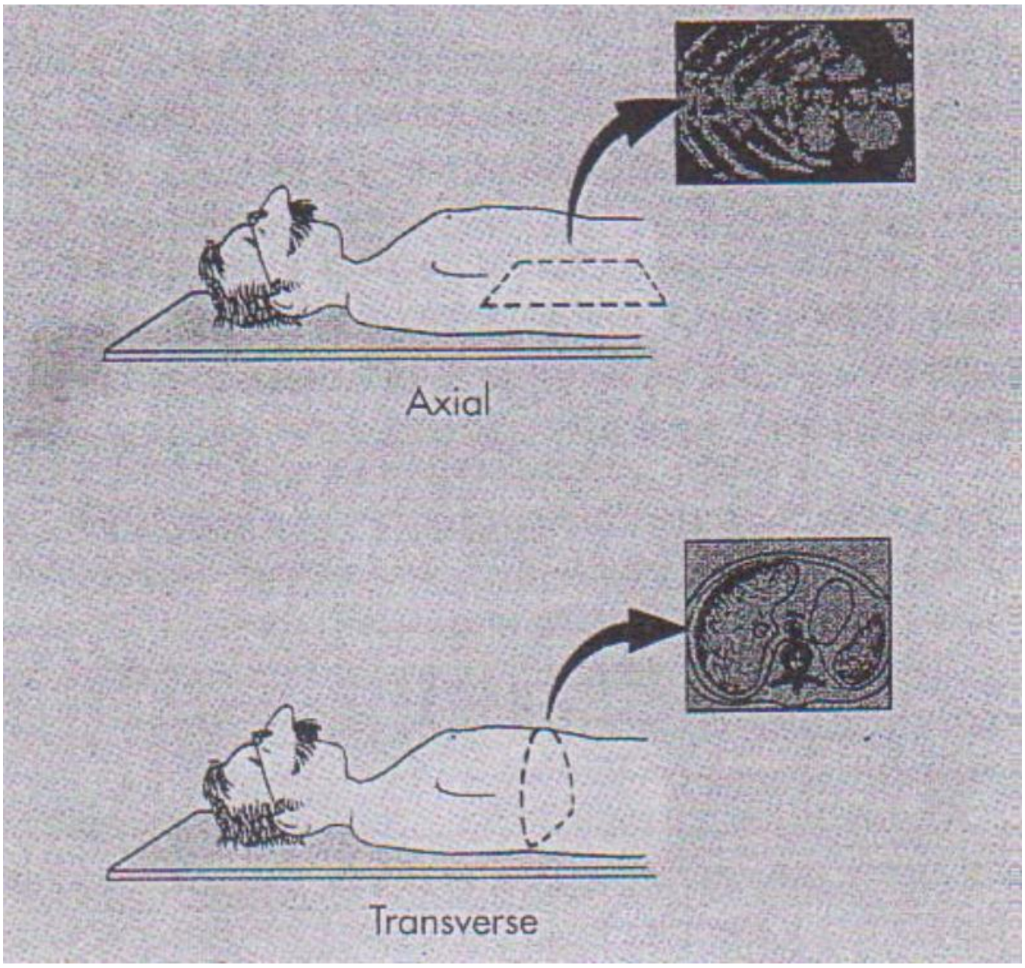

Figure 1-15: *Conventional tomography results in an image that is parallel to the long Axis of the body. CT produces a transverse image* ***(Stewart and Bushong, 2004).***

1.2.6.4.2 Types of computed tomography:

I. High-resolution computed tomography:

High Resolution Computed Tomography HRCT is a medical diagnostic test of the lung that is used for assessment and diagnosis of interstitial diseases of the lung. It is performed with the use of special techniques of computed tomography scanning for estimation of the lung parenchyma. HRCT is obtained by using a conventional Computer axial Tomographic scanner. However, imaging parameters are specifically set so as to increase the spatial resolution. A narrow (usually 1–2 mm) slice width is used with a reconstruction algorithm of high spatial resolution image is used and the field of view (FOV) is decreased, so as to reduce each pixel size. Other factors affect scanning (e.g. focal spot) could be improved for the better resolution at the expense of scan speed. As High-resolution CT's purpose is to estimate a generalized lung disease, the test is performed conventionally. Thin sections are taken 10–40 mm apart. This will result in some images that could be representative of the lungs in general, however that covers approximately only one tenth of the lungs. HRCT is not suitable for the assessment of localized lung diseases or lung cancer because it does not perform imaging for the whole lungs. Similarly, due to high-resolution algorithm and thin sections, HRCT images have seriously high levels of noise. This may leave them non-diagnostic for the mediastinum soft-tissues. Contrast agents intravenously are not used for HRCT because the lung has very high contrast naturally (soft tissue against air), and the technique itself is not suitable for evaluation of the soft tissue and blood vessels, which are the main targets for contrast agents. **(Lee et al, 2006).Fig.1-16.**

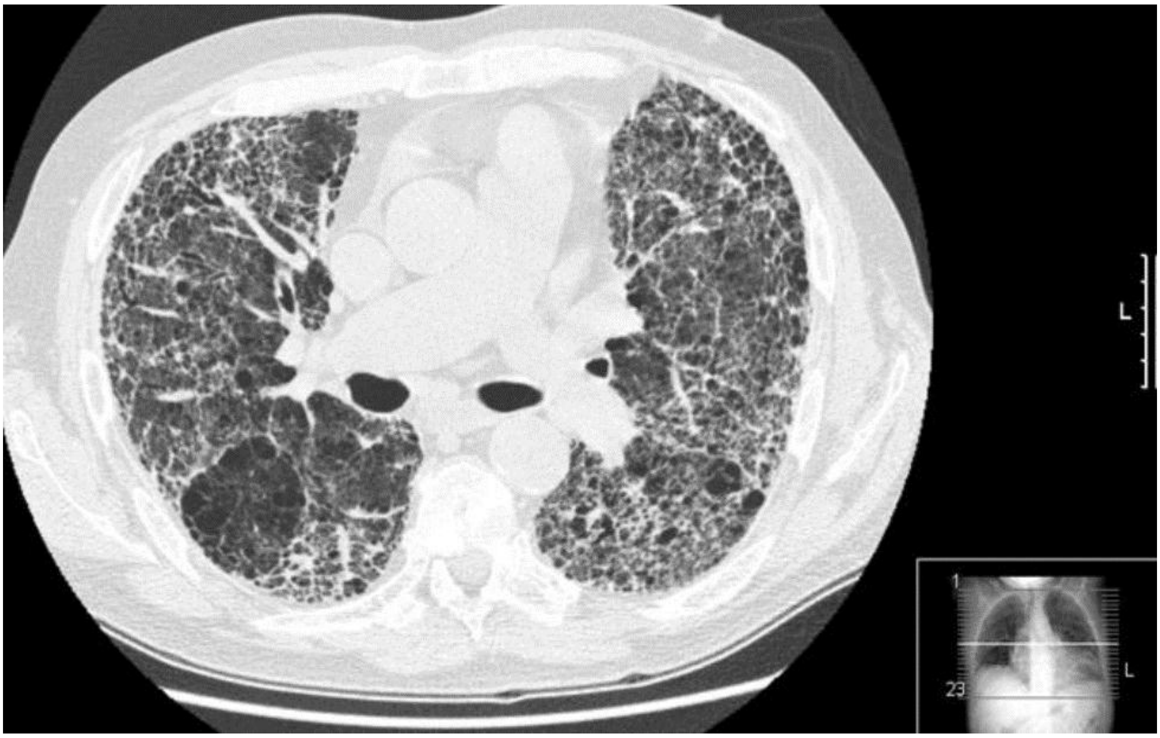

Figure 1-16: *HRCT of lung revealing extensive fibrosis probably from usual interstitial pneumonitis. There are also large emphysematous bullae.* ***(Lee et al, 2006).***

II. Helical or spiral computed tomography:

In 1989, CT scanners were introduced and were capable of acquiring image data in a helical fashion **(Fig.1-17).** The gantry in the helical scanners contain detectors and attached x-ray tube which are going continuously around the patient along with the table. The patient is lying on that table and advances through the gantry without stopping. A continuous helix of data is obtained along with the beam of x-ray moving down the patient. Imaging with this scanner is now the standard and the highest spatial resolution result from overlapping reconstructions. Helical scanners help in getting improved multiplanar image reconstructions which allows images to be created from the original axial plane in either the coronal, sagittal, or oblique plane. Also these scanneres reduced radiation dose and a reduced examination time as compared with conventional CT scanners (also called dynamic incremental scanning) **(White and Pharaoh, 2014).**

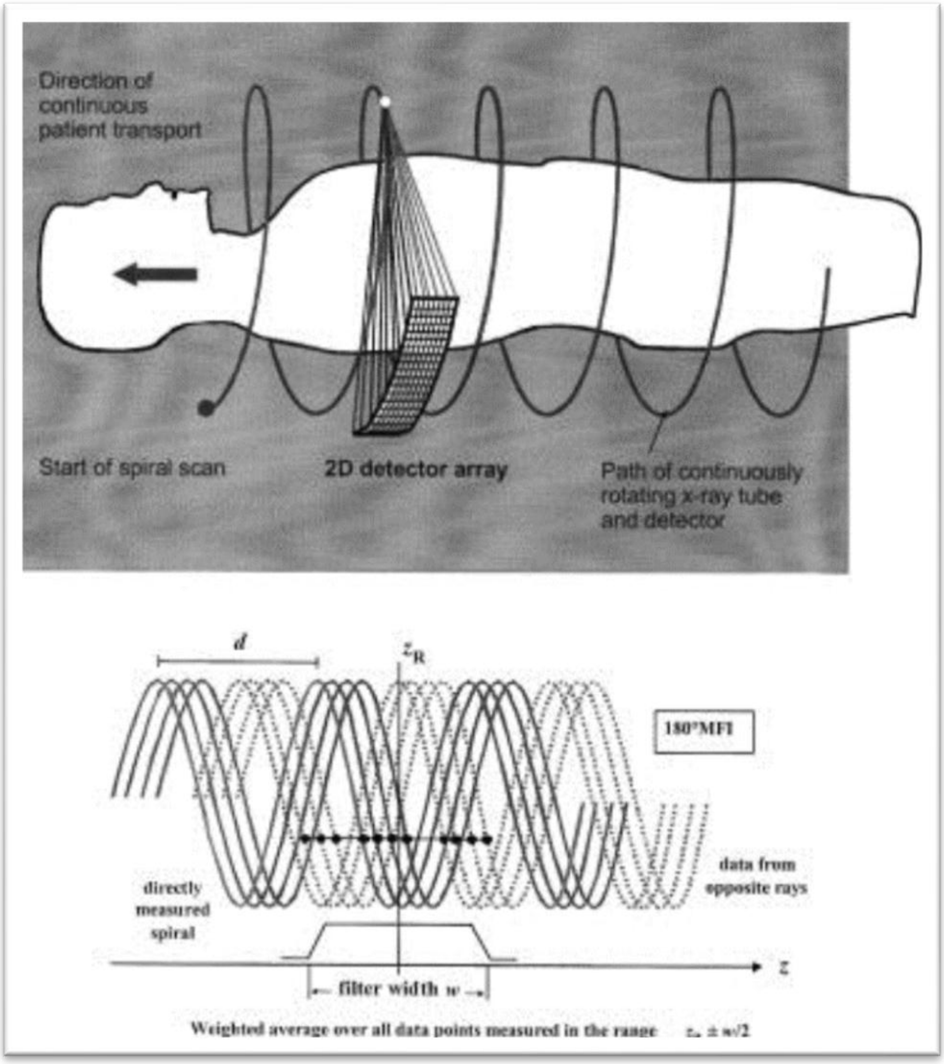

Figure 1-17: *Spiral tomography* ***(Lee et al, 2006).***

III. Multidetector helical computed tomographic (MDCT) scanners:

Multislice CT imaging and multirow CT imaging are alternative terms for the same technology and were used in 1998. Imaging with MDCT has become used widely and has had an important and strong clinical impact. Mostly 64 or 128 arrays of adjacent detectors are used with this method in conjunction with a helical CT scanner. Moreover, the time that is required for the tube of the x-ray to fulfil a complete cycle of rotation around the patient has been decreased to less than 0.26 second (4 rotations/second). All these improvements made the multiple slices images to be captured simultaneously and quickly, therefore considerable reduction in both time of exposure and artifacts of involuntary motion as breathing, peristalsis, or heart contractions which is important for pediatric, trauma patients and patients who can’tt hold breathing for long period of time. Besides, the quality of axial, reformatted, and 3 dimensional images is highly improved with this type of scanning technique when compare them with scanners of single slice technique **(fig. 1-18, 1-19). (White and Pharaoh, 2014).**

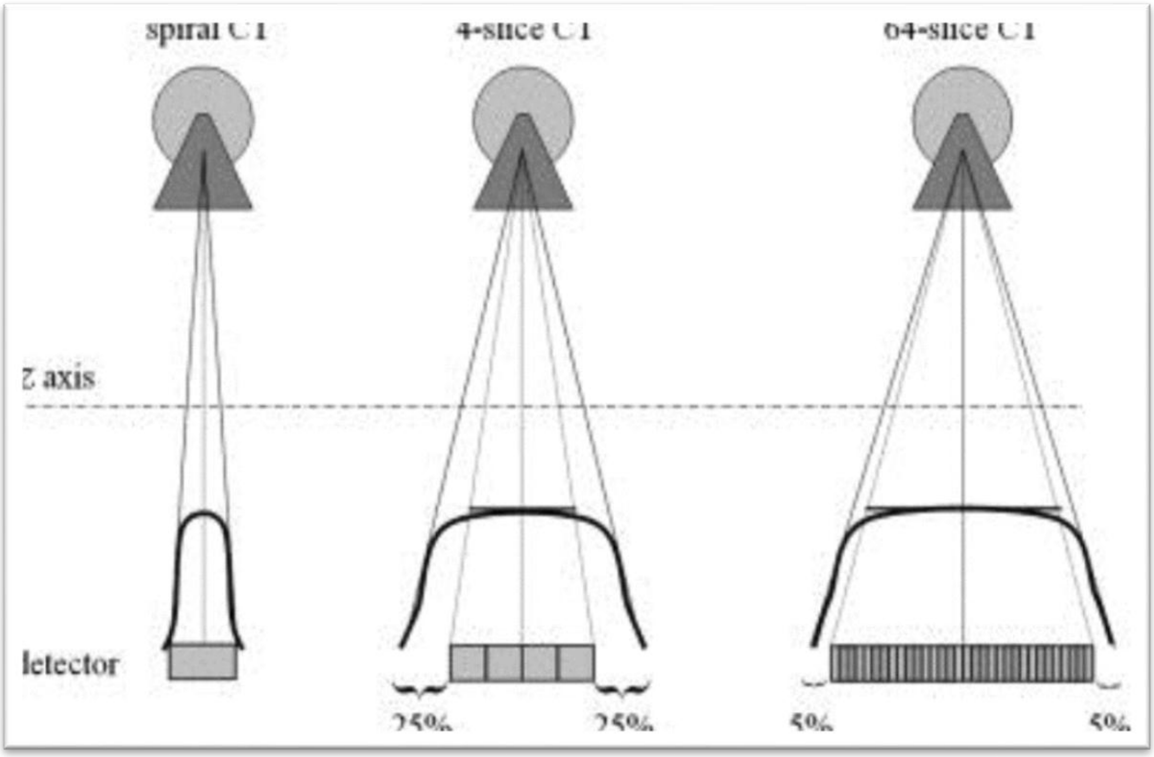

Figure 1-18: *Single slice and multiple slice CT* ***(Stewart, 2004).***

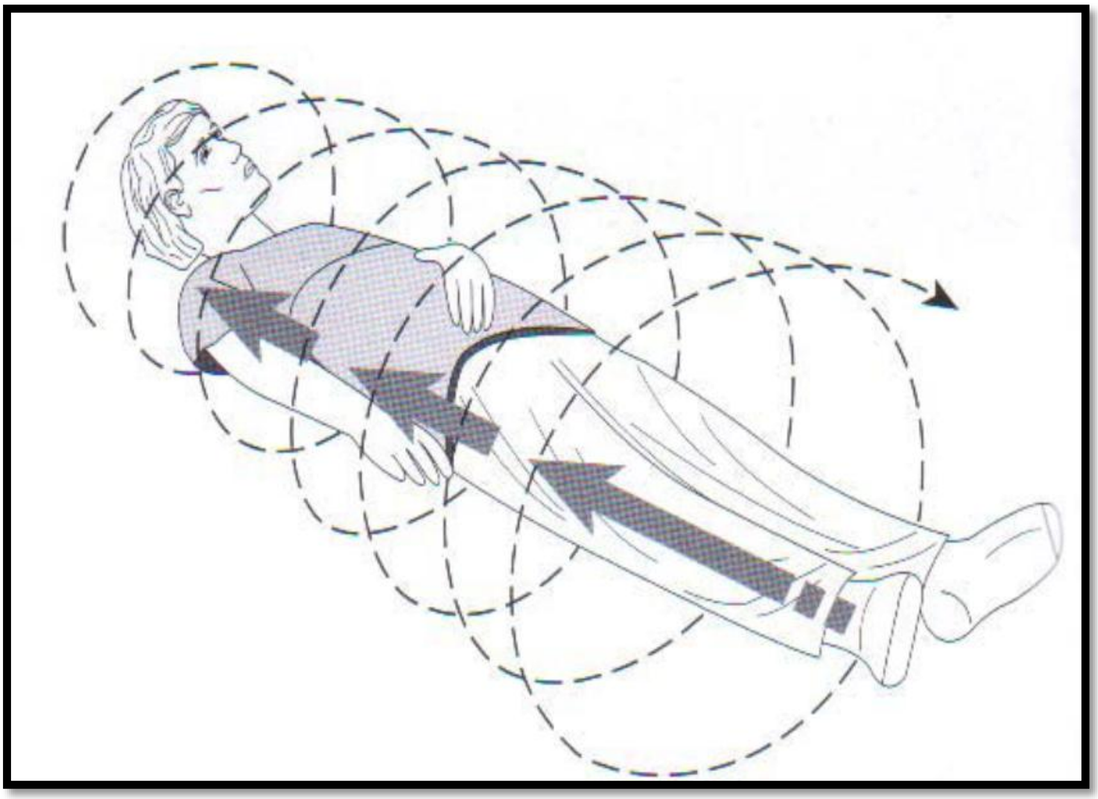

Figure 1-19: *Helical scanners, the patient in continuous moving along the gantry with continuous rotation of the x-ray tube around the patient in a circular movement. The net effect is a description of helical beam and image path through the patient* ***(White & Pharaoh, 2009).***

1.2.6.4.3. Computed tomographic image:

Each pixel in the image is nominated in a CT number that represent density of tissue so as the image will be displayed. The number of CT is proportional to the degree of attenuation of x-ray beam that is caused by the material within the voxel. CT number, that is also called Hounsfield units (HU) ,named so after the inventor sir god Frey Hounsfield, extent from -1000 to +1000, that is each of which correspond a specific level of beam attenuation as shown in **table (1-1) (White and Pharaoh, 2014).**

The scale of Hounsfield is used to measure radio density and can provide an accurate absolute density, in reference to medical-grade CT scans, for the type of tissue depicted. The radio density that is measured in Hounsfield Units is not accurate in CBCT scan. This is because of different grayscale values of different areas appear in the scan depending on their relative position in the scanned organ. The image value of a voxel of an organ depends on the position in the image volume despite of possessing identical densities **(Swennen & Schutyser, 2006).**

Table 1-1: *Typical HU for tissues and air* ***(White and Pharaoh, 2014)***

Tissue	Hounsfield unite
Bone	+400 to +1000
Soft tissue	+40 to +80
Water	0
Fat	−60 to −100
Lung	−400 to −600
Air	−1000

Some newer machines of CT have a range more that +1000 that may reach to 4000 HU. It is helpful to set the mean as well as the range of CT numbers that are displayed on the monitor since that the human eyes are capable of distinguishing nearly 40 shades of grey only. As shown as in **Fig. (1-20).** The images are optimized and improved as in cases of viewing bone the HU unites set for bone window that may have range (window width, or WW) of 700 and mean(window level, or WL) of 500. On the other hand, an image that is optimized for soft tissues viewing usually have range of 400 units as WW and range of 40 as WL. In such images the bone appears to be light while soft tissues appear be grey and air is black. Those images displayed on monitor by convention as if the viewer presents with patient lies on his back and viewer standing at patient’s feet. Consequently, the patient`s right side will be seen on the left and anterior will appear at the top **(White and Pharaoh, 2014). Fig. (1-19).**

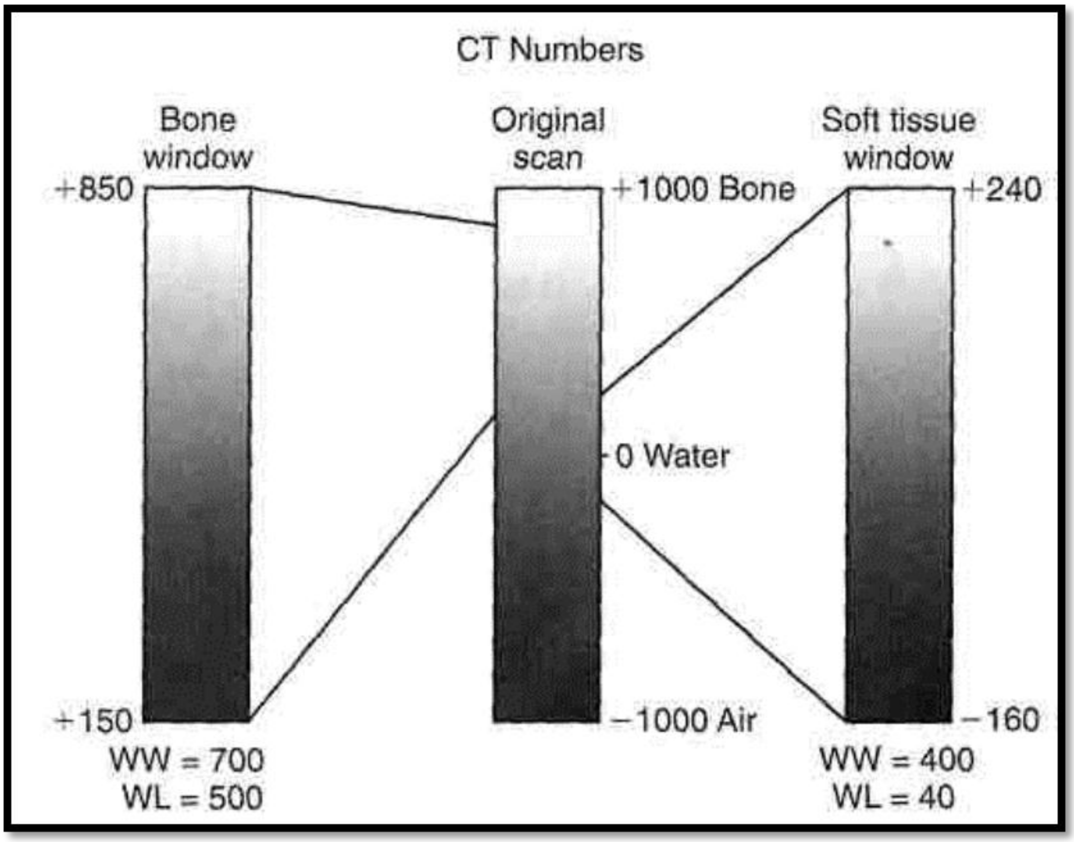

Figure 1-20: *Window Level and Width. CT numbers, also called Hounsfield units (HU), that are scaled for cortical bone (+1000), water (0), and air (-1000)* ***(White and Pharaoh, 2014).***

1.2.6.4.4 CT Scanning of Maxillary Sinus

The paranasal sinuses are complicated anatomical structures with a considerable inter-individual differences. The use of computed tomography (CT) in the work-up of paranasal sinus pathology instead of plain radiography was suggested and approved in the beginning of the 1990’s **(White *et al,* 1990).** Due to the limitation and restriction of information obtained from plain radiograph, advanced imaging techniques have become more and more necessary for the assessment of sinus problems and diseases and has almost considered replacement for plain radiography and conventional imaging for the paranasal sinuses investigations. And since the advanced imaging techniques can provide multiplanar images for the sinuses, MDCT or cone beam CT examinations may give significant contribution in specific definition and localization of disease extension, especially in patients having recurrent or chronic sinusitis. Coronal multi detector CT and cone beam CT imaging is beneficial in presenting preferable visualization and exhibition of the ostiomeatal complex area and nasal cavities and for estimation of any response in the bone surrounding diseased sinus **(White and Pharaoh, 2014). Fig.1-21.**

Imaging plays an important role in the sino nasal disease assessment and evaluation, as a myriad pathologic processes can have a non-specific presentation clinically, CT is commonly the first imaging technique that is ordered and is comparatively accessible, inexpensive and provides developed evaluation of osseous structures. Also, CT is also used preoperatively for surgical mapping **(Mossa-Basha *et al*, 2013)**

It is obvious that Computer Tomography (CT) scan is a very accurate modality for Imaging used to assess the sino-nasal cavities. They make excellent evaluation of the paranasal sinuses, craniofacial bones, in addition to the pneumatization extent. With CT all of these invetigations of the sinuses become possible and much easier **(Attia et al., 2012).**

Pernilla (2011) showed that CT is a very good and robust technique for the estimation of various dimensions of the frontal and maxillary sinuses and the adjacent structures.

Figure 1-21: *Coronal view of the maxillary sinuses display full radiopacification of the sinus (left one) and thickening of circumferential mucosal of the right sinus.* ***(White and Pharaoh, 2014).***

John et al (2006) stated that CT has become a beneficial diagnostic tool in the investigation of the paranasal sinuses and a complimentary part of surgical planning. It is also used for providing intraoperative road maps. Nowadays, computed tomography is radiologically the examination of choice to evaluate the paranasal sinuses in patients complaining of sinusitis.

Maryam *et al* (2010) stated that the volumetric measurements of maxillary sinus by both two-dimensional and three-dimensional reconstructed image methods are dependable and precise.

Several studies have investigated the maxillary sinus dimension measurements by (CT) scans and turned to be useable for determination of age and sex at time that other methods are indecisive. The axial, coronal and sagittal sections that are obtained by MRI and CT enable better assessment of these structures **(Jehan *et al*., 2014).**

Chapter Two

Materials and Methods

Chapter two

Materials and method

2.1. The sample

2.1.1 Sample selection

Out of 140 patients, (45) Iraqi patients with age ranged from (20-40 years) who fulfil the sample selection criteria, were enrolled. They attended Ghazi al Hariri hospital for specialized surgery in Baghdad city and admitted to ENT department then referred to have CT scan from October 2015 to April 2016. According to presence of clinical symptoms for nasal or sinus diseases they were divided into two groups:

i. Asymptomatic.

ii. Symptomatic.

While according to the deviation of nasal septum viewed radiologically, the study sample was divided into 3 groups:

i. Patients with mild nasal septum deviation (15).
ii. Patients with moderate nasal septum deviation (15).
iii. Patients with severe nasal septum deviation (15).

All the patients were well informed about the aim and the method of the study. They were informed that they were free to participate or no and can withdraw from the study at any time they want. They signed on a special consent form after their agreement to participate **(Appendix II).**

2.1.2 Exclusion criteria for sample selection

- Patients with reported systemic disease that may affect the bone and its metabolism like hyperparathyroidism, osteoporosis, tuberculosis, Cushing syndrome or taking certain drugs like parathyroid hormones, bisphosphonate, estrogen and glucocorticoids for long period of time.
- Patients with middle third fractures or maxillofacial deformities.
- Patients who had previous facial surgical procedures or with cleft palate or ectopic canine and supernumerary teeth.
- Maxillary sinuses serious or extensive pathology that may affect the examined area.

2.1.3. Case Sheet:

The selected patients were asked about name, age, general health and medical history and these data were documented in a preset special form case sheet **(appendix I).**

2.2. Materials:

2.2.1. CT scanner machine:

Coronal and axial images were performed for all patients using CT scanner (SOMATOM definition AS, Siemens machine, Erlangen, Germany) with the aid of **syngo** software. **(fig.2-1)** with the following parameters:

- Scan mode = spiral
- Window level = 2000
- Window width = 400

- KV = 120
- mAs = 200
- Slice thickness = 1 mm
- Exposure time = 10.16 sec
- Kernel = H70s sharp FR
- Scan direction = caudocranial
- Image order = anterior to posterior.

Figure 2-1: *Spiral CT scanner (Siemens, SOMATOM AS).*

2.2.2. Laptop (Lenovo).

2.2.3. Auto CAD software (2011).

After manipulation of images (axial and coronal) on the computer monitor of the CT scanner machine to achieve best image quality, they are transferred to Lenovo laptop to calculate the measurements by using AutoCAD software (2011).

2.3. Methods:

2.3.1. Patient positioning:

- The patients lied in supine position on the table of the CT scanner.
- The head of the patient was positions in the head rest as shown in the **fig. (2-2).**

Figure 2-2: *Patient's head positioned in the head rest*

2.3.2 Measuring the nasal septal deviation:

A method of non-clinical quantitative analysis calculated the angle of septal deviation **(Fig. 2-3).**

Two lines were created to form the angle. The first line is drawn connecting the crista galli and premaxilla. The second line is drawn between the crista galli and the most deviated point of the nasal septal bone or cartilage. The angle between these lines represents the amount of deviation present. The detected angles with this analysis were categorized into three types. Mild deviation is defined as ≤8°, moderate as 9°-15° and severe ≥16°. **(Setlur and Goyal, 2011). Fig. (2- 3, 4, 5).**

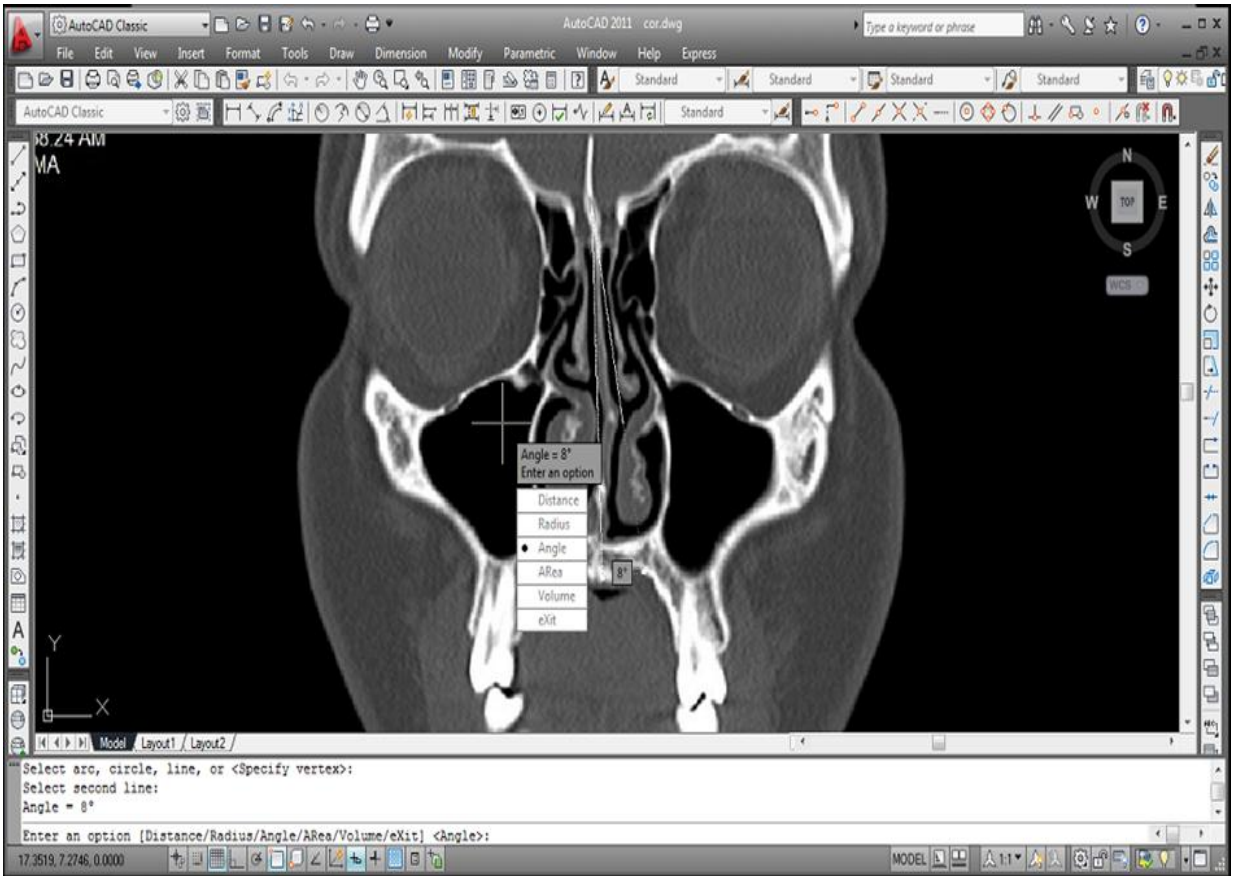

Figure 2-3: *group I of mild nasal septum deviation.*

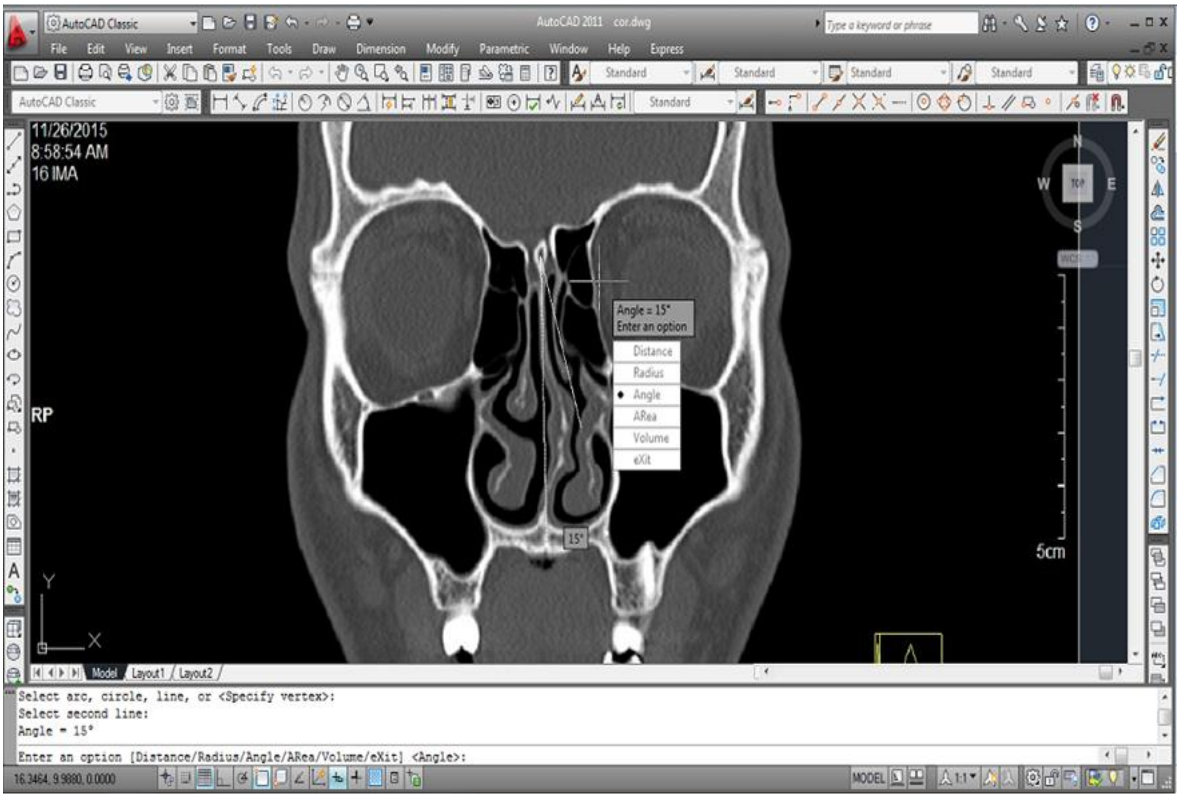

Figure 2-4*: group II with moderate nasal septum deviation.*

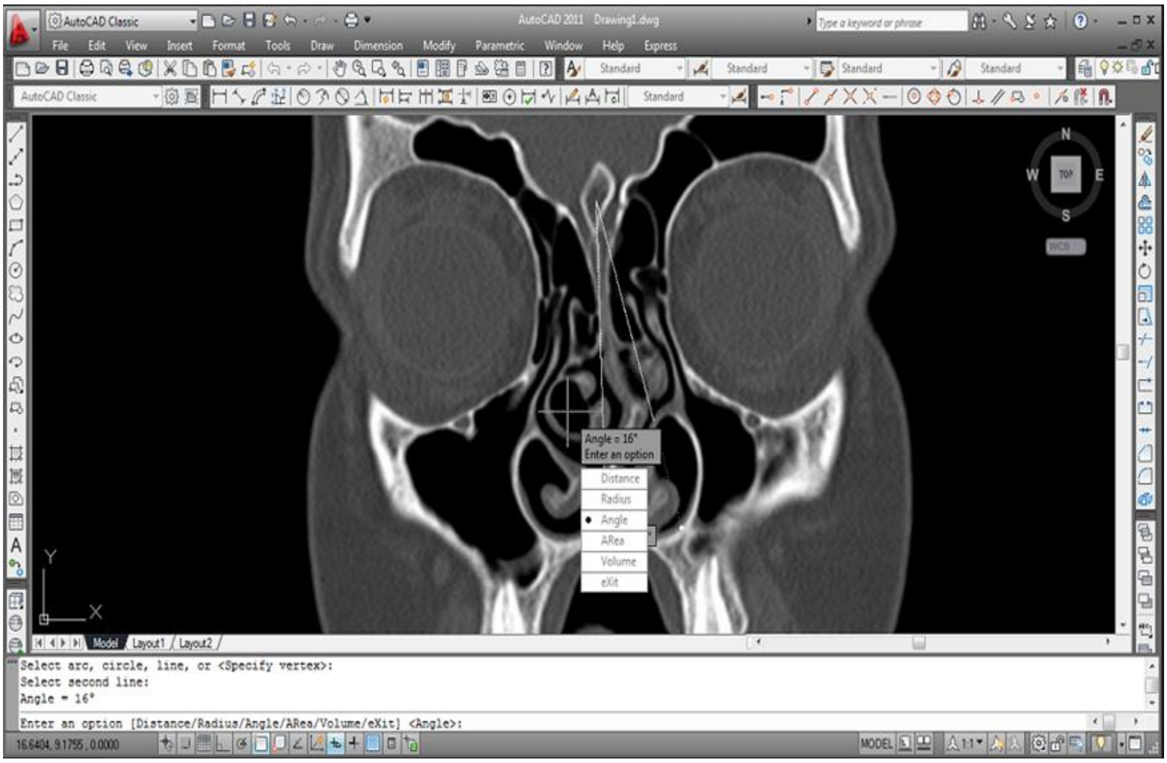

Figure 2-5: *group III with severe nasal septum deviation.*

2.3.3 Measuring the maxillary sinus volume:

- Maxillary sinus volumes according to **Uchida *et al*, 1998** calculated by overlapping CT images (sections) on axial views. The volume of each section was:
  - $dV = dS \times \Delta h$

Where (dS) is the area of the maxillary sinus in a given section and (Δh) is the slice thickness of the section.

- The area of the maxillary sinus in each slice was calculated using AutoCAD application. The image of each slice was inserted in the program, aligned and scaled so as to be measured with (mm^2) unit rather than AutoCAD unit then the maxillary sinus radiolucency is outlined and calculated with a special commands **(fig.2-6).** The area obtained from each image is multiplied by 1 which represent the thickness of the slice. The result would be the volume of each section.

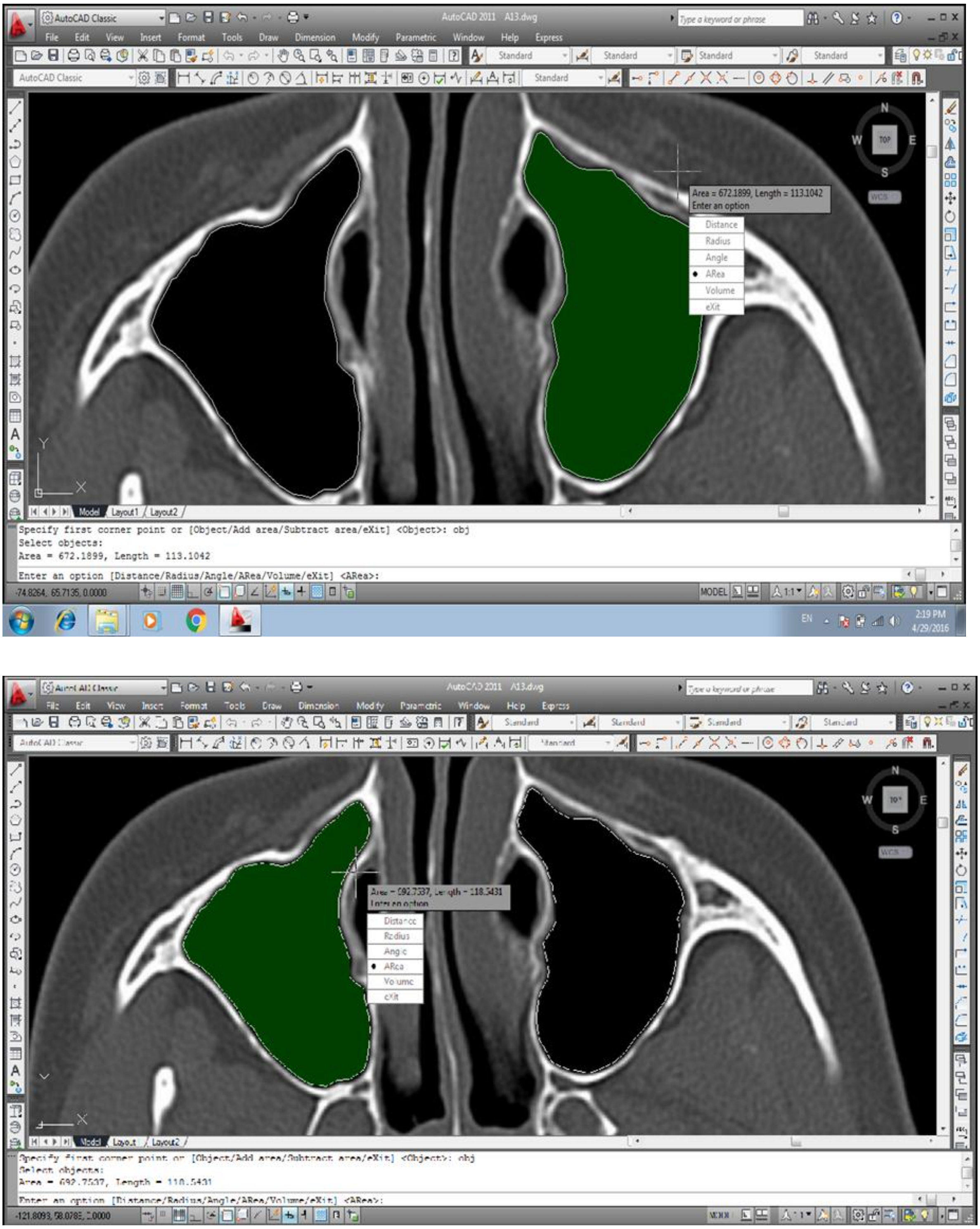

Figure 2-6: *using AutoCAD for calculating the area of both sinuses on each slice.*

- The volume (V) of the region from the antral floor to a height of (n) mm was calculated as the sum of the volumes of each section (dS) **(fig. 2-7)**, so the total volume of maxillary sinus on either sides from the floor of antrum to its top was calculated also according Uchida et al in 1998 as described below:

$$v = \sum_{i=1}^{n} dS \times \Delta h$$

Notes:

1. All area measurements were calculated with AutoCAD software (2011).
2. All the resulted volumes were measured in millilitres (ml) and the angles in degree.

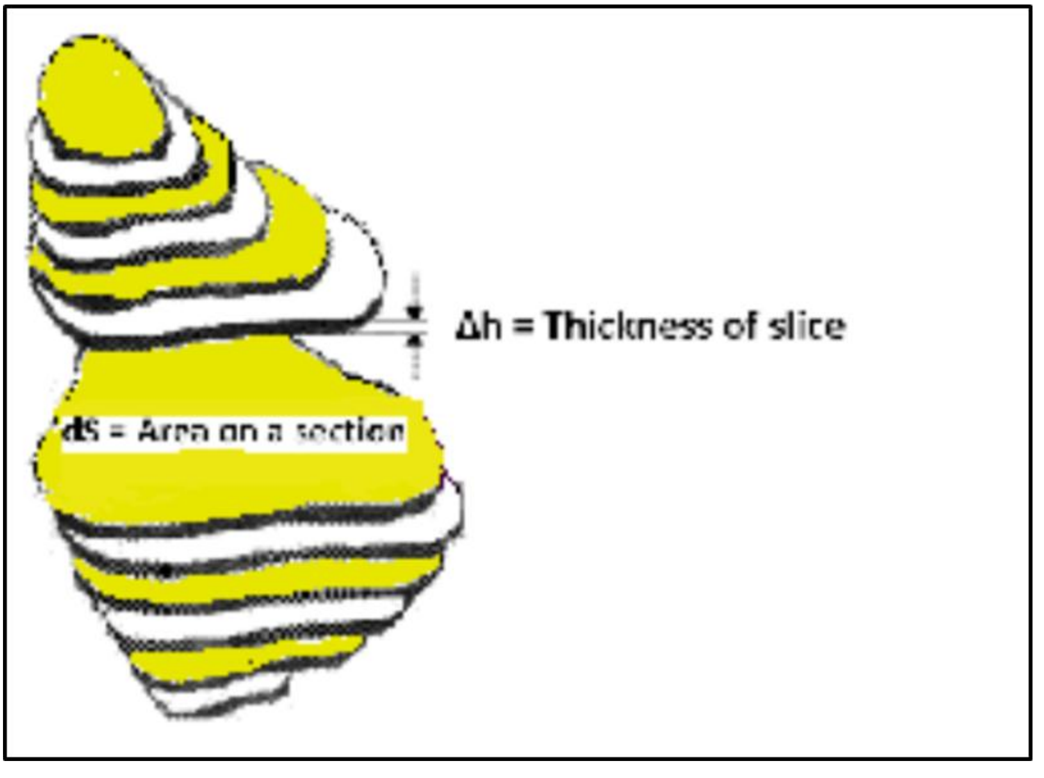

Figure 2-7: *Diagram of maxillary sinus showed the method used in this study for measuring maxillary sinus volume using CT images* ***(Uchida et al, 1998).***

2.4. Calibration procedure

Before starting the application of the study, calibration procedures were done to be sure from the correction of all the measurements and assess the reliability of determined points and calculations. So that 10 CT images were randomly selected and two types of calibration were done.

2.4.1. Intra examiner calibration

All measurements of 10 randomly selected CT images were done and they were repeated after three weeks from the first readings to overcome any memory bias. Comparing the two measurements by applying paired t-test which showed non-significant difference as shown in **table (2-1).**

Table (2-1)*: intra examiner calibration.*

Maxillary sinus volume (mm3)	First measurement	Second measurement	Intra-examiner differences
Range	(7644 to 16925)	(7642 to 16921)	(-4 to 3)
Mean	12187.5	12186.3	-1.2
SD	2923.7	2923.56	2.15
SE	924.6	924.512	0.68
N	10	10	10
CV%			0.02%
P (paired t-test)			0.111[NS]

2.4.2. Inter examiner calibration

This type of calibration include the reliability of the researcher. So the same 10 measurements were performed by anther radiology specialist at the same time. Comparing the two measurements and applying paired t-test showed non-significant difference. Mean, SD and standard errors were also calculated as shown in **table (2-2).**

Table (2-2): *inter examiner calibration*

Maxillary sinus volume (mm3)	First measurement	Second examiner	Inter-examiners differences
Range	(7644 to 16925)	(7640 to 16928)	(-4 to 4)
Mean	12187.5	12188.4	0.9
SD	2923.74	2924.5	2.42
SE	924.568	924.8	0.767
N	10	10	10
CV%			0.02%
P (paired t-test)			0.271[NS]

2.5. Statistical analysis

Data were translated into a computerized database structure. The database was examined for errors using range and logical data cleaning methods, and inconsistencies were remedied. An expert statistical advice was sought for. Statistical analyses were done using IBMSPSS version 21 computer software (Statistical Package for Social Sciences) in association with Microsoft Excel 2016.

Compliance of quantitative random variables with Gaussian curve (normal distribution) was analyzed using the Kolmogorov-Smirnov test. The sinus size measurements were normally distributed quantitative continuous outcome variables. Such variables are described by mean, SD (standard deviation) and SE (standard error). The statistical significance of difference in mean between 2 groups was assessed using the Students t-test, while between more than 2 groups ANOVA test was used.

Associations between 2 categorical variables was explored by cross-tabulation. The statistical significance of such associations was assessed by Chi-square (χ^2) test. An estimate was considered statistically significant if its P value was less than an α level of significance of 0.05.

Paired t-test was used to test the statistical significance of difference between paired measurements (inter-examiners and intra-examiner differences). The coefficient of variation was used to measure the magnitude of intra-observer or inter-observers error in measurements as a percentage of mean baseline measurement ([SD of differences / mean of baseline] x 100).

The statistical significance, direction and strength of linear correlation between two quantitative normally distributed variables was measured by Pearson's linear correlation coefficient.

A multiple linear regression model was used to study the net and independent effect of a set of explanatory variable on a quantitative outcome (dependent) variable. The model provides the following parameters:

1. P (model): In order to generalize the results obtained, the model should be statistically significant.
2. Unstandardized partial regression coefficient: Measures the amount of change expected in the dependent variable for each unit increase in the independent variable after adjusting for other explanatory variables included in the model.
3. P for regression coefficient: reflects the statistical significance of the calculated partial regression coefficient of each explanatory variable included in the model.

4. R2 (Determination coefficient): measures the overall performance of the model since it reflects the amount of variation in the dependent variable explained by the model. The closer its value to 100% the better the model fit.

Cohen's d is a standardized measure of effect size for difference between 2 means, which can be compared across different variables and studies, since it has no unit of measurement. Cohen's d = (mean1-mean2) / Pooled SD of the 2 groups. Cohen's d < 0.3 small effect, 0.3-0.7 (medium effect), while 0.8 and higher is a large effect.

$$Cohen's\ d = \frac{\bar{x}_1 - \bar{x}_2}{S_P}$$

$$S_p = \sqrt{\frac{(n_1 - 1)S_1^{\ 2} + (n_2 - 1)S_2^{\ 2}}{(n_1 + n_2 - 2)}}$$

- Where S_p is the pooled standard deviation
- N is the sample size
- X is the sample mean

Chapter Three

Results

Chapter three

Results

3.1. Description of sample

Total number of 45 Iraqi patients were enrolled in this study who ranged (20-40) years old .Based on the degree of deviation of nasal septum in the radiographic image they were categorized into three groups: the first group with mild NSD with (15) patients. The second group of moderate NSD with (15) patients and the third one with another (15) patients having severe NSD. **Fig. (3-1)**

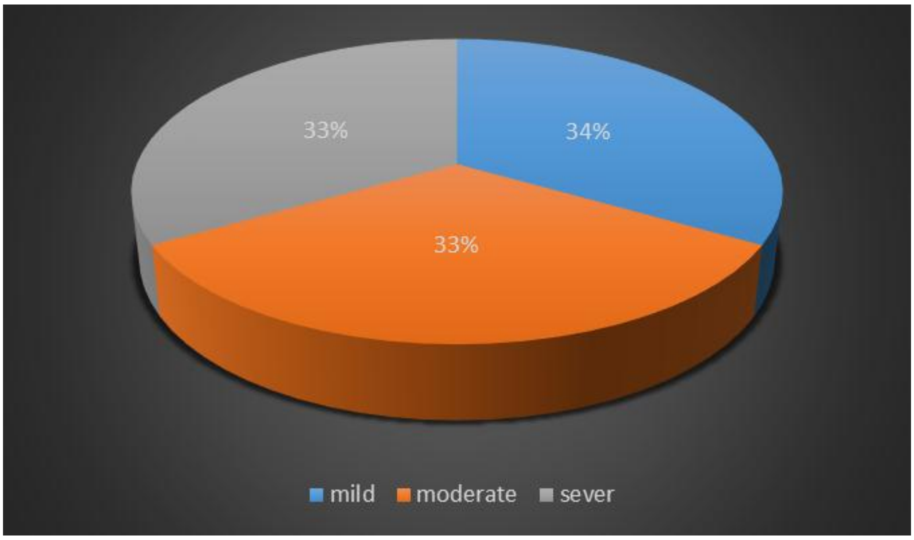

Figure 3-1: *pie chart showing the frequency distribution by severity of nasal septum deviation.*

3.2. Frequency distribution of Nasal Septum Deviation according to study variables.

The prevalence rate of variables within the study sample was shown in **table 3-1.** Females represent (53.3%) while males were the rest of subjects (46.7%). From the total study sample, 23 patients (51.1%) had different kinds of symptoms and 22 patients were without any symptoms representing (48.9%).

Table 3-1: *frequent distribution of study sample by selected variables.*

	N	%
Gender (Male Vs Female)		
Female	24	53.3
Male	21	46.7
Total	45	100.0
Direction of nasal septum deviation (Left Vs Right)		
Right	19	42.2
Left	26	57.8
Total	45	100.0
Deviation of nasal symptoms (symptomatic Vs asymptomatic)		
Asymptomatic	22	48.9
Symptomatic	23	51.1
total	45	100.0
Classification of nasal septum deviation angle		
mild (angle<=8)	15	33.3
moderate (angle 9 to 15)	15	33.3
sever (angle>=16)	15	33.3
Total	45	100.0

3.3. Maxillary sinus measurements with the severity of NSD angle

The maxillary sinus volumes had been calculated for both sides and the results showed that the mean volume of ipsi-lateral maxillary sinus was highest among subjects with mild degree of nasal septum deviation (13.709) ml and lowest among those with sever deviation (11.52) ml. The differences observed among the three groups however failed to reach the level of statistical significance. There was a weak and statistically insignificant positive linear correlation between ipsi-lateral sinus volume and severity of nasal septum deviation. **Fig. (3-2)**

There were no important or statistically significant differences in the mean of contra lateral maxillary sinus volumes between the three categories of nasal septum deviation angle in addition there was no linear correlation between volume and nasal septum deviation severity as shown in **table (3-2). Fig. (3-3)**

The mean difference between contra lateral and ipsi lateral maxillary sinus volume was lowest among those with mild nasal septum deviation (0.586) ml and significantly increases with increasing severity of nasal septum deviation to reach its maximum value of (3.008) ml among those with severe grade of nasal septum deviation ($p<0.001$). The linear correlation between contra and ipsi lateral volume difference and nasal septum angle was moderately strong and statistically significant. As shown in **table (3-3)** the differences between contra lateral and ipsi lateral maxillary sinus volume ranged between reductions of (1.742) ml to an increase to a higher value for contra lateral sinus volume by a mean of (1.763) ml. **fig. (3-4)**

The magnitude of discrepancy between contra lateral and ipsi lateral sinus volume attributed to nasal septum deviation was evaluated as a moderately strong effect (Cohen's d=0.48) and the effect of nasal septum deviation on paired difference between maxillary sinus of the two sides increases from very small effect of (Cohen's d=0.13) among those with mild nasal septum deviation angle to a markedly strong effect of (Cohen's d=1.08) for those having sever deviation. And this showed a strong negative linear correlation coefficient between ipsi and contra lateral sinus volume (r=0.861) and this means that if one variable gets bigger, the other variable tends to be smaller. **Fig. (3-5)**

***Table 3-2**: the difference in maxillary sinus volumes and severity of nasal septum deviation.*

	Classification of nasal septum deviation angle			P(ANOVA trend)
	mild (angle<=8)	**moderate (angle 9 to 15)**	**severe (angle>=16)**	
Ipsi-lateral max. sinus vol. (ml)				0.1[NS]
Range	(7.507 to 24.611)	(5.701 to 16.401)	(5.004 to 15.104)	
Mean	13.709	11.525	11.52	
SD	4.605	2.867	2.786	
SE	1.189	0.74	0.719	
N	15	15	15	
r=-0.247 P=0.1[NS]				
Contra-lateral max. sinus vol. (ml)				0.87[NS]
Range	(7.249 to 23.161)	(6.575 to 21.414)	(8.989 to 18.972)	
Mean	14.295	13.22	14.528	
SD	4.233	4.124	2.777	
SE	1.093	1.065	0.717	
N	15	15	15	
r=0.023 P=0.88[NS]				
Difference between Contra-lateral and Ipsi-lateral max. sinus vol. (ml)				<0.001
Range	(-1.742 to 2.489)	(-1.05 to 8.396)	(1.93 to 4.174)	
Mean	0.586	1.695	3.008	
SD	1.375	2.466	0.797	
SE	0.355	0.637	0.206	
N	15	15	15	
r=0.505 P<0.001				

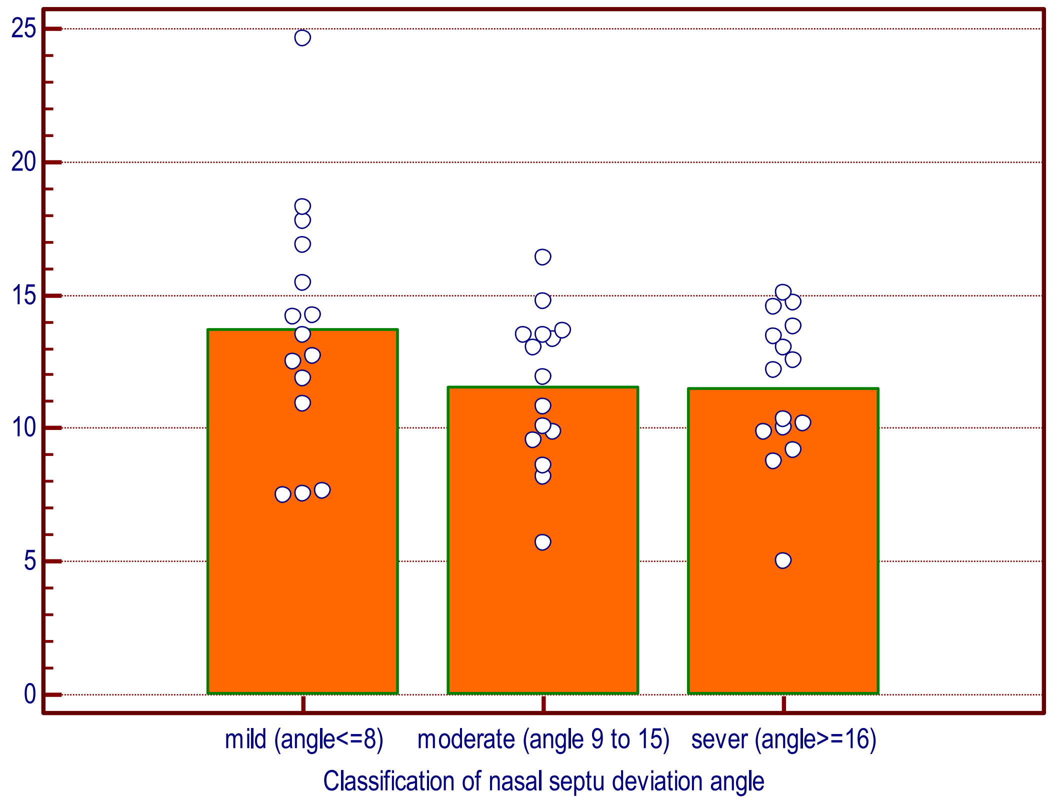

Figure 3-2: *Dot diagram with error bars showing the mean (with its 95% confidence interval) ipsi-lateral maxillary sinus volume by severity category of nasal septum deviation.*

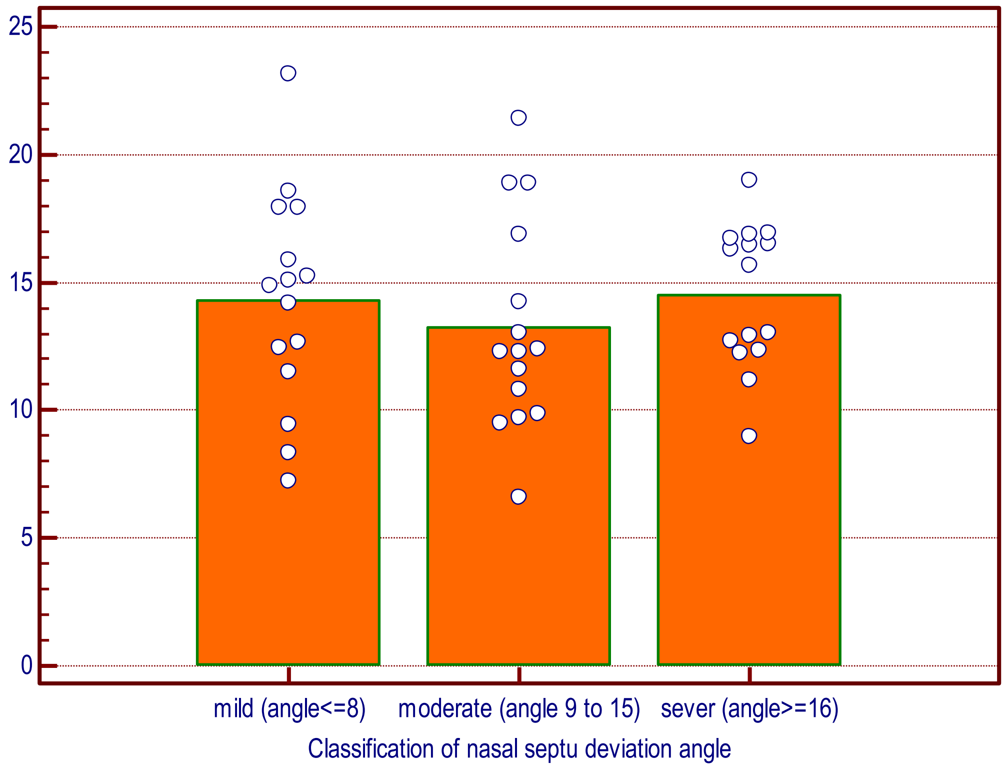

Figure 3-3: *Dot diagram with error bars showing the mean (with its 95% confidence interval) contra-lateral maxillary sinus volume by severity category of nasal septum deviation.*

***Table 3-3**: the mean paired differences between contra and ipsi lateral maxillary sinus volume stratified by NSD angle severity class.*

Classification of NSD angle	Ipsi-lateral max. sinus vol. (ml)	Contra-lateral max. sinus vol. (ml)	Difference between Contra and Ipsi-lateral max. sinus vol. (ml)	P
mild (angle<=8)				0.12[NS]
Range	(7.507 to 24.611)	(7.249 to 23.161)	(-1.742 to 2.489)	
Mean	13.709	14.295	0.586	
SD	4.605	4.233	1.375	
SE	1.189	1.093	0.355	
N	15	15	15	
Cohen's d			0.13	
moderate (angle 9 to 15)				0.019
Range	(5.701 to 16.401)	(6.575 to 21.414)	(-1.05 to 8.396)	
Mean	11.525	13.22	1.695	
SD	2.867	4.124	2.466	
SE	0.74	1.065	0.637	
N	15	15	15	
Cohen's d			0.48	
sever (angle>=16)				<0.001
Range	(5.004 to 15.104)	(8.989 to 18.972)	(1.93 to 4.174)	
Mean	11.52	14.528	3.008	
SD	2.786	2.777	0.797	
SE	0.719	0.717	0.206	
N	15	15	15	
Cohen's d			1.08	
Total				<0.001
Range	(5.004 to 24.611)	(6.575 to 23.161)	(-1.742 to 8.396)	
Mean	12.251	14.014	1.763	
SD	3.595	3.728	1.934	
SE	0.536	0.556	0.288	
N	45	45	45	
Cohen's d			0.48	

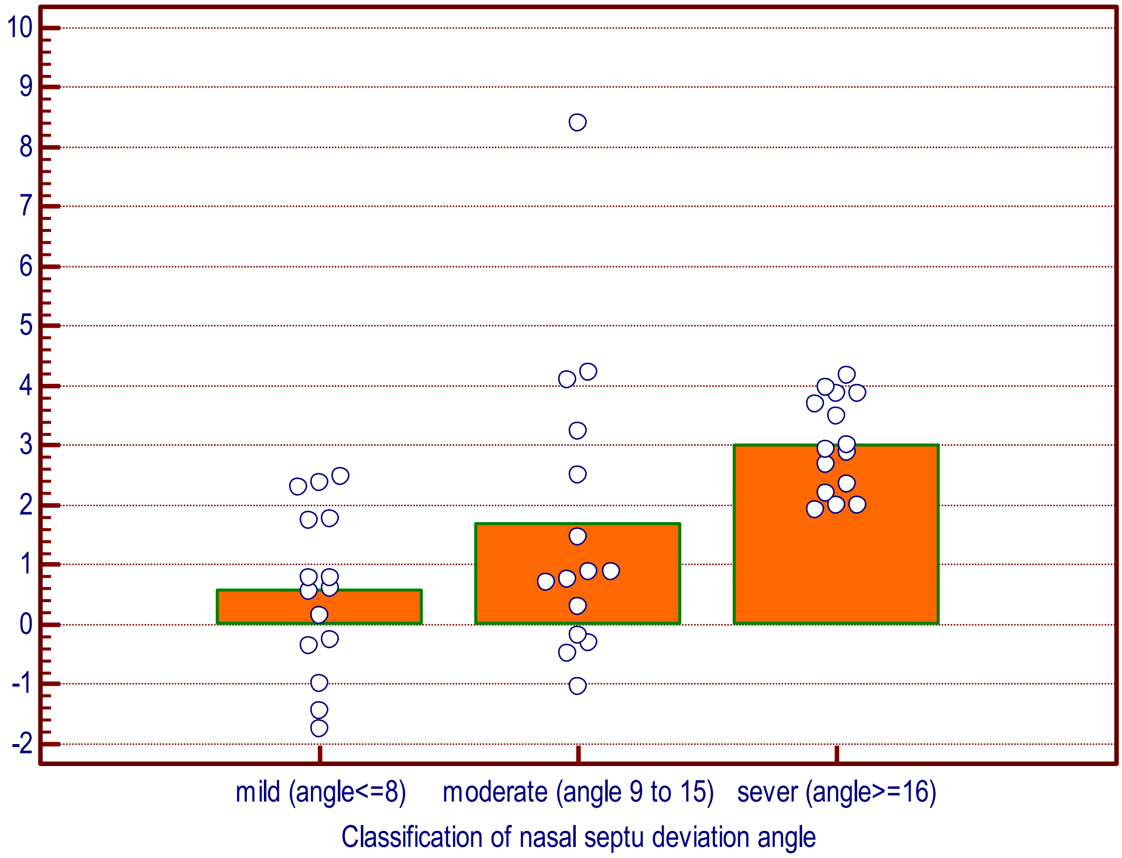

Figure 3-4: *Dot diagram with error bars showing the mean (with its 95% confidence interval) differences between ipsi and contra-lateral maxillary sinus volume by severity category of nasal septum deviation.*

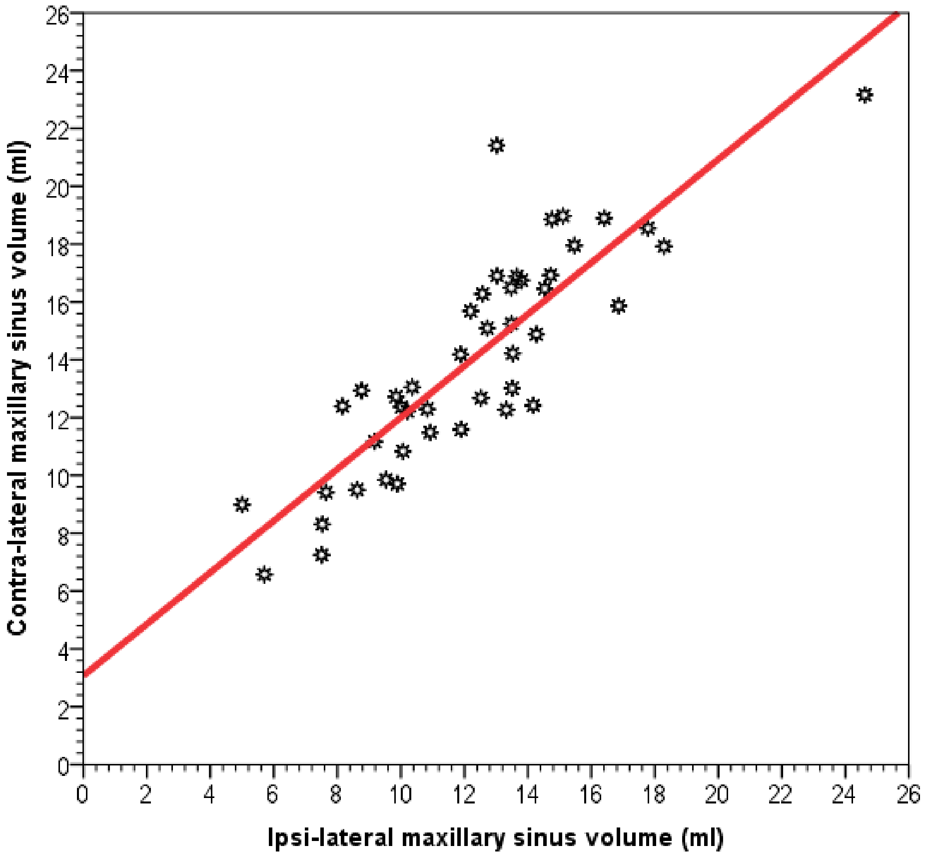

Figure 3-5: *Scatter diagram with fitted regression line showing the linear correlation between ipsi and contra-lateral maxillary sinus volume (r=0.86 P<0.001).*

3.4. Correlation of Maxillary Sinus measurements with NSD angle, age and gender

As shown in **Table (3-4)** the dependent variable (response variable) and severity class of nasal septum deviation together with age and gender as explanatory independent variables showed that the sever nasal septum deviation is expected to significantly increase the difference between contra and ipsi lateral maxillay sinus volume by a mean of (2.422) ml. This was the strongest predictor for possible change in response variable while having the moderate nasal septum deviation is expected to increase the difference by a mean of (1.003) ml compared to those with mild nasal septum deviation. This effect failed to reach the level of statistical significancy.

The observed effects of NSD severity class were pure effects after adjusting for the possible confounder effects of age and gender.

For each one year increase in age, the difference between contra and ipsi lateral maxillary sinus volume is expected to increase by a mean of (0.43) ml after adjusting for other independent variable included in the model. This, however, was not statistically significance. On the other hand, being a male is expected to increase the difference by a mean of (0.246) ml compared to female after adjusting other variable

The model was statistically significant and able to explain 28.5 % of variation in the response variable.

Table 3-4: *Multiple linear model using difference between contra and ipsi lateral maxillary sinus volume with NSD severity class.*

Difference between Contra-lateral and Ipsi-lateral maxillary sinus volume (ml)	Unstandardized partial regression Coefficients	P	Standardized Coefficients
(Constant)	0.315	0.55[NS]	
Moderate nasal septal deviation angle	1.003	0.12[NS]	0.247
Severe nasal septal deviation angle	2.422	<0.001	0.597
Age group (years)	0.430	0.41[NS]	0.112
Gender (Male Vs Female)	0.246	0.64[NS]	0.064

R2=0.285
P (Model) = 0.008

Again, the dependent variable with the magnitude of NSD angle together with age and gender showed that each degree of deviation is expected to increase the difference between contra and ipsi lateral sinuses by a mean of (0.219) ml which is statistically significant. **Table (3-5)**. While for each year of age, the increase of difference expected by (0.294) ml and being a male may increase the difference between the sinuses by (0.034) ml which are both (age and gender) after adjusting other independent variables have failed to reach the level of significance.

The model was statistically significant and able to explain 27.7% of variation in dependent variable.

Table 3-5: *Multiple linear regression model using difference between contra and ipsi lateral maxillary sinus volume with NSD magnitude.*

Difference between Contra-lateral and Ipsi-lateral maxillary sinus volume (ml)	Unstandardized partial regression Coefficients	P	Standardized Coefficients
(Constant)	-1.971	0.16[NS]	
Nasal septal deviation angle	0.219	<0.001	0.519
Gender (Male Vs Female)	0.294	0.57[NS]	0.077
Age (years)	0.034	0.39[NS]	0.117

R2=0.277
P (Model) = 0.004

3.5. Association between explanatory variables and relative frequency of having symptoms

According to having symptoms or not, none of subjects with mild nasal septum deviation severity class had any symptoms while 100% of those with sever deviation had various symptoms like fever, nasal drainage, headache and toothache. The association between nasal septum deviation severity class and having symptoms was statistically significant as shown in **table (3-6) and fig. (3-6).**

When comparing between presence of nasal deviation and having symptoms, the result showed a remarked difference, **table (3-7).** The mean NSD angle was significantly higher among those with symptoms (16) compare to asymptomatic group (8). The effect of NSD angle on the probability of having symptoms was evaluated as a very strong effect (Cohen’s d=3.36). **Fig. (3-7)**

The mean of ipsi lateral maxillary sinus volume of symptomatic group was (11.8) ml which was slightly lower than mean volume of those who were asymptomatic (12.7) ml and this was statistically insignificant (Cohen's d=0.26) while the difference in mean of contralateral maxillary sinus volume between symptomatic and asymptomatic groups was (1.52) which statistically moderately affected (Cohen's d=0.4). But when measuring the mean of difference between the contra and ipsi lateral maxillary sinus volume of asymptomatic patients, it was (0.51) ml which is a way lower than that of symptomatic group who had mean difference of (2.96) ml. statistically, this was strongly significant (Cohen's d=1.63). **Fig. (3-8)**

Table 3-6: *Association between variables and relative frequency of having symptoms.*

	Symptomatic Vs asymptomatic						
	Asymptomatic		Symptomatic		Total		
	N	%	N	%	N	%	P
Classification of nasal septum deviation angle							<0.001
mild (angle<=8)	15	100.0	0	0.0	15	100.0	
moderate (angle 9 to 15)	7	46.7	8	53.3	15	100.0	
sever (angle>=16)	0	0.0	15	100.0	15	100.0	
Age group (years)							0.89[NS]
<30	12	48.0	13	52.0	25	100.0	
30-40	10	50.0	10	50.0	20	100.0	
Gender (Male Vs Female)							0.66[NS]
Female	11	45.8	13	54.2	24	100.0	
Male	11	52.4	10	47.6	21	100.0	

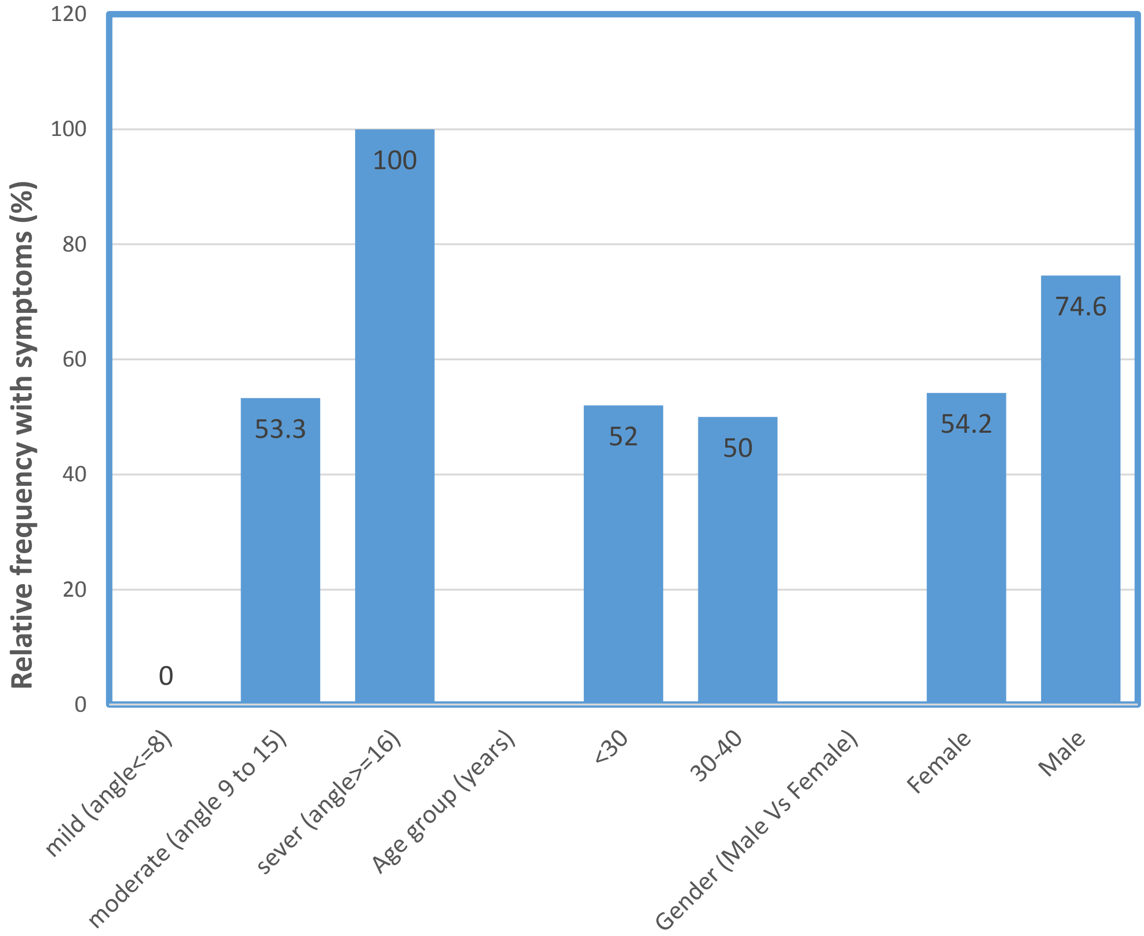

Figure 3-6: *Bar chart showing the rate of having symptoms by selected variables*

Table 3-7: *Difference in mean of selected measurements between symptomatic and asymptomatic groups.*

	Symptomatic Vs asymptomatic			Difference in mean	
	Asymptomatic	Symptomatic	P		Cohen's d
Nasal septal deviation angle			<0.001	8	3.36
Range	(5 to 12)	(10 to 20)			
Mean	8	16			
SD	2	2.7			
SE	0.43	0.57			
N	22	23			
Ipsi-lateral maxillary sinus volume (ml)			0.39[NS]	-0.929	-0.26
Range	(7.507 to 24.611)	(5.004 to 16.401)			
Mean	12.726	11.797			
SD	4.131	3.018			
SE	0.881	0.629			
N	22	23			
Contra-lateral maxillary sinus volume (ml)			0.17[Ns]	1.521	0.41
Range	(7.249 to 23.161)	(6.575 to 21.414)			
Mean	13.237	14.758			
SD	3.873	3.507			
SE	0.826	0.731			
N	22	23			
Difference between Contra-lateral and Ipsi-lateral maxillary sinus volume (ml)			<0.001	2.45	1.63
Range	(-1.742 to 2.489)	(-1.05 to 8.396)			
Mean	0.511	2.961			
SD	1.192	1.748			
SE	0.254	0.364			
N	22	23			

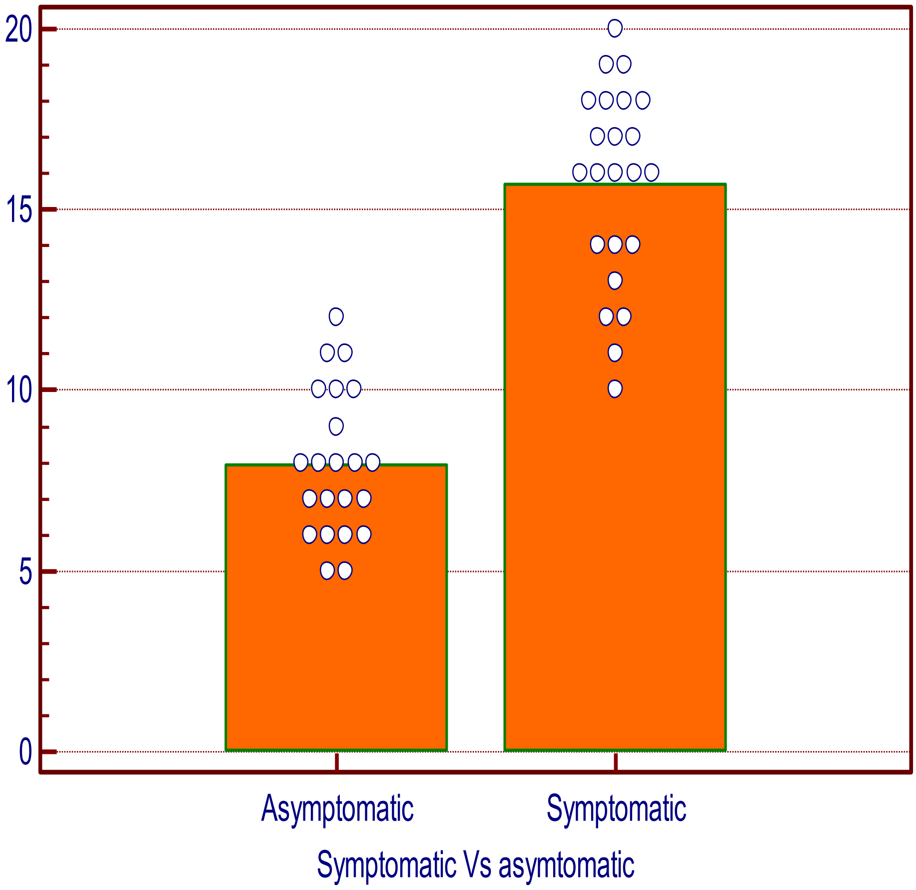

Figure 3-7: *Dot diagram with error bars showing the difference in mean (with its 95% confidence interval) nasal septal deviation angel between symptomatic and asymptomatic patients.*

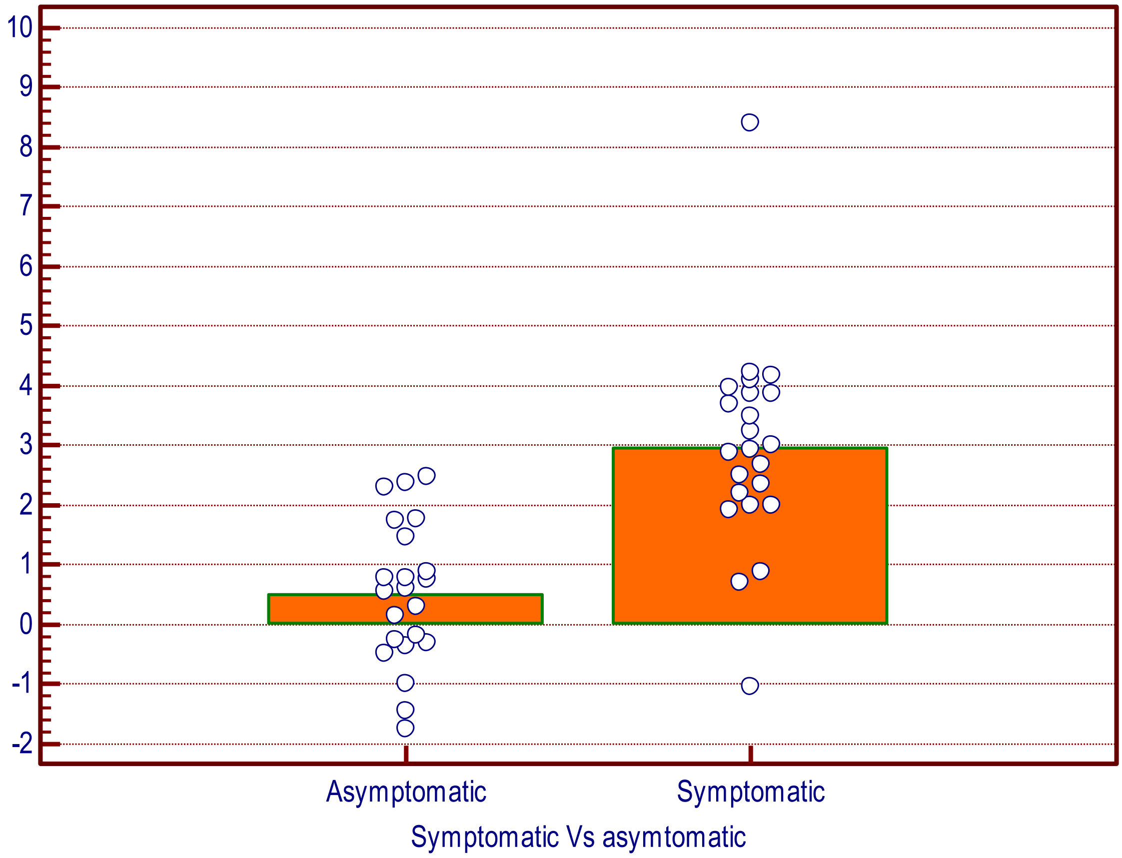

Figure 3-8: *Dot diagram with error bars showing the difference in mean (with its 95% confidence interval) differences between ipsi and contra-lateral maxillary sinus volume between symptomatic and asymptomatic patients.*

3.6. Different measurements of selected variables with age groups and gender

By looking at **table (3-8)** and comparing between means of the two age groups in relation to NSD angle, the means were not that different. Patients who were under 30 years old had a mean NSD angle of (12) while patients between (30-40) years had a mean of (11) and statistically this was non-significant (Cohen's d=0.22). The difference in mean for the two age groups concerning the ipsi lateral maxillary sinus volume and contra lateral sinus volume were (0.82) and (1.24) respectively and both of them were weak statistically and non-significant.(Cohen's d=0.23) for ipsi lateral sinus and (Cohen's d=0.33) for contra lateral sinus volume. That went the same manner with the difference between contra and ipsi lateral sinus volume for the two groups. The mean of difference for the age group under 30 years was (1.57) which was close to (1.99) of patients between (30-40) years and again statistically this is not near to be significant (Cohen’s d=0.22).

In **table (3-9)** measurements of the selected variables in relation to gender have been taken. In our study there was no difference in the mean of nasal septum deviation angle between males and females. Looking at the mean of volume for ipsi lateral maxillary sinus for both male and female groups showed very close measurements and no statistical difference (Cohen’s d=0.03) which went the same way with the mean volume of contra lateral maxillary sinus and also no any statistical significance (Cohen’s d=0.04). That lead to the result that the difference between contra lateral and ipsi lateral maxillary sinus volume (Cohen’s d=0.12) was statistically insignificant.

Table 3-8: *The difference between mean of selected measurements according to age groups*

	Age group (years)		P	Difference in mean	Cohen's d
	<30	30-40			
Nasal septal deviation angle			0.55[NS]	-1	-0.22
Range	(6 to 20)	(5 to 19)			
Mean	12	11			
SD	4.6	4.6			
SE	0.93	1.02			
N	25	20			
r=-0.074 P=0.63[NS]					
Ipsi-lateral maxillary sinus volume (ml)			0.45[NS]	0.824	0.23
Range	(5.701 to 17.778)	(5.004 to 24.611)			
Mean	11.885	12.709			
SD	3.243	4.03			
SE	0.649	0.901			
N	25	20			
r=0.08 P=0.6[NS]					
Contra-lateral maxillary sinus volume (ml)			0.27[NS]	1.243	0.33
Range	(6.575 to 18.972)	(7.249 to 23.161)			
Mean	13.462	14.705			
SD	3.323	4.163			
SE	0.665	0.931			
N	25	20			
r=0.125 P=0.41[NS]					
Difference between Contra-lateral and Ipsi-lateral maxillary sinus volume (ml)			0.48[NS]	0.419	0.22
Range	(-1.742 to 4.23)	(-1.45 to 8.396)			
Mean	1.577	1.996			
SD	1.628	2.282			
SE	0.326	0.51			
N	25	20			
r=0.093 P=0.55[NS]					

Table 3-9: *The difference between mean of selected measurements with gender.*

	Gender (Male Vs Female)			Difference in mean	
	Female	Male	P		Cohen's d
Nasal septal deviation angle			0.65[NS]	0	0
Range	(6 to 19)	(5 to 20)			
Mean	12	12			
SD	4.6	4.6			
SE	0.95	1			
N	24	21			
Ipsi-lateral maxillary sinus volume (ml)			0.93[NS]	-0.092	-0.03
Range	(5.701 to 18.287)	(5.004 to 24.611)			
Mean	12.294	12.202			
SD	3.3	3.988			
SE	0.674	0.87			
N	24	21			
Contra-lateral maxillary sinus volume (ml)			0.9[NS]	0.143	0.04
Range	(6.575 to 18.972)	(8.989 to 23.161)			
Mean	13.947	14.09			
SD	3.552	4.007			
SE	0.725	0.874			
N	24	21			
Difference between Contra-lateral and Ipsi-lateral maxillary sinus volume (ml)			0.69[NS]	0.234	0.12
Range	(-1.05 to 4.174)	(-1.742 to 8.396)			
Mean	1.654	1.888			
SD	1.589	2.301			
SE	0.324	0.502			
N	24	21			

Chapter Four

Discussion

Chapter four

Discussion

4.1. Sample distribution

The current study was done to investigate the possible relation between deviated nasal septum and maxillary sinus volume both ipsi laterally and contra laterally along with the presence of symptoms. The deviation of septum was classified according to the radiological image and quantitative measurement to define the deviation.

4.2. Maxillary sinus measurements

Volumes of maxillary sinus were calculated for both sides (left-sided and right-sided deviation). The volume of the sinuses at the closed side of nasal septum showed little regression from mild to moderate and to sever deviation, however, this regression didn’t show the significant difference and nearly same result for the contralateral sinus volumes for the three categories which showed no important statistical effect. This is agreed with a similar study done by **Karatas *et al* in 2015** on 83 patients having deviated septum and found that there was no significant difference between the ipsilaterlal maxillary sinus volumes of mild and sever groups. However, that difference in the ipsi lateral volumes was significant between the mild, moderate groups and moderate, sever groups.

Similarly the present result is agreed with study performed by **Stallman *et al* (2004)** who reported no relation between any deviation degree of nasal septum and sinus diseases and with **Mogensen and Tos, 1987** who found in surgical experimental study that the nasal cavities in closed side did not show any histological or anatomical change or any signs of sinusitis in which sinusitis defined as 3mm of mucosal thickening in mucosa of maxillary sinus. Whereas by using a similar technique, **Shin *et al* (2005)** reported that anatomical and histologic alterations were demonstrated on obstructed side.

In the current study the difference between the two sides sinuses was significant and agreed with **Karatas *et al*, (2015)** in their study stating that there was significant difference between ipsi lateral and contralateral maxillary sinus volumes which is agreed also with **Gencer *et al* (2013)** who found that for both sided whether left or right deviation of nasal septum the comparison between the ipsilateral and contra lateral sinus maxillary volume showed statistically significant difference.

In an interesting study, **Diner *et al* (1986)** used unilateral congenital choanal atresia as a model of decreasing air flow in the nasal passages, they showed asymmetrical development of the paranasal sinuses in patients with choanal atresia. Also **Gencer *et al* (2013)** mentioned that the effect of deviation in both mild and moderate was not that remarkable on sinuses volumes while severe deviation effect was clear and showed significant impact on those parameters. The contralateral sinus volume tended to be bigger than that of ipsilateral when compared to them. That agreed with this study in which the mild deviation showed weak or no effect, moderate one revealed slightly more obvious impact reaching to remarkable strong effect of the severe deviation on the sinus volume in which, it was the largest difference between the contra and ipsi lateral sinuses. This could be attributed to the pressure of the septum applied at the ostium and narrowing of the osteomeatal complex that may affect the air flow and mucociliary function of the maxillary sinus mucous membrane (**Kennedy, 2001)**.

4.3. Maxillary sinus measurements in relation with NSD, age and gender

Nasal and paranasal passage and cavities is related to the deviation of nasal septum and this was proved in several studies. The mechanical theory of **Stammberger (1990)** said that secretion accumulates in the sinus as a result of the narrowing of the ostiomeatal complex and causes chronic rhinosinusitis. The classical definition of chronic rhinosinusitis said that inflammation of nasal and paranasal sinus mucosa lasting for at least 12 weeks **(Benninger, 2003).** It was concluded in a review published by **Orlandi (2010)** that NSD and chronic rhinosinusitis are related; and this relation was more obvious particularly with increase the severity of the nasoseptal angle which is greater than 10°. An increased incidence and severity of bilateral chronic sinus disease was present with increasing septal deviations was found in a study performed by **(Elahi *et al*, 2000).** However, they stated that Ostiomeatal complex obstruction in the direction of septal angulation was associated with nasal septal deformity while contralateral OMC obstruction was associated with middle turbinate and lateral nasal wall abnormalities. In **(2008) Hatipoglu *et al*** found that the incidence of sinusitis in severe nasal septal deviation is higher when compared with mild and moderate groups. While **Collet *et al* (2001) and Smith *et al* (2010)** failed to find a relation between the degree of deviated septum and sinusitis. In the present study, it was found that the difference between the two sinuses increase with higher angle of deviation. In a study performed on 463 cases with nasal obstruction done by **(Mohebbi *et al*, 2012)** it was concluded that there was no association between the severity of sinusitis, osteomeatal involvement and the degree of septal deviation. **Ozkurt et al (2014)** found that the frequency of rhino sinusitis increased with increasing the NSD degree but not statistically significant and in this study it was found that the difference between the two sided sinuses increased with mild and moderate deviation, however it was not significant in mild deviation progressing to be statistically significant with more high degrees of the angle reaching to severe deviation.

Smith *et al*. (2010) in their volumetric tomographical study which was done on 883 subjects estimating the role of concha bullosa and nasal septum deviation on maxillary sinusitis stated that the male showed significantly higher evidence of maxillary sinusitis compared to females with no effect of age group**. Nayak *et al* (2002) and Shoib *et al* (2016)** stated that the incidence of nasal septal deviation was more on male than in females. Same findings was found by **Madani *et al* (2013) and Ozkurt *et al* (2014)** who said that the deviated septum was higher in male subjects and was significant.

It was found in a study carried by **Van der Veken *et al* (1990)** that the deviation of nasal septum linearly increased with increasing age and reached up to 70% in the advanced age, in addition, **Gray (1978)** stated that nasal septal deviation was found in 30% level in children and 80% level in adults.

In the present study, it was revealed that deviated septum severity had an effect on the sinuses to be increased with each year of age but not to the extent of significancy. Also, the effect is tend to be more impacted on the sinuses in males compared to females but again it was not statistically significant which could be due to limited sample size and age groups.

4.4. Relation of explanatory variables and frequency of having symptoms

Ostial patency is essential to the function of the maxillary sinus. Normally, all paranasal air sinuses open into the lateral wall of the nasal cavity by various small ostia. A deviated nasal septum can obstruct these ostia and may trap fluid in a sinus causing recurrent or chronic sinusitis, this was revealed by **(Ganjian *et al*, 1999).** An important role of Nasal septal deviation has been found in causing sinusitis. Asymmetric nasal septum can force nasal turbinate laterally and narrowing of the middle meatus may result so ultimately block the drainage of the ipsilateral Maxillary sinus **(Talaiepour *et al*, 2005).**

Biswas *et al* (2013) in their study re-emphasized the concepts that the nasal septum deviation position and osteomeatal complex considered as key factors in causation of various sinonasal pathologies like sinusitis. Deviated nasal septum causes a decrease in the critical area of the osteomeatal unit predisposing to obstruction and related complications which was found to be the maximum anatomical variation in a study performed by **(Dua *et al*, 2005).** In other study carried out by **Harar *et al* (2004)** when performed on 500 subjects to investigate the role of septum deviation on chronic rhino sinusitis, they didn’t find any significant relation between the severity of septum deviation and severity of sinusitis. While **Hatipoglu *et al* (2008)**, who did their study on 130 patients, found that the prevalence of sinusitis was significantly more among those with severe septum deviation than those with mild to moderate deviation and this agreed with the present study. **Thiagarajan and Arjunan (2012)** revealed that mild deviations involving nasal septum are asymptomatic and are incidental finding on the other hand gross and sever deviations of nasal septum may cause deformities involving dorsum of nose, nasal obstruction, and pain due to nerve entrapment and sinusitis due to obstruction at the level of middle meatus. In the same line **Janardhan *et al* (2005)** found that majority of their asymptomatic group were having mild septum deviation and **Yasan *et al* (2000)** mentioned that the mild and moderate NSD was not considered a risk factor for chronic sinus disease. Only gross deviation of the nasal septum itself is a risk factor for the development of sinus disease which is also agreed with the current study.

It was found that all patients with severe deviation were having different kinds of symptoms while those with mild deviation were with asymptomatic and even unaware of having nasal septum deviation. In a study of **Elahi and Frenkiel (2000)** it had been revealed that bilateral sinus disease involvement could be related to the presence of nasal septal deviation and contributed to increase the incidence and severity of bilateral chronic sinus disease which was accompanied with increasing angle of deviation. They explained it by pressure effect of deviation and OMC obstruction at the same side along with contralateral OMC narrowing due to middle turbinate and lateral nasal wall abnormalities. Further, **Karatas *et al* (2015)** showed in their study that the probability to encounter maxillary and frontal sinusitis ipsilaterlal to deviated nasal septum increased in a significant way with both left and right sided patients.

In the current study it was revealed that the mean volume of ipsi lateral maxillary sinuses in symptomatic group (gross deviation) tends to be smaller than those sinuses of asymptomatic ones (mild deviation), however that was not significant while the mean contralateral maxillary sinus volume of symptomatic group was larger than those of asymptomatic in a significant way. This larger volume of contralateral sinus could be due to aerodynamic theory said by **Blaugrund (1989)** according to which the decreasing mucociliary activity occurs following the nasal flow rate increase and mucosal dryness in relation with the nasal septal deviation. Another theory that may explain the increasing volume of the contralateral side of symptomatic group is mentioned in a studies **(Sa´nchez Ferna´ndez et al, 2000)** who said that it could be caused by the osteolytic erosion of sinus bone wall due to chronic inflammation.

4.5. Measurements of different selected variables with age groups and gender

Different studies had been made to investigate the growth of nasal septum and its relation to age and gender and most of them went to the way that nasal septum show little or no growth after puberty age. **Antoszewski *et al* (2005)** claimed that any nasal surgery better to be performed after the age of 18 since the growth of the nose increases until the age of 18 while after this age does not show a significant difference. Another study carried out by **Vetter *et al* (1984)** said that the anterior part of nasal cartilage show high cell density with the highest proliferation rate in childhood and this cell density increasing until puberty then the central part of nasal septum shows decreasing of growth rate after puberty. **Kim *et al* (2008)** stated in their study that the length of total dorsal nasal septum and the cartilaginous dorsal length increased until the age of twenty with no significant difference in these lengths beyond the age of twenty. Also the growth rate of nasal bone increased up to the twenties while in older adults there was no significant differences, except a little decrease in the sixties. The present study showed that angle of nasal septum had no statistical difference between subjects of 20-30 and those more than 30 years. Concerning maxillary sinus volume, most studies have focused on the evaluation of maxillary sinus volume with limited number probing the causes for asymmetrical growth. However, the growth rate of maxillary sinus noted to be in two phases of acceleration. The first one is after birth to 3 years and the second one between 7-12 years **(Graney, 1998).** According to **Jun *et al* (2005)** the maxillary sinus volume reach the adult size by the age 17-25 and that agreed with our result which showed no significant difference between the subject of twenties and thirties.

Investigating the diseased nasal cavities, a study performed on Korean population by **Cho *et al* (2010)** showed that there is significant increase in chronic rhino sinusitis with increased age which markedly higher among those who were fifties and older without any gender differences. While the current study showed no significant difference between patients of twenties with those of thirties. However, this could be attributed to the limited number of our subjects. In a study performed by **Shoib *et al* (2016)**. They found that the deviated septum was more and statistically significant in male than female and same result found by **Nayak *et al* (2002)** and **Ozkurt *et al* (2014)** but in the present study, the females was insignificantly more than male. Our result related to the ipsi and contra lateral maxillary sinus volume between male and female were also not significant, nevertheless, these results need to be re-evaluated with a larger sample size and wider range of age groups.

Chapter Five

Conclusions and Suggestion

Chapter Five

Conclusions and suggestions

5.1. Conclusions:

According to the result obtained it has been concluded the following:

1. CT specifically shows a precise, available and non-expensive tool providing excellent information about the osseous structure of head and face particularly nasal septum and maxillary sinus.
2. Deviated Nasal septum which is one of the frequent anatomical variation could not be obvious that is sometimes found incidentally, particularly in mild degree and it may not be associated with any signs or symptoms. Increasing deviation shows increase in possibility of various symptoms and this appear to be apparent with sever deviations.
3. The volume of the maxillary sinuses could be affected by the nasal septum deviation. They tend to be smaller at the same side of deviation (ipsi lateral) and larger at the opposite side to deviation (contra lateral).
4. The mean difference between the ipsi and contra lateral maxillary sinuses tend to increase with increased angle of nasal septum to reach the maximum difference in severe deviations.
5. The mean difference between two sided sinuses is more and significant in symptomatic patients while those who were asymptomatic show no significant difference.

6. The effect of nasal septum deviation show no significant difference between male and females and also no significant difference between subjects in twenties and thirties.

5.2 Suggestions:

1. Further longitudinal study with larger sample size and wider range of age to investigate the effect of deviated nasal septum on maxillary sinus volume using CBCT.

2. Clinical and radiological investigation of the effect of concha bullosa on the maxillary sinus volume.

3. Cone beam analysis for the effect of anterior ethmoidal air cell (Haller cell) on the maxillary sinus volume and development of sinus diseases

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Appendix (I)

<u>موافقة للإشتراك فى البحث العلمي</u>

اسم الباحث:

عنوان البحث:

مكان إجراء البحث:

أنت مدعو(ة) للمشاركة ببحث علمي سريري سيجرى في .... الرجاء أن تأخذ(ي) الوقت الكافي لقراءة المعلومات التالية بتأن قبل أن تقرر(ي) إذا كنت تريد(ين) المشاركة أم لا. بإمكانك طلب إيضاحات أو معلومات إضافية عن أي شيء مذكور في هذه الاستمارة أو عن هذه الدراسة ككل من طبيبك.

في حال وافقت على المشاركة في هذه الدراسة، سيبقى اسمك طي الكتمان . لن يكون لأي شخص، ما لم ينص القانون على ذلك، حق الاطلاع على ملفك الطبي باستثناء الطبيب المسؤول عن الدراسة ومعاونيه.

<u>موافقة المشترك:</u>

لقد قرأت استمارة القبول هذه وفهمت مضمونها. تمت الإجابة على أسئلتي جميعها. وبناء عليه فأنني، حرا مختارا، أجيز إجراء هذا البحث و أوافق على الإشتراك فيه، وإني أعلم ان الباحث الدكتور.................................. وزملاءه ومعاونيه او مساعديه سيكونون مستعدين للإجابة على أسئلتي، وأنه باستطاعتي الإتصال بهم على الهاتف .... واذا شعرت لاحقا ان الأجوبة تحتاج الى مزيد من الإيضاح فسوف أتصل بأحد اعضاء لجنة الأخلاقيات. كما أعرف تمام المعرفة بانني حر في الإنسحاب من هذا البحث متى شئت حتى بعد التوقيع على الموافقة دون ان يؤثر ذلك على العناية الطبية المقدمة لي.

إسم المشترك:

توقيع المشترك:

Appendix (II)

<u>Case sheet</u>

- **Patient's name:**
- **Age:**
- **Gender:**
- **Past medical history:**
- **Oral examination:**
- **Symptoms:**

☐ Blockage of one or both nostrils.

☐ Nasal congestion, sometimes one-sided.

☐ Nosebleeds.

☐ Frequent sinus infections.

☐ Facial pain, headaches, postnasal drip.

☐ Others.

- **Nasal septum:**

☐ No-deviation ☐ Deviation

- **Angle of DNS:**

I. **Mild (angle ≤80):**
II. **Moderate (angle 9o to 150):**
III. **Sever (angle ≥160):**

- **Maxillary sinus volumes**

Ipsilateral: (in which sections were estimated from the antral floor to heights of (n) in axial sections).

Contralateral: (in which sections were estimated from the antral floor to heights of (n) in axial sections)

العلاقه بين درجة انحراف الحاجز الانفي و حجم الجيوب الانفيه عند البالغين باستخدام الاشعه المقطعيه المخروطيه.

اطروحه مقدمه الى مجلس كلية طب الاسنان/جامعة بغداد

كجزء من متطلبات درجة الماجستير في علوم اشعة الفم و الوجه و الفكين

مقدمة من قبل الطالب

همسه جمال مهدي

بكالوريوس طب و جراحة الفم و الاسنان

بأشراف

أ.د. لمياء حامد النقيب

ماجستير اشعة الفم و الوجه و الفكين

محرم 1437 تشرين الثاني 2016

الخلاصه

خلفية: الجيوب الفكية هي واحدة من أربعة أزواج من الجيوب الأنفية والتي تقع داخل عظم الفك العلوي. تؤدي هذه الجيوب عدة وظائف مثل تقليل وزن الرأس، العمل على تدفئة و ترطيب الهواء الداخل,حماية الاجزاء الحيويه داخل الرأس وودورها في رنين و صدى الصوت. تتأثر احجام وسلامة الجيوب الفكيه بالاختلافات التشريحيه و يعتبر انحراف الحاجز الانفي واحدا من اكثر الاختلافات التشريحيه شيوعا

الهدف من الدراسة: تقييم وتقدير دور انحراف الحاجز الأنفي ,ان وجد ,على حجم الجيوب الانفيه الفكيه في كلا الجانبين. الجانب المجاور للانحراف و الجانب المضاد للانحراف.

المواد و طريقة العمل: تضمنت هذه الدراسه 45 مريضا تتراوح اعمارهم بين(20-40) عاما من مراجعي مستشفى غازي الحريري ضمن الفتره من تشرين الاول 2015 الى نيسان2016.تم فحصهم سريريا واشعاعيا وبعد التأكد من وجود انحراف في الحاجز الانفي تم تقسيمهم سريريا الى فئتين: فئه بدون اعراض سريريه وفئه باعراض سريريه. وحسب الصوره الشعاعيه تم تقسيمهم الى ثلاث فئات :بسيط, متوسط, شديد و ذلك اعتمادا على درجة زاوية الانحراف المقاسه في الصوره المقطعيه الشعاعيه المأخوذه بواسطة المفراس الحلزوني . تم الحصول على زاوية من رسم خطين. ألاول هو الخط الرابط بين عرف جالي وصولا الى عظم القواطع العلويه والخط الثاني من عرف جالي الى الجزء الأكثر بروزا من الحاجز الأنفي. تم حساب حجم الجيب الفكي من مجموع أحجام المقاطع المحوريه لكل جيب من الجيوب الأنفية. و تم الحصول على حجم كل مقطع من حاصل ضرب مساحه المقطع الواحد في سمكه

ألنتائج: بلغ متوسط حجم الجيب الفكي في نفس الجانب من الانحراف ألاعلى قيمه بين أولئك ذوو الانحراف البسيط والأدنى قيمه بين الذين يعانون من انحراف شديد. ومع ذلك، فإن الاختلافات في متوسط الحجم بين المجموعات الثلاثه لم يظهر دلاله احصائيه. وجدت نتائج مقاربه بالنسبة لحجم الجيوب الأنفية في الجانب المعاكس للانحراف حيث لم تظهر دلائل احصائيه في الفروقات بين متوسط احجام الجيوب في الجانب المعاكس للانحراف. لم يكن هناك فرق كبير بين المجموعات الثلاث ولا علاقة خطية بين حجم الجيوب الأنفية وشدة الانحراف. كان متوسط الفرق بين حجم الجيب الجانبي المجاور للحاجز المنحرف و الجيب المعاكس هو الأدنى من بين أولئك ذوو الانحراف البسيط بينما يظهر متوسط الفرق بين الحجمين القيمه القصوى عند اؤلئك ذوو الانحراف الشديد.اظهرت النتائج الاحصائيه وجود علاقه خطيه واضحه بين حجم الجيوب المجاوره و المعاكسه للانحراف مع درجة زاوية الانحراف

الخلاصة: حجم الجيوب الأنفية في نفس الجانب (المجاور) للانحراف أصغر من ذلك الذي على الجانب الآخر(المعاكس) للانحراف. الفرق بين حجم الجيوب على جانبي الحاجز الانفي اكبر في حالات الانحراف الشديد. كذلك الفرق بين حجم الجيوب كان اكبر في الفئه ذات الاعراض السريريه من تلك الفئه بدون وجود اعراض.

الكلمات الرئيسية: حجم الجيب الفكي، انحراف الحاجز الأنفي، التصوير المقطعي الحلزوني