Sudan University of Science and Technology

College of Graduate Studies

Characterizing of normal Mandibular Bone Structures Using Three Dimensional CT Image

توصيف الأجزاء التشريحية الطبيعية لعظام الفك الأسفل باستخدام التصوير بالأشعة المقطعية ثلاثي الأبعاد

A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF PH.D. IN DIAGNOSTIC IMAGING TECHNOLOGY

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الآيـــة

بسم الله الرحمن الرحيم

قـــال تعالى

﴿وَقُل رَّبِّ زِدْنِي عِلْماً﴾

سـورة طـه: الآيـة 114

Dedication

To the soul of my kind mother…

To my father…

To my Wife…

To my brothers and sisters…

Acknowledgment

*Praise and thanks are due to **Allah, the lord and creator.***

Special thanks to my supervisor, Dr. Caroline Edward Ayad for her valuable and continuous help and guidance.

My thanks are extended to the staff of Radiology Department in Khartoum military hospital, which they helped me in collecting the information.

Finally I would like to thank everybody who helped me prepare and finish this study.

Abstract

Mandible is largest and strongest bone of skull, having various morphological structures and features show associated changes according to age, gender for human.

The aim of this study is to characterize the mandible and to find out it has relation with age and gender of the human and establish local reference for the Sudanese mandible measurement and compare these measurements with other population by using CT scan 3D imaging and applying axial section projection as well as sagittal section for CT facial protocol. 160 patients were selected to participate in this study by choosing 92 men with a mean of age is (21-49) years and 68 women with a mean age of (23-45).

The result of this study showed that the measurement of bi condylar breadth of the mandible were differ between males and females and the males have greater measurement mean (115.24mm) than females mean (109.81mm),while The mandibular symphysis height mean was greater in females (35.76 mm) than males (34.30 mm). The study was showed that in Sudanese population the bi bicondylar breadth and mandibular body length measurement change significantly with increasing age Comparing with other populations in addition to that the mental foramen width mean in right side is (4.29mm) and left side is (3.53mm), This was considered to be greater measurement than other previously studied populations. Since, if Sudanese people their ages or gender were known, new equation will be establish in order to standardize a local reference for mandibles and mental for a means measurements.

ملخص الدراســة

الفك الأسفل هو أعظم وأقوى عظام الجمجمة ولديه أجزاء تشريحية متنوعة وملامح توضح تغيرات مصاحبة وفقا لعمر وجنس الإنسان.

الهدف من هذه الدراسة هو توصيف الفك الأسفل لإيجاد أن له علاقة بعمر وجنس الإنسان وتأسيس مرجع محلي لقياسات الفك الأسفل للسودانيين ومقارنة هذه القياسات مع الشعوب الأخرى باستخدام التصوير بالأشعة المقطعية ثلاثي الأبعاد وتطبيق وضعية المقطع العرضي بالإضافة إلى المقطع الجانبي لبرتوكول الأشعة المقطعية للوجه. أجريت هذه الدراسة على عدد 160 مريض وتم اختيار 92 ذكر مع متوسط أعمار (21 – 49) سنة و68 أنثى مع متوسط أعمار (23 – 45) سنة.

نتائج الدراسة أظهرت أن قياس طول المسافة بين زوج لقمتي الفك الأسفل يختلف بين الذكور والإناث والذكور لهم مقياس وسط حسابي (115.24 ملم) أكبر مقارنة بمقياس الوسط الحسابي (109.8 ملم) للنساء بينما الوسط الحسابي لطول ارتفاق الفك الأسفل اكبر عند النساء (35.76 ملم) منه عند الرجال(34.30 ملم).

أظهرت الدراسة أن قياسات طول المسافة بين زوج لقمتي الفك الأسفل وطول جسم الفك الأسفل يتغيران ً بزيادة العمر مقارنة بالشعوب الأخرى بالإضافة إلى أن الوسط الحسابي لقطر فتحة الفك الأسفل اليمنى (4.29 ملم) والفتحة اليسرى (3.53 ملم) وهذه تعتبر قياسات اكبر إذا ما قورنت بالدراسات السابقة للشعوب الأخرى ولذا إذا علم عمر وجنس السودانيين يمكن من وضع معادلة تؤسس لعمل معيار مرجعي محلي لقياسات الفك الأسفل وفتحتي الفك الأسفل.

List of Abbreviation

CBCT:	Cone Beam Computed Tomography
CT:	Computer Tomography
DICOM:	Digital Imaging and Communications in Medicine
3D:	Three Dimensional
Kv:	Kilo volt
M:	Mandible
mA:	mili Amper
MF :	Mental Foramen
mm:	mili meter
MPR:	Multi Planar Reconstruction
OPG:	Ortho Pan Tomography
PBL:	Petrous Bone Length
SPSS:	Statistical Package for Social Sciences
TMJ:	Tembro Mandibular Joint

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Chapter one

Introduction

Chapter one
Introduction

1.1 Introduction:

The mandible is the largest and strongest facial bone and retains its shape better than other bones in the forensic and physical anthropologic field and the best preserved after death. The sex differences are well marked in the bony pelvis and skull. Sex determination from a given bone of an individual is of great value for medical jurist who often gives expert opinion from the available skeletal remains, so The mandible can be used to distinguish among ethnic groups and between sexes and having various morphological features may show changes with reference to age, gender and race. (Jayachandra. T, et al: 2014).

The ability of CT imaging to display fine bone details, makes it an ideal modality for lesions that involve bone. CT with three dimensional reformat reconstruction is one of imaging modalities that is used to evaluate and measuring the mandible morphology as well as been applied to trauma and craniofacial reconstructive surgery, and has been used for treatment of congenital and acquired deformities. (White Sc, et al: 2009).

Three-dimensional craniofacial CT imaging has been developed and progressed during the past two decades. The advancement of the hardware and software has made the imaging study more convenient, user friendly, and affordable. Processing and analysis of the imaging data are readily performed on personal computers. Accuracy of the 3-dimensional measurement has been validated. Collaborative study can be achieved with other departments the 3-dimensional CT imaging has been developed, improved, and widely used. The 3-dimensional images are not only good quality, but also contain significance that is helpful for medical research and clinical applications so as to demonstrate the anatomy and pathologic conditions of the mandible. (Roshanak Ghaffari, et al: 2013).

1.2 Problem of the study:

The normal anatomical variation of mandible Structures don't measure clearly by another imaging modalities and techniques (Periapical. occlusal and panoramic) compared with CT which has high accuracy, sensitivity and there is no overlapping. On the other hand there is no previous study has been done in Sudanese people so as to compare it with other population.

1.3 Objective:

1.3.1 General objective:

To characterize the mandible bone structures and mental foramen width to find out the norms if there is age and gender related deference measurement.

1.3.2 Specific objective:

1. To establish a local reference for the Sudanese mandible bone structures and mental foramen width measurement.
2. To compare the Sudanese mandible bone structures and mental foramen width with other population.

1.4 Importance of the study:

This study will enhance the performance of measuring Sudanese mandible structures compare with other nationality by using three dimensional CT.

1.5 Overview of the study:

This study consisted of five chapters. Chapter one is an introduction which includes; problem and objective of the study. Chapter two is a literature review which includes; Anatomy, Physiology, Pathology and previous studies. Chapter three is about research materials and methodology. In Chapter four the results are presented and Chapter five includes; discussion, conclusions and recommendations in addition to the references and appendix.

Chapter Two

Literature Review

Chapter Two

Literature Review

2.1 Anatomy and physiology of mandible:

The mandibleis the largest and strongest bone of the face, serves for the reception of the lower teeth. It consists of a curved, horizontal portion, the body**,** and two perpendicular portions, the rami**,** which unite with the ends of the body nearly at right angles. (Julian et al:1998).

2.1.1The Body of the mandible:

The body is curved somewhat like a horseshoe and has two surfaces and two borders.

2.1.1.1 Body Surfaces:

2.1.1.1.1 **External body surface** :

It is marked in the median line by a faint ridge, indicating the symphysis or line of junction of the two pieces of which the bone is composed at an early period of life. This ridge divides below and encloses a triangular eminence, the mental protuberance**,** the base of which is depressed in the center but raised on either side to form the mental tubercle on either side of the symphysis, just below the incisor teeth, is a depression, the incisive fossa**,** which gives origin to the Mental is and a small portion of the Orbicularis oris. Below the second premolar tooth, on either side, midway between the upper and lower borders of the body, is the mental foramen**,** for the passage of the mental vessels and nerve. Running backward and upward from each mental tubercle is a faint ridge, the oblique line**,** which is continuous with the anterior border of the ramus; it affords attachment to the Quadratus labii inferioris and Triangular is; the Platysma is attached below it. (Whaites et al: 2003).

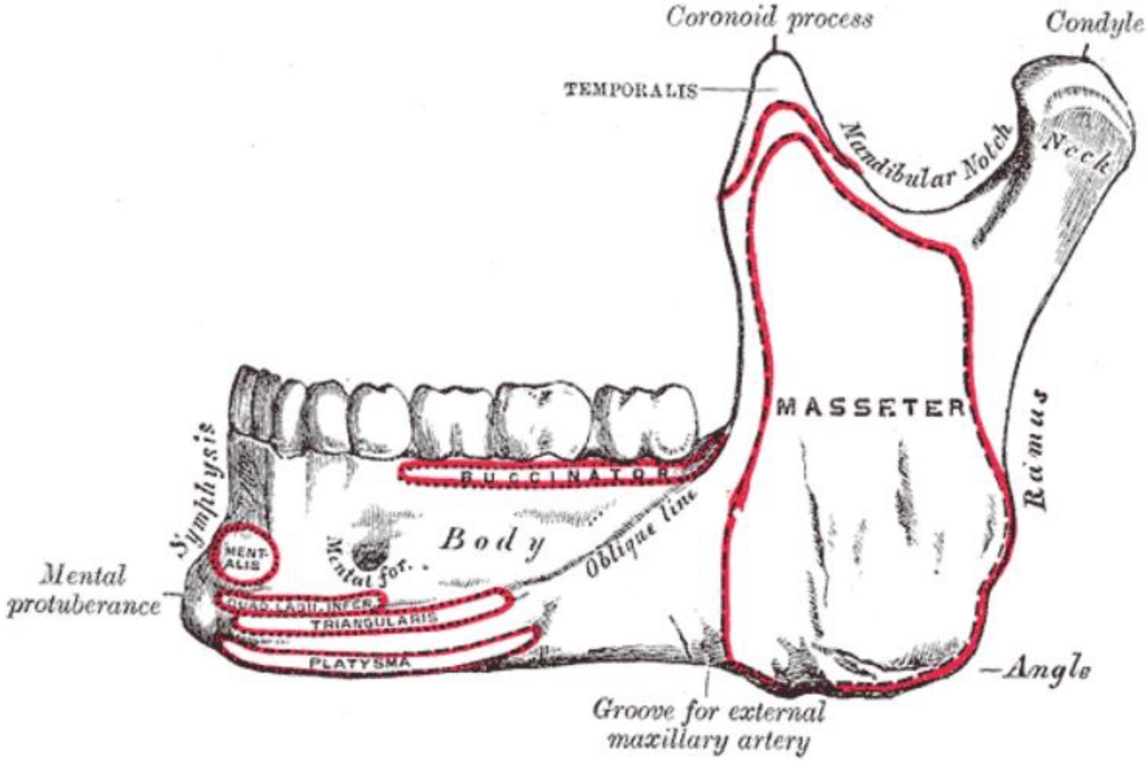

Fig. (2-1): Outer surface of the Mandible body

(Wikibedia,Laberti.com,org:2015)

2.1.1.1.2 Internal body surface:

It is concave from side to side. Near the lower part of the symphysis is a pair of laterally placed spines, termed the mental spines**,** which give origin to the Genioglossi. Immediately below these is a second pair of spines, or more frequently a median ridge or impression, for the origin of the Geniohyoidei. In some cases the mental spines are fused to form a single eminence, in others they are absent and their position is indicated merely by an irregularity of the surface. Above the mental spines a median foramen and furrow are sometimes seen; they mark the line of union of the halves of the bone. Below the mental spines, on either side of the middle line, is an oval depression for the attachment of the anterior belly of the Digastricus.

Extending upward and backward on either side from the lower part of the symphysis is the mylohyoid line**,** which gives origin to the Mylohyoideus; the posterior part of this line, near the alveolar margin, gives attachment to a small part of the Constrictor pharyng is superior, and to the pterygomandibular raphé. Above the anterior part of this line is a smooth triangular area against which the sublingual gland rests, and below the hinder part, an oval fossa for the sub maxillary gland. (Whaites et al: 2003).

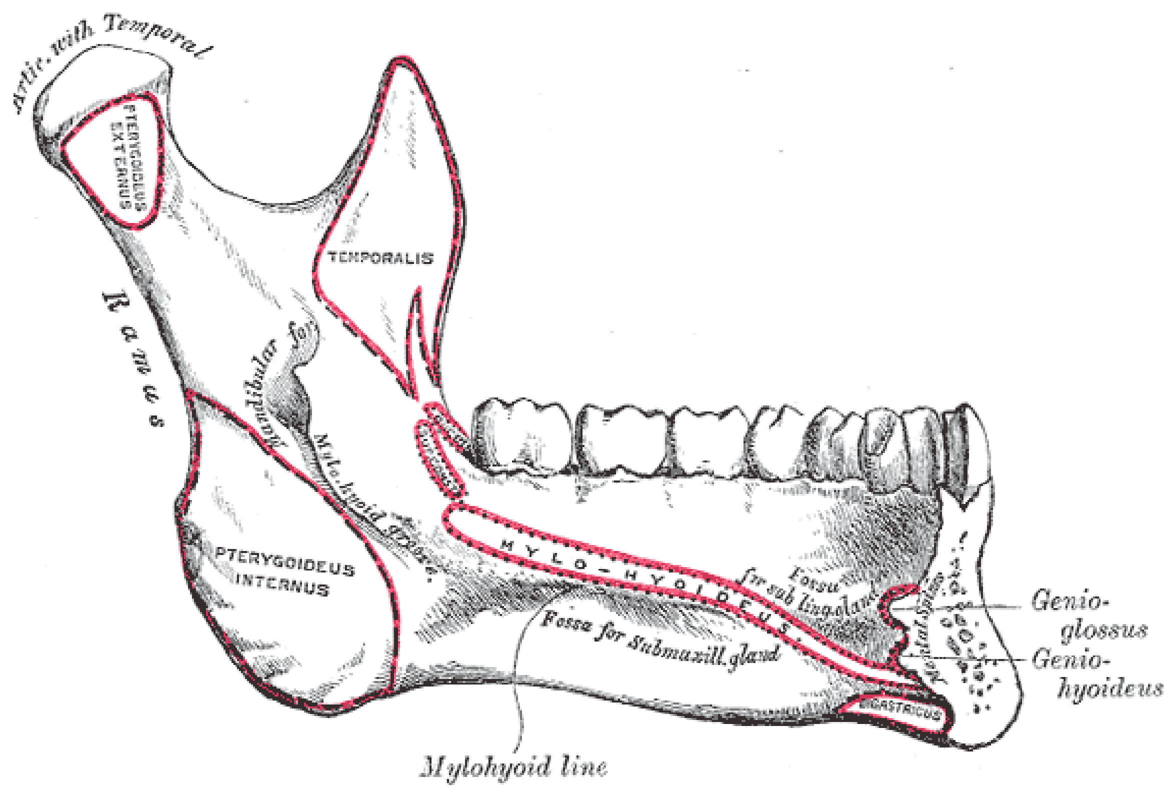

Fig. (2-2): Mandible body Inner surface of the Mandible body (Wikibedia,Laberti.com,org:2015)

2.1.1.2 Body Borders:

2.1.1.2.1 Superior or alveolar body border:

It is wider behind than in front, hollowed into cavities, for the reception of the teeth; these cavities are sixteen in number, and vary in depth and size according to the teeth which they contain. To the outer lip of the superior border, on either side, the Buccinator is attached as far forward as the first molar tooth. (Bernard liebgott: 2001).

2.1.1.2.2 Inferior body border:

Is rounded, longer than the superior, and thicker in front than behind; at the point where it joins the lower border of the ramus a shallow groove; for the external maxillary artery, may be present. (Bernard liebgott: 2001).

2.1.2 The Ramus (*ramus mandibulæ; perpendicular portion*):

The ramus is quadrilateral in shape, and has two surfaces, four borders, and two processes.

2.1.2.1 Ramus Surfaces:

2.1.2.1.1 Ramus lateral surface:

It is flat and marked by oblique ridges at its lower part; it gives attachment throughout nearly the whole of its extent to the Masseter.

2.1.2.1.2 Ramus medial surface:

It presents about its center the oblique mandibular foramen**,** for the entrance of the inferior alveolar vessels and nerve. The margin of this opening is irregular; it presents in front of prominent ridge, surmounted by a sharp spine, the lingula mandibulæ**,** which gives attachment to the spheno mandibular ligament; at its lower and back part is a notch from which the mylohyoid groove runs obliquely downward and forward, and lodges the mylohyoid vessels and nerve. Behind this groove is a rough surface, for the insertion of the Pterygoideus internus. The mandibular canal runs obliquely downward and forward in the ramus, and then horizontally forward in the body, where it is placed under the alveoli and communicates with them by small openings. On arriving at the incisor teeth, it turns back to communicate with the mental foramen, giving off two small canals which run to the cavities containing the incisor teeth. In the posterior two-thirds of the bone the canal is situated nearer the internal surface of the mandible; and in the anterior third, nearer its external surface. It contains the inferior alveolar vessels and nerve, from which branches are distributed to the teeth. (Julian et al: 1998).

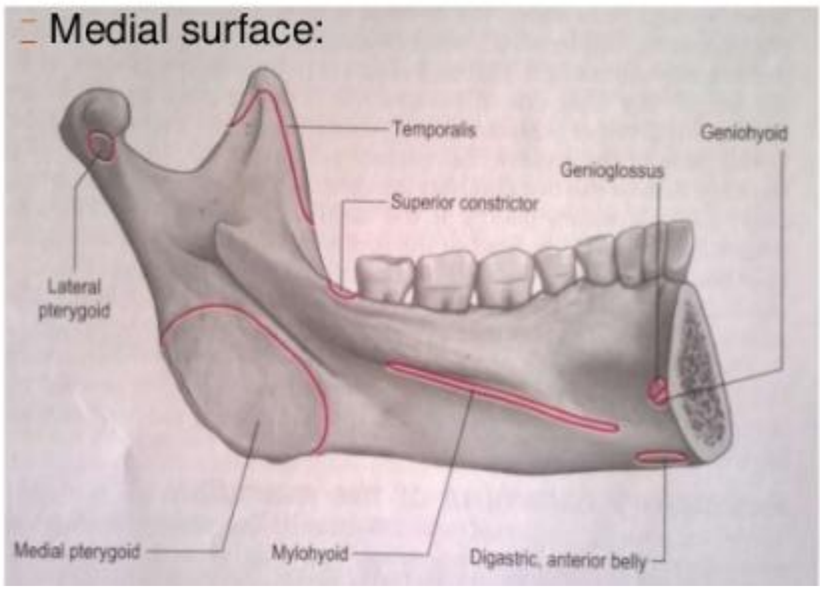

Fig. (2-3): Medial ramus (Wikibedia,Laberti.com,org:2015)

2.1.2.2 Ramus border:

2.1.2.2.1 Lower border of the ramus:

It is thick, straight, and continuous with the inferior border of the body of the bone. At its junction with the posterior border is the angle of the mandible**,** which may be either inverted or everted and is marked by rough, oblique ridges on each side, for the attachment of the Masseter laterally, and the Pterygoideus internus medially; the stylomandibular ligament is attached to the angle between these muscles.

2.1.2.2.2 Anterior border:

It is thin above, thicker below, and continuous with the oblique line.

2.1.2.2.3 Posterior border:

It is thick, smooth, rounded, and covered by the parotid gland.

2.1.2.2.4 Upper border:

It is thin, and is surmounted by two processes, the coronoid in front and the behind, separated by a deep concavity, the mandibular notch.

2.1.3 Coronoid Process (*processus coronoideus*):

It is a thin, triangular eminence, which is flattened from side to side and varies in shape and size. This convex is continuous below with the anterior border of the ramus, *posterior border* is concave and forms the anterior boundary of the mandibular notch and *lateral surface* is smooth, and affords insertion to the Temporalis and Masseter. As well as *medial surface* gives insertion to the Temporalis, and presents a ridge which begins near the apex of the process and runs downward and forward to the inner side of the last molar tooth. Between this ridge and the anterior border is a grooved triangular area. (Julian et al: 1998).

2.1.4 Condyloid Process (*process us condyloideus*):

Is thicker than the coronoid, and consists of two portions: the condyle, and the constricted portion which supports it, theneck. The condyle presents an articular surface for articulation with the articular disk of the temporomandibular joint; it is convex from before backward and from side to side, and extends farther on the posterior than on the anterior surface. Its long axis is directed medial ward and slightly backward, and if prolonged to the middle line will meet that of the opposite condyle near the anterior margin of the foramen magnum. At the lateral extremity of the condyle is a small tubercle for the attachment of the temporomandibular ligament. The neck is flattened from before backward, and strengthened by ridges which descend from the forepart and sides of the condyle. Its posterior surface is convex while anterior presents a depression for the attachment of the Pterygoideus externus. (Julian etal:1998).

2.1.5 Mandibular notch:

It is separate the two processes, deep semilunar depression, and it is crossed by the masseteric vessels and nerve. (Julian,etal:1998).

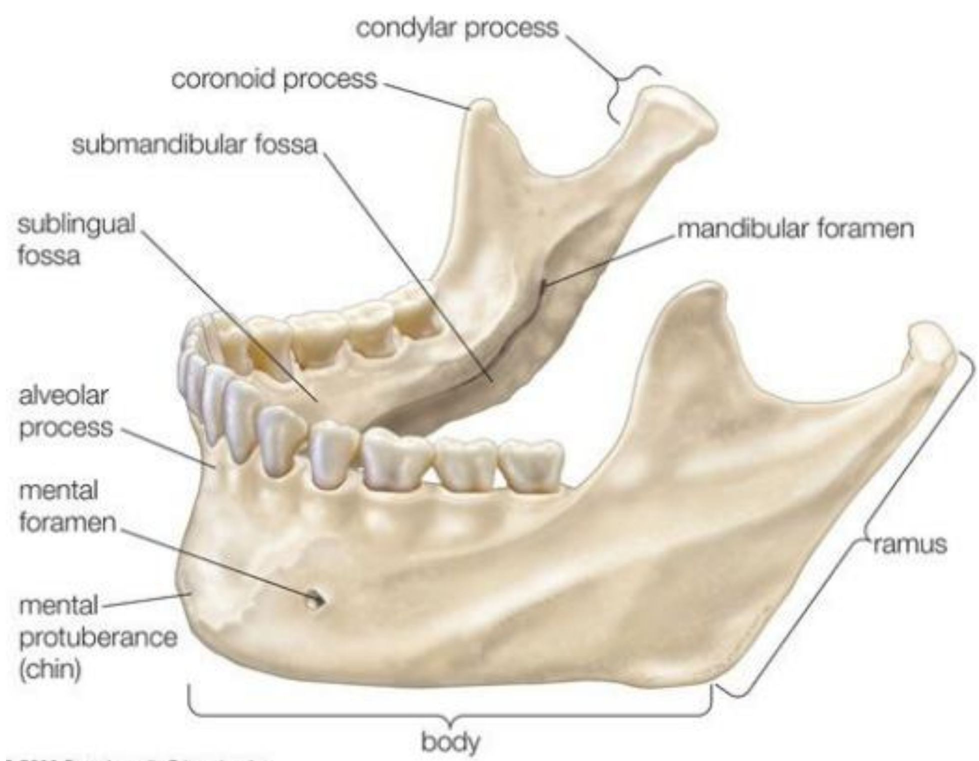

Fig.(2-4): The mandible bone structures

(Wikibedia,Laberti.com,org:2015)

2.1.6Ossification of mandible :

The mandible is ossified in the fibrous membrane covering the outer surfaces of Meckel’s cartilages. These cartilages form the cartilaginous bar of the mandibular arch and are two in number, a right and a left. Their proximal or cranial ends are connected with the ear capsules, and their distal extremities are joined to one another at the symphysis by mesodermal tissue. They run forward immediately below the condyles and then, bending downward, lie in a groove near the lower border of the bone; in front of the canine tooth they incline upward to the symphysis. From the proximal end of each cartilage the malleus and incus, two of the bones of the middle ear, are developed; the next succeeding portion, as far as the lingula, is replaced by fibrous tissue, which persists to form the sphenomandibular ligament. Between the lingula and the canine tooth the cartilage disappears, while the portion of it below and behind the incisor teeth becomes ossified and incorporated with this part of the mandible. Ossification takes place in the membrane covering the outer surface of the ventral end of Meckel’s cartilage and each half of the bone is formed from a single center which appears, near the mental foramen, about ossification takes place in the membrane covering the outer the sixth week of fetal life. By the tenth week the portion of Meckel’s cartilage which lies below and behind the incisor teeth is surrounded and invaded by the membrane bone. Somewhat later, accessory nuclei of cartilage make their appearance, viz., a wedge-shaped nucleus in the condyloid process and extending downward through the ramus; a small strip along the anterior border of the coronoid process; and smaller nuclei in the front part of both alveolar walls and along the front of the lower border of the bone. These accessory nuclei possess no separate ossific centers, but are invaded by the surrounding membrane bone and undergo absorption. The inner alveolar border, usually described as arising from a separate ossific center (*splenial center*), is formed in the human mandible by an ingrowth from the main mass of the bone. At birth the bone consists of two parts, united by a fibrous symphysis, in which ossification takes place during the first year. (Bernard Lielgott: 2001).

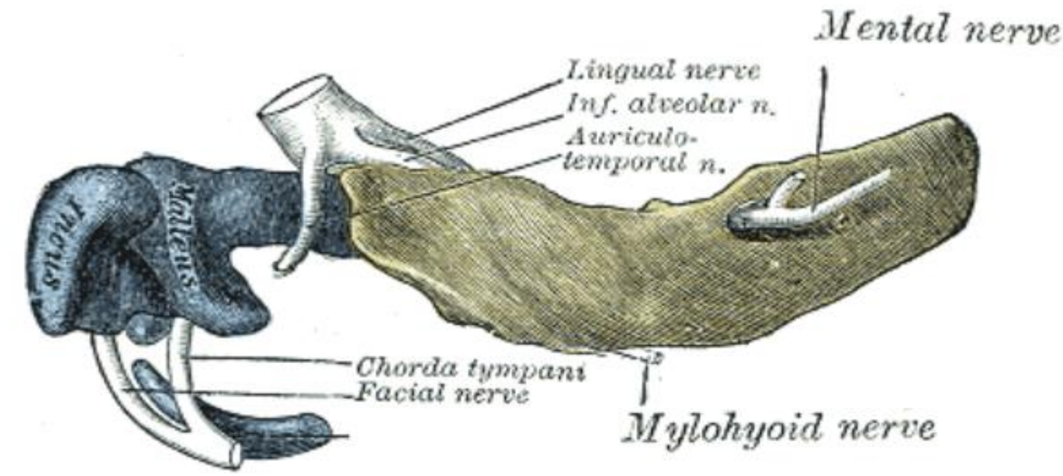

Fig.(2-5): Mandible of human embryo 24 mm. long. Outer aspect (Wikibedia,Laberti.com,org:2015)

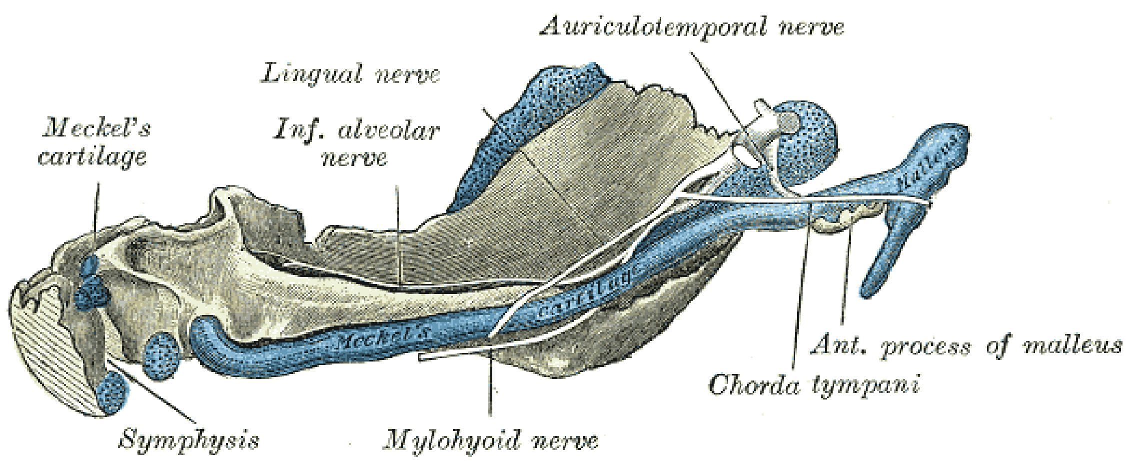

Fig. (2-6): Mandible of human embryo 24 mm. long. Inner aspect (Wikibedia,Laberti.com,org:2015)

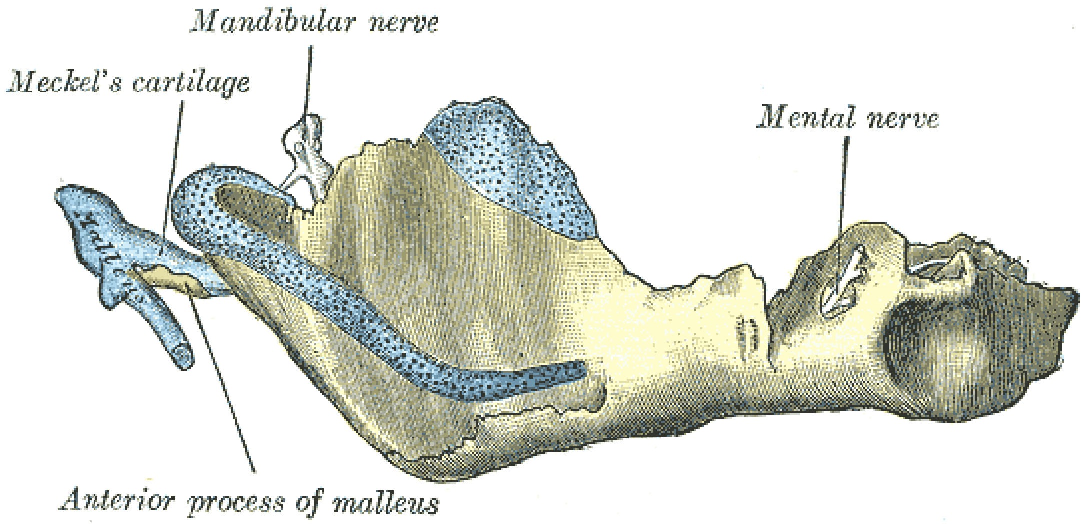

Fig. (2-7): Mandible of human embryo 95 mm. long. Outer aspect. Nuclei of cartilage stippled (Wikibedia,Laberti.com,org:2015)

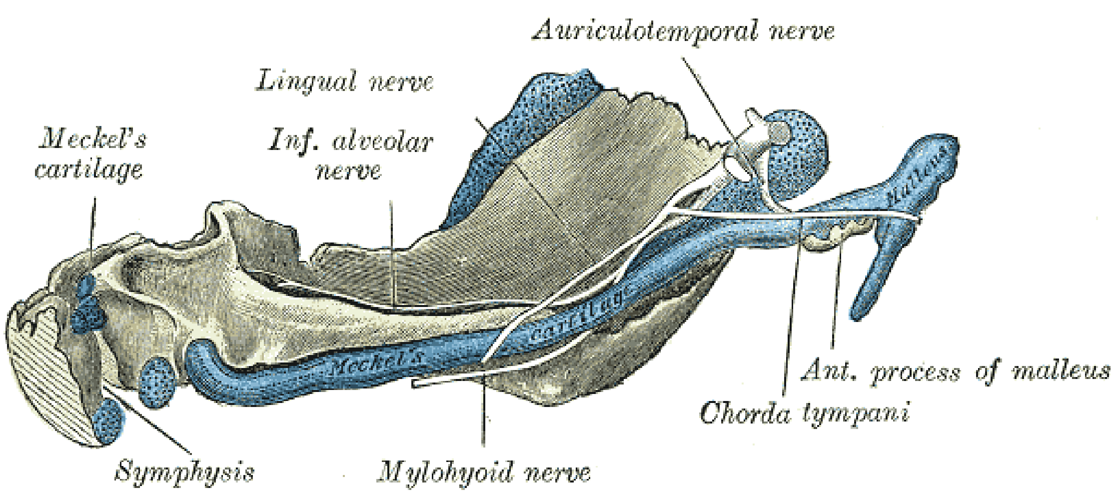

Fig.(2-8): Mandible of human embryo 95 mm. long. Inner aspect. Nuclei of cartilage stippled (Wikibedia,Laberti.com,org:2015)

2.1.7Changes Produced in the Mandible by Age:

2.1.7.1 Change at birth:

The body of the bone is a mere shell, containing the sockets of the two incisor, the canine, and the two deciduous molar teeth, imperfectly partitioned off from one another. The mandibular canal is of large size, and runs near the lower border of the bone; the mental foramen opens beneath the socket of the first deciduous molar tooth. The angle is obtuse (175°), and the condyloid portion is nearly in line with the body. The coronoid process is of comparatively large size, and projects above the level of the condyle. (Bernard Lielgott: 2001).

Fig. (2-9): Mandible at birth (Wikibedia,Laberti.com,org:2015)

2.1.7.2 Change after birth:

The two segments of the bone become joined at the symphysis, from below upward, in the first year; but a trace of separation may be visible in the beginning of the second year, near the alveolar margin. The body becomes elongated in its whole length, but more especially behind the mental foramen, to provide space for the three additional teeth developed in this part. The depth of the body increases owing to increased growth of the alveolar part, to afford room for the roots of the teeth, and by thickening of the sub dental portion which enables the jaw to withstand the powerful action of the masticatory muscles; but the alveolar portion is the deeper of the two, and, consequently, the chief part of the body lies above the oblique line. The mandibular canal, after the second dentition, is situated just above the level of the mylohyoid line; and the mental foramen occupies the position usual to it in the adult. The angle becomes less obtuse, owing to the separation of the jaws by the teeth; about the fourth year it is 140°. (Bernard Lielgott: 2001).

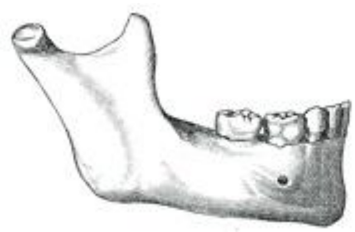

Fig. (2-10): Mandible in childhood (Wikibedia,Laberti.com,org:2015)

2.1.7.3 Change in the adult:

The alveolar and sub dental portions of the body are usually of equal depth. The mental foramen opens midway between the upper and lower borders of the bone, and the mandibular canal runs nearly parallel with the mylohyoid line. The ramus is almost vertical in direction, the angle measuring from 110° to 120°.

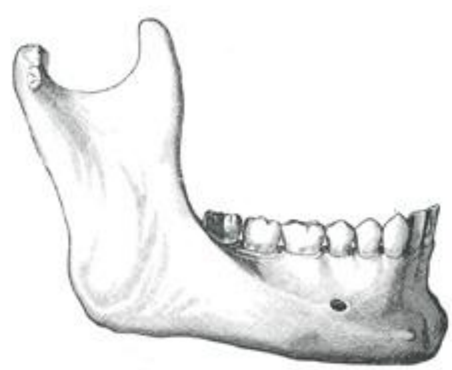

Fig. (2-11): Mandible in the adult(Wikibedia,Laberti.com,org:2015)

2.1.7.4 Change in old age:

The bone becomes greatly reduced in size, for with the loss of the teeth the alveolar process is absorbed, and, consequently, the chief part of the bone is below the oblique line. The mandibular canal, with the mental foramen opening from it, is close to the alveolar border. The ramus is oblique in direction, the angle measures about 140°, and the neck of the condyle is more or less bent backward. (Bernard Lielgott: 2001).

Fig.(2-12): Mandible in old age. side view of the mandible at different period life (Wikibedia,Laberti.com,org:2015)

2.1.8 Land marks of the mandible:

2.1.8.1 Bicondylar breadth:

Distance between most lateral points on the two condyles.

2.1.8.2 Bigonial breadth:

Distance between right and left gonia (outer point on either side of the lower jaw at which the jawbone angles upward). .(Michael.C.Li:2013)

2.18.3 Mandibular body length:

Distance between most anterior margin of (v)the chin to a line connecting right and left gonions

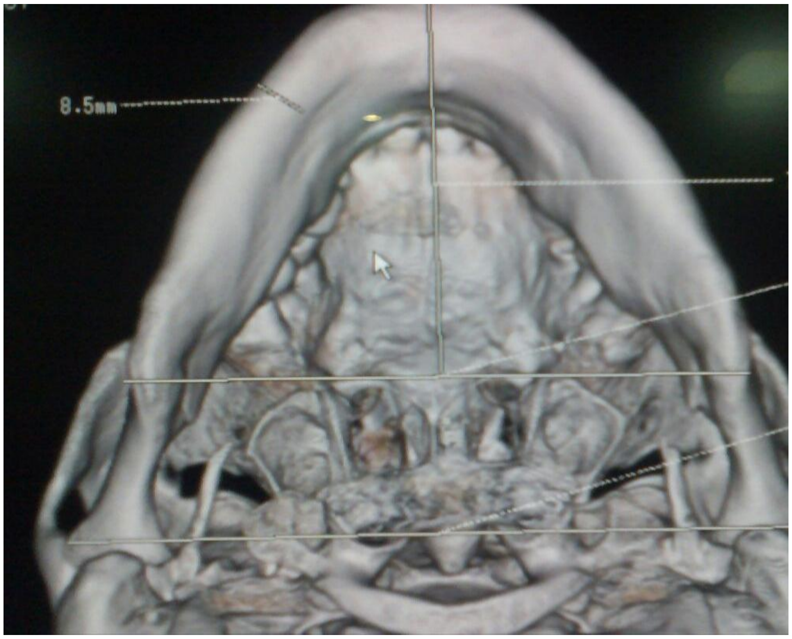

Fig. (2 -13): Mandible body length, bigonial breadthand bicondylar breadth

2.1.8.4 Corpus width:

Width measured at the region at the mental foramen.

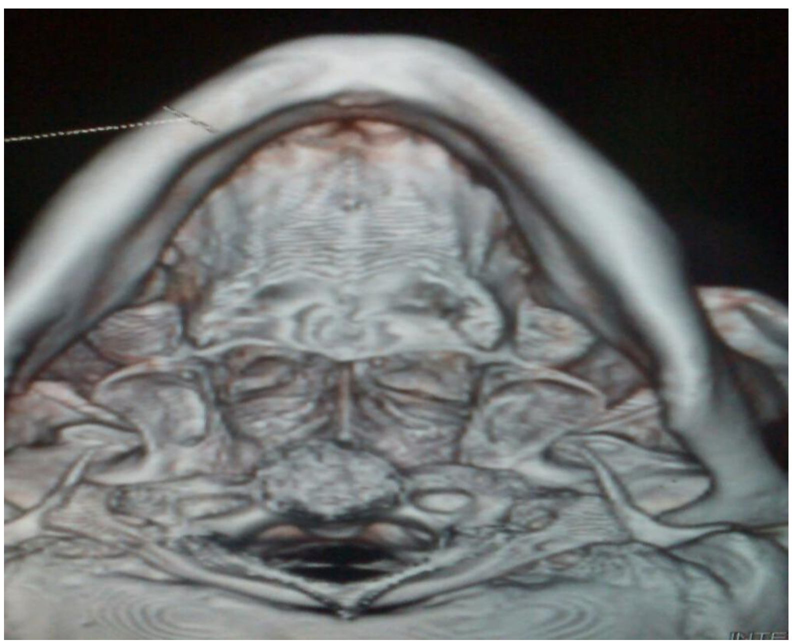

Fig. (2-14): The mandibular corpus width.

2.1.8.5Ramus height:

Distance between highest point of mandibular condyle to gonion.

2.1.8.6Ramus breadth:

Minimum width of mandibular ramus from anterior to posterior.

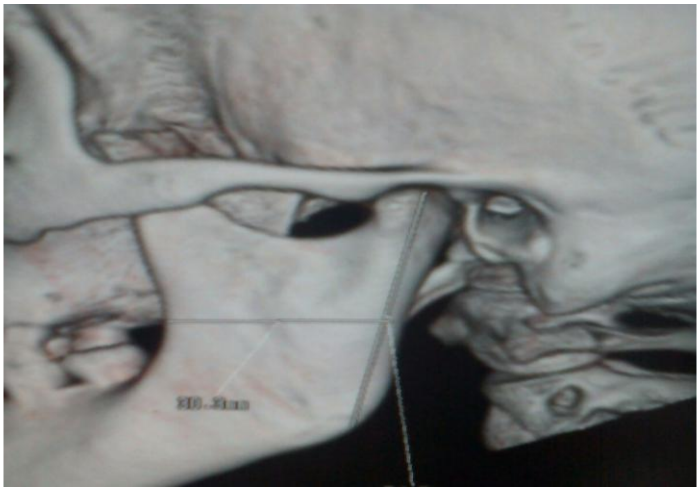

Fig.(2-15): The mandibular ramus height and breadth.

2.1.8.7Petrous bone length:

Distance between lateral border of petrous bone and base of the skull. (Michael.C.Li:2013).

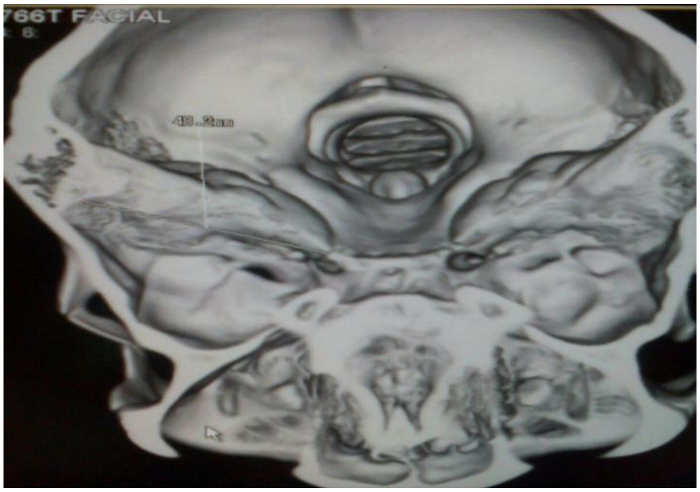

Fig. (2-16): Petrous bone length

2.1.8.8 Mandibular symphysis height:

Distance between infra dentale (apex of the septum between the mandibular central incisors) to gnathion (most inferior point of the mandible in the midline). .(Michael. C.Li: 2013).

Fig.(2-17): The mandibular symphasis height.

2.1.8.9 Mental foramen:

It is located on the anterior surface of the mandible. It permits passage of the mental nerve and vessels. (Michael.C.Li:2013).

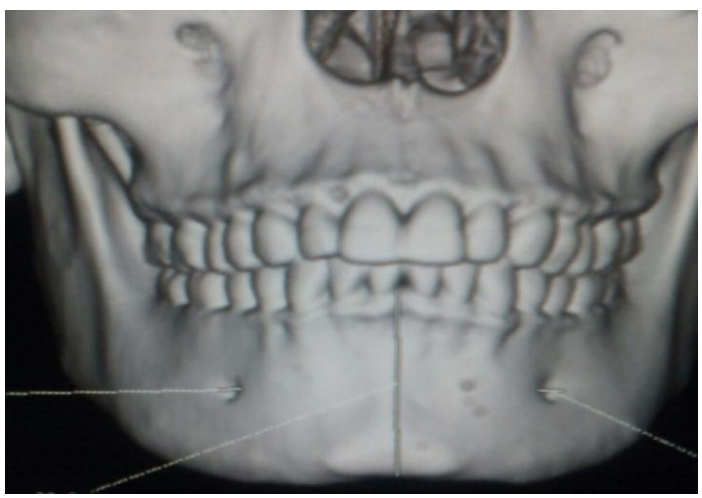

Fig. (2 – 18): Rt and Lt mental foramen width

2.2 Pathology of the mandible:

There are several diseases occur to mandible but the common of them are:

2.2.1 Mandibular fractures:

It is broken through mandibular bone occurs due to trauma and often associated with other facial trauma.

2.2.2 Mandibular dislocation:

It is a separation of mandible from temporomandibular joint (TMJ) and lower jaw does not go back in place on its own.

2.2.3 Mandibular Osteonecrosis:

It is occur when the mandible bones lose their blood supply

2.2.4 Mandibular tumors:

It is a calcifying epithelial tumor (CEOT) or pindprog tumor either benign or malignant tumor and it most often found in the mandibular molar/ premolar region.

2.2.5 Temporomandibular joint Dysfunction:

It is an umbrella term covering pain and dysfunction of the muscles of mastication (the muscles that move the jaw) and the temporomandibular joints (the joints which connect the mandible to the skull. (Edward Sheffield: 1996).

2.3 Imaging modalities use to detect and measure the mandible:

2.3.1 CT scan three dimensional modalities:

CT Provide crucial information un obtainable by other investigations or any another diagnostic methods and alter subsequent testament planning. It is helpful in excluding involvement by primary osseous or soft tissue lesion adjacent to the mandible. But it has a little value in examining abnormalities related to the dentition or cancellous bone of the mandible (Anne. G. Osboorn, et al, 2010). The ability of CT imaging to display fine bone details, makes it an ideal modality for lesions that involve bone. The three-dimensional CT has been applied to trauma and craniofacial reconstructive surgery, and has been used for treatment of congenital and acquired deformities (White Sc, et al, 2009). Early literature analyzing facial bone aging, focused on the orbit and mid face. It was believed that the bony face continued to grow with age, particularly with the increase in facial width and depth. In contrast, many recent studies suggest that the bone aging of the facial bone is a process primarily of contraction and morphologic changes. (Shaw RB Jr, et al, 2011).

CT aided three dimension al reconstruction is a method for morphological study of human body, which involve processing serial image of the organism .in the field of mandibular three dimensional reconstruction, there are many ways to obtain accuracy difference of two and three dimensional (Ming Chen, etal,2007). The computed tomography (CT) examination was done by using spiral computed tomography e computed tomography images were obtained with the patients in centric occlusion and their heads were positioned so that Frankfort horizontal and midsagittal plane were perpendicular to floor. The spiral CT (Toshiba) was performed to obtained 3 - 5 mm slice thickness tomographic imaging, slices spaced at

2 mm intervals, using spiral technique. Because this procedure provides images in axial plane it was reformatted to produce image sagittally. The measurements were determined directly on the selected image structures on the screen by two examiners for all subjects. Inter examiner reliability of the reproducibility of the measurement was assessed twice during the study in seven subjects by repeating all measurements (k-score for each measurement was never lower than 0.76). Examination of Craniomandibular articulation morphology and condyle position was done using following parameters for that on both right and left sides (K.c. Probhat, et al,2012).

In this study Axial projection was applied with brain and facial protocols as well as sagittal views for facial protocols. All of these protocols used two dimensional as localizer and Digital Imaging and Communications in Medicine (DICOM) files were rendered into three-dimensional reconstruction using Anatomize Invivo5 software. The cross-sectional images generated during a CT scan can be reformatted in multiple planes, and can even generate three-dimensional images. These images can be viewed on a computer monitor, printed on film or transferred to a CD or DVD. (White Sc, et al, 2009).

2.3.2 Other imaging modalities and techniques:

2.3.2.1 Lateral cephalometeric:

It is a technique uses to survey the skull, facial and mandible bones for evidence of trauma, diseases and developmental abnormalities. (Rehab. M: 2007).

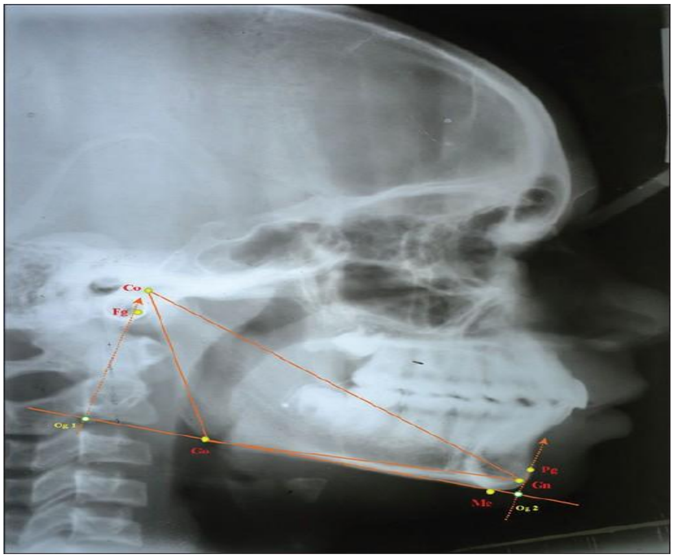

Fig.(2-19): Lateral cephalogram for mandible.

2.3.2.2 Lateral oblique:

It is a technique uses two oblique lateral projections to examine the mandible, one for the body and one for the ramus. This techniques cannot allow two sides in one film because it gives overlapping structures, so it need two views when there is a fractures bilaterally. (Rehab. M: 2007).

Fig.(2-20): lateral oblique of the mandible.

2.3.2.3 Ortho-Pan-Tomography(OPG):

It is radiological techniques to visualize the facial structures that include both the maxilla and mandibular dental arch and their supporting structures. This techniques has limitations which include uneven magnification, geometric distortion and give overlapping structures such as the cervicle spine as well as the mental foramen becomes more difficult to identify and may not be seen clearly. (Stewart C,etal: 1992).

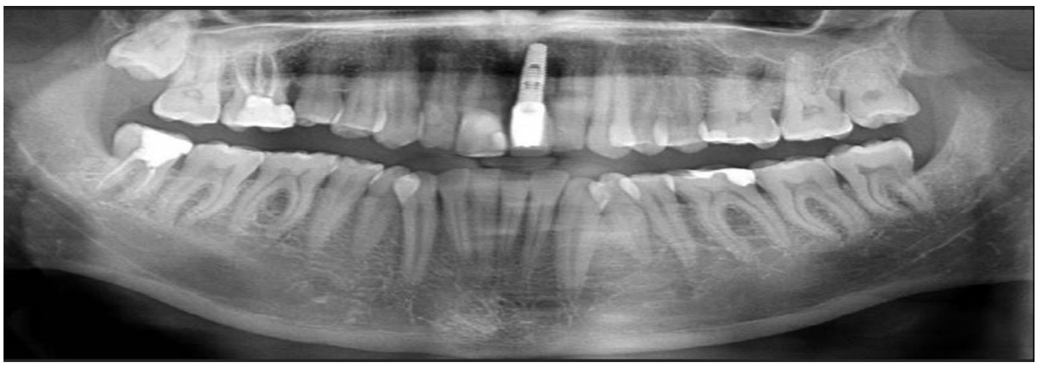

Fig.(2-21):Ortho Panto Tomography (OPG).

2.3.2.4 Cone Beam Computer Tomography (CBCT):

Cone beam CT (CBCT) is a new technology specially designed for dental clinical use. It quickly gains more popularity compared with micro-CT in measurement of density for mineralized tissue due to its adequate image quality and relatively lower radiation dosage. The effective dose of CBCT varies depending on devices and FOV (field of view) (Ludlow et al, 2006). Although radiation from CBCT is much lower compared with CT, it is still at least about 7-8 times higher than conventional panoramic radiographs (Ludlow et al, 2006). Other advantages of CBCT include high resolution level, low cost, fast scan and compact size for space saving (Arai et al, 1999).

Image quality of CBCT scans is influenced by a number of variables, such as the scanning unit, the field of view (FOV), scanning time, tube voltage and current, and voxel size (Kamburoglu et al, 2011). Voxel size can influence the characteristics of the final image in several ways: the smaller the voxel size, the greater the noise, the higher the resolution (Al-Rawi et al, 2010). Studies have shown that density values obtained by CBCT images varied depending on devices (Isoda et al, 2012). CBCT has been shown to be a reliable and appropriate tool for linear measurement of bony anatomic structures. However, presence of soft tissue and different voxel size affect the precision of the data. (Patcas et al, 2012). Study by Sun et al indicated that measurements of bone thickness in CBCT images with a voxel size of 0.25 mm were closer to the direct measurements than 0.4 mm images (Sun et al, 2011).

The CBCT scans were measured and analyzed by the principal investigator using SimPlant Pro Crystal computer software. The CBCT scans were segmented to create a three-dimensional skeleton. This was done through the software using thresholds based on differences in the permeability of the tissues to the x-rays.

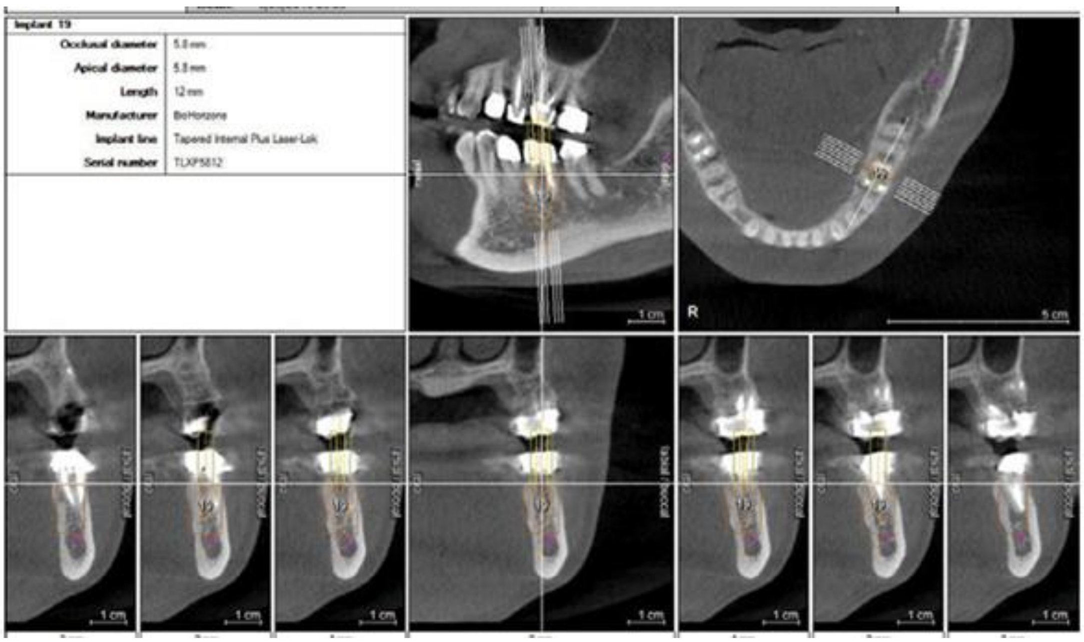

Fig. (2-22): Cone Beam Computer Tomography (CBCT) of the mandible

2.4 CT mandible measurement (Previous studies):

Studied on three dimensional CT measuring mandibles morphology in 54 normal Chinese adult. They found that there were significant between female and male when they measured the length, height, depth, thickness and angle of the mandiblular contour indicating that each individual has it own morphologic between male and female. (Chen Quan, et al: 2015).

Studied on Evaluation of normal anatomy of the mandible using three dimensional CT and orthopantomography, This study was conducted to assess the 3D CT and OPG techniques in demonstrating the anatomy of the mandible including body, ramus, symphysis menti and TMJ, lamina Dura, pulp canal, root of the teeth, mandibular canal, mandibular angle. Samples of twenty Sudaneseadult male patients of ages between (20-60years). Results of this study show that the OPG technique was the best in demonstrating the root of the teeth (45%), TMJ(10%), Ramus (15%), Lamina Dura (5%), where the 3D CT was the best in demonstrating mandibular angle, and body of mandible, ramus, smphysis menti for(95%), respectively, and TMJ for (70%). Both techniques failed to demonstrate pulp canal, and mandibular canal, (0%). (Caoline E Ayad, et al: 2012).

Studied on Correlation of the Gonial Cortical Width of Mandible with Age andGender60 adult human(male and female) OPG were evaluated and divided into six age groups (35-65 years) with equal on number of males and females. Gonial Index was measured bilaterally every radiograph. The measurements were analyzed for interactions with age and sex, They found that. The gonial index remained independent of age, but it was influenced by the variations of gender to a significant extent. (Bathala s, et al: 2008).

Studied on Comparison study on the 3D reconstruction of mandible according to Virtul Chinese Human slice data and CT data, this study resulted that To reconstruct 3D digital model of human bone by specific software is a beneficial way for our research. The 3D mandible model reconstructed by adopting virtual human slices is more accurate than that by adopting CT pictures. (Ming Chen, etal :2007).

Studied on Study of Position, Shape, Size and Incidence of Mental Foramen and Accessory Mental Foramen in Indian Adult Human Skulls, the study showed that None of the mandibles presented with bilateral accessory mental foramen. Shape was predominantly round with 94 percent on right side and 87percent on left side while it was oval in 6 percent on right side and 13 percent on left side. Average size of mental foramen was 2.79 mm on right side while it was 2.57 mm on left side. Average size of accessory mental foramen was 1.00 mm varying from 0.5 mm to 4.00 mm. Mental foramen was located below the apex of second premolar in 68.8 percent mandibles while it is 17.8percent between first and second premolars and in 11.5percent, it is between second premolar and first molar. Accessory mental foramen lies 0.67mm lateral to mental foramen and below the apex of first molar tooth (Rajani Singh, et al: 2010).

Studied on Human mandible and they found that For each mandible accurate measurements were taken for 22 variables namely, (1) Symphyseal height, (2) Coronoid height, (3) Minimum breadth of ramus, (4) Maximum breadth of ramus, (5) Height of ramus – right, (6) Height of ramus – left, (7) Body height, (8) Body thickness, (9) Body length,(10) Bigonial dimeter, (11) Bicondylar diameter, (12) Bimental breadth, (13) Mandibular angle, (14) Length of lower jaw, (15) Inter incisor width, (16) Inter premolar width, (17) Inter molar width, (18) Arch length, (19) Anthropometric arch length, (20) Anthropometric arch width, (21) Bicornoid width and (22) Mandibular index. The measurements were compared to the values of known sex to distinguish the sex of mandible. Every parameter, independent of other parameters provides certain percentage of certainty about the sex of mandible of unknown sex. This percentage of certainity significantly shifts when considered in combination with other parameters. Therefore, based only on one or two variables the sex of mandible cannot be decided. When all the variables are considered together and treated statistically, six factors have been extracted which could explain 75.2 percent of total variation in the data from all variables. Six dominating characters that possibly explain the nature of the mandible are (1) height of the ramus-right, (2) body thickness, (3) anthropometric arch width, (4) inter incisor width, (5) mandibular index and (6) mandibular angle. The present study reveals that mandibles of unknown gender can be sexed to the extent of 75 percent accuracy by carefully studying all the 22 parameters listed above and by statistically treating the data. (Tjayachandra Pillai, et al: 2014).

Studied on Computed Tomography Evaluation of Craniomandibular Articulation in Class II Division 1 Malocclusion and Class I Normal Occlusion Subjects in North Indian Population, the study resulted that There was no difference found in the condylar process and joint morphology between right and left sides of both Angle’s Class I normal occlusion and Angle’s class II division 1 malocclusion. Evaluation of the position of the condyles in their respective mandibular fossae showed concentric position with a tendency towards anterior positioning for both right and left sides of the subjects with Angle’s Class I normal occlusion as well as subjects with Angle’s class II division 1 malocclusion. (K. C. Prabhat: 2012).

Studied on Evaluation of Dentition and Mandibular Morphology of Egyptian Mummies through CT. Study used Eight DICOM files from CT Scans of mummy heads were obtained from The Field Museum in Chicago, IL. Using DICOM rendering software, 6 Egyptian mummies were evaluated dentally and 7 mandibular measurements were made. Researcher found that Dental evaluation revealed that each mummy had a high level of tooth wear and an average DMT score higher than modern day Americans. There was a statistically significant difference found in 6 mandibular measurements between ancient Egyptians and modern Egyptians and Americans. The observed high level of tooth wear is reflective of the coarse diet of ancient Egyptians and the higher DMT score could be accounted by absence of dental care in ancient Egypt. Changes in mandibular morphology follow trends found in other anthropology studies. In general, the mandibular morphology for Egyptians has changed from long and narrow to shorter and broader. (Michael. C. li: 2013).

Studied on Morphological Study of Mandible and they found that The triangular shape of lingula were 51% out of that male were 39% and female were 12%. The truncated shape of lingual were 13% out of that male were 11% and female were 2%. The nodular shape of lingula were 24% out of that male were 15% and female were 9%. The assimilated shape of lingula were 12% out of that male were 17% and female were 5%. The shape of coronoid process was triangular in 68%, Hook shaped in 24% and round shape in 8% of case, so the shape of coronoid process and lingula of mandible very helpful in anthropological and forensic practice. (Vikas. C. Desai, et al :2014).

Studied on The size variation and related implications of mandibles in northern China in the past7000 years. They found that to better understand variation of Holocene Chinese mandiblular morphology, a study was conducted on 23 metric traits of Neolithic(n=54), Bronze-Iron Ages (n=184) and modern(n=92) adult male mandibles from northern China. Results indicate that the linear characters of these Chinese mandibles evolved in the past 7000 years. From the Neolithic to Bronze-Iron Ages to present day, the overall size of mandibles decreased. The linear characters of the mandiblular features varied between different time periods. The decrease of thickness and height of the mandibular corpus primarily occurred during the Neolithic to Bronze-Iron Ages. The decrease in main size was during the Bronze -Iron Ages to present day. It is possible that mandibles became thinner before the overall size decreased. Comparisons also indicate that the bottom part of the face may have decreased more greatly in breadth than the upper portion. The decrease in mandible size may be associated with changes in climate and diet, and with changes in the craniums size. (Li Haijun, et al: 2012).

Studied on Mandibular Ramus and Gonial Angle Measurements as Predictors of Sex and Age in an Egyptian Population Sample: A Digital Panoramic Study. This study showed that Males statistically significant higher mean linear ramus measurements and lower meangonial angle values than females. Condylar and coronoid ramus heights were the most significant predictors for sex and age respectively. The discriminate function equation was: (D=14.698-1.895 Condylar ramus height) with an accuracy of 81% in males and77.9% in females and an overall accuracy of 79.6%. The regression equation for age, estimation in the whole studied sample was: (Age=-32.306+8.481 Coronoid ramus height)that yields no significance on comparing actual and estimated ages. As result of the selected Egyptian population sample, the mandibular ramus showed a high sexual dimorphism and proved to be beneficial in sex and age estimation; while, the gonial angle could assist in sex estimation only. (Noha Salih Abu taleb, etal :2015).

Studied on Morphological and Radiological Variations of Mandibular Condyles in Health and Diseases. They found that variability in the shapes and sizes of condyles should be an important factor in diagnosing the disorders of temporo mandibular joint. (Shruthi Hegde, et al: 2013).

Studied on Quantitative Analysis of Human Mandibular Shape Using Three-Dimensional Geometric Morphometrics. This study resulted visualization of size-related shape differences in the recenthuman sample suggests that only oneproposed Neanderthal mandibular trait, the retromolar gap, occurs in modern humans with increased centroid size (partially supportinghypothesis), a finding consistent with previous studies. (Elisabbeth Nicholoson, et al: 2006).

Studied on Radiographic study of the mental foramen in a selected Saudipopulation. This study has 400 patients using panoramic radiographs. It resulted that the commonest position of the mental foramen was in line with the longitudinal axis of the second premolar (45.3%) followed closely by location between the ®rst and secondpremolars (42.7%). The mental foramenwas symmetrical in80% of patients. Finally, they found that Clinicians should expect to ®nd the position of the mental foramen to besymmetrical and in line with the second premolar teeth. (NM AL Jasser, et al: 1998).

(Frank L,et al: 2003) studied on Comparison of Mandibular Landmarks from Computed Tomography and 3D Digitizer Data. They recorded 3D coordinates for 28 mandibular landmarks from three-dimensional reconstructions of CT axial slices using the image analysis programe TDIPS. The images were acquired from a pediatric series of human mandibles (neonate to 13 years of age) from the Bosma collection (Shapiro and Richtsmeier, 1997, Am. J. Phys. Anthropol. 103:415– 416).

To test the accuracy of these coordinate data, we recorded the same 28 landmarks directly on the Bosma mandibles using a Polhemus3Space digitizer. This study demonstrates that landmark coordinate data can be reliably collected from digital CT images of the human mandible. They define a set of mandibular landmarks useful in evaluating the effects of craniofacial disorders, growth and other biological processes.

Took a global perspective in investigating mandibular changes between hunter-gatherer and agriculturalist populations. Eleven populations from around the world were included and 6 11were categorized as agriculturalists and 5 as hunter-gatherers. The results of this study showed that agriculturalist populations have shorter and broader mandibles with taller and more angled rami and coronoid processes, and hunter-gatherer populations have longer and narrower mandibles with short and upright rami and coronoid processes. (Noreen Von Cramon: 2011).

Studied craniofacial variation on skulls from ancient Nubia. The skulls in the study were divided into three time periods and were as follows: hunter-gather (12,000 – 6,400 BC), transition (3,400 – 1,000 BC), and agricultural (350 – 1100 AD). Sixteen craniofacial measurements which included 8 mandibular measurements were taken. From the analysis, the authors concluded that there was a progressive decrease in size and robustness of the mandible in the transition from the hunter-gather to agricultural time periods. The authors propose that this decrease in the mandible is due primarily to change in masticatory function and diet. (Carslson, et al: 1977).

In the most recent CT scan study of an Egyptian Mummy, Pelo et al. (2012) evaluated dentition and performed cephalometric analysis on a 20-30 year old female Egyptian Mummy found in Fayum dating from the second century BC. In order to perform cephalometric analysis, the mandible was virtually positioned into the probable occlusion as the female was mummified with her mouth open. The cephalometric analysis was compared to the cephalometric analysis published in the Thekkaniyil et al. study in 2000 in which the mandible was also virtually repositioned to a closed position. Both analyses revealed similar measurements. The dental evaluation by Pelo et al. revealed a full dentition with good alignment, no tooth decay, one bony defect, and tooth wear. (Pelo, et al: 2012).

Studied on Egyptian mummy used high resolution CT scans of a mummified skull revealed absence of the anterior maxillary sinus walls, contiguous inferior orbital rims, zygomatic arches bilaterally, right zygoma, and right and left coronoid processes without evidence of external excisions on the scalp, face and jaw. It was hypothesized that these mutilations were part of a burial ritual, the "Opening of the Mouth" Ceremony. From the lack of excisions on the scalp, face and jaw, the author believed that the osteotomies were done intra-orally. To test whether performing the osteotomies would be possible using simple tools, the procedure was carried out on a human cadaver head. The CT scans were then taken to compare to the CT scans of the mummy head. (Peacock, et al: 2011).

The procedure was done without difficulty and the CT scans of the human head showed similar destructions as seen on the mummy head. This study was able to give insight into the mummification process through the use of CT scan.

studied on Linear measurements on CT Scan have been shown to be as accurate as direct measurements made with a digital caliper In their study, they compared linear measurements with a digital caliper on six human dry skulls with metal spheres at various anatomical landmarks to measurements acquired through CT scan and imaging software. A spiral 64 slice CT scanner scanned each skull set at 1 mm thick slices. The results showed that there was no significant difference between measurements throughout the mandible in all three planes of space and thus concluded that linear measurements on CT scan were just as accurate as digital caliper. (Varghese, et al: 2010).

Chapter Three

Material and Methods

Chapter Three

Material and Methods

3.1 Material

3.1.1 Equipment:

The equipment was used is CT Toshiba Aquilion (64slices) and Digital Imaging and Communications in Medicine (DICOM) files were rendered into three-dimensional reconstruction using Anatomize Invivo5 software. with parameters is used as below:

Table 3.1: Applied imaging machine:

X-ray machine	Type	Kv	mA	Time	Slice thickness	Interval space
CT Unit	Toshiba (64 slice)	120	300	0.75 sec	3mm - 5mm	2mm – 3mm

Fig.(3 -1): CT scan equimpent

3.2Methods:

3.2.1 Population of the study:

The study population was composed of patient (Male and female) presenting to the CT unit of Military Hospital in Khartoum during the period from December 2013 to June 2016.

3.2.2 Study sample:

The sample size consisted of 160patients with different age,sex and size (92men with a mean of age is (21-49) years and 68 women with a mean age of (23-45).

3.2.3 Inclusion criteria:

The radiographs that were clinically diagnosed as normal mandible with patients need CT brain and facial scan.

3.2.4 Exclusions criteria:

Any abnormality of mandible for example: fractures, infection, tumors and other mandible diseases.

3.2.5 methodology of data measurement:

The study selected 160 patients (male and female) with CT modalities (64slices) was used. axial projection was applied with brain protocols as well as sagittal views for facial protocols. All of these protocols used two dimensional as localizer and Digital Imaging and Communications in Medicine (DICOM) files were rendered into three-dimensional reconstruction using Anatomize Invivo5 software.

The mandibular is measured by selecting right and left mental foramina ,right ramus height, left ramus breadth, bicondylar breadth, bigonial breadth, Mandibular body length, mandibular symphysis height, Corpus width and left petrous bone length. All of these following mandibular land marks is measured as distance between two points in each of them as below:

Bicondylar breadth:

Distance between most lateral points on the two condyles.

Bigonial breadth:

Distance between right and left gonia (outer point on either side of the lower jaw at which the jawbone angles upward).

Mandibular body length:

Distance between most anterior margin of the chin to a line connecting right and left gonions.

Mandibular symphysis height:

Distance between infra dentale (apex of the septum between the mandibular central incisors) to gnathion (most inferior point of the mandible in the midline).

Corpus width:

Width measured at the region at the mental foramen..

Ramus height:

Distance between highest point of mandibular condyle to gonion.

Ramus breadth:

Minimum width of mandibular ramus from anterior to posterior.

Petrous bone length:

Distance between lateral border of petrous bone and base of the skull

3.2.6 Duration of the study:

This study was done during the period from September2013to September 2016.

3.2.7 Data collection

The data was collected by master data sheets using the variables of age, sex and size of skull patient.

3.3 Data analysis

Data were analyzed by using SPSS program and the results were presented in form of graphs and tables.

3.4 Ethical consideration

- No identification or individual details were published.
- No information or patient details will be disclosed or used for reasons other than the study.

3.5 Methods of three dimensional CT mandible techniques used:

The under taken techniques were CT brain and facial (mandible) protocols and procedures were done as follow:

3.5.1 Patient preparations:

The patient prepared by wearing comfortable, loose-fitting clothing and may be given a gown to wear during the procedure.

Metal objects, including jewelry, eyeglasses, dentures and hairpins which affect the CT images so they removed prior to exam. Also asked the patient to remove hearing aids and removable dental work and does not rotate.

3.5.2 Equipment preparation:

The CT scanner is typically a large, box-like machine with a hole, or short tunnel, in the center. The patient lied on a narrow examination table that slides into and out of this tunnel. Rotating around him, the x-ray tube and electronic x-ray detectors are located opposite each other in a ring, called a gantry. The computer workstation that processes the imaging information is located in a separate control room, where the technologist operated the scanner and monitors. The patient examination in direct visual contact and usually with the ability to hear and talk to him with the use of a speaker and microphone.

3.5.3 Patient position:

The patient was lied in CT exam table and positioned flat on the back (supine) Head was rested on the head holder so No rotation and no tilt of the head, Arms along the sides of the body, Straps and pillows was used to help the patient maintain the correct position and to hold still during the exam Next, the table was moved quickly through the scanner to determine the correct starting position for the scans. Then, the table was moved slowly through the machine as the actual CT scanning is performed.

3.5.4 Scan procedures:

Before the scan ,the light beam was positioned in 4 lines, sagittal, coronal and two transfer lights (external and internal)and A localizer radiograph was taken (Scout or or topogram view) .Also asked the patient to hold breath during the scanning.

Any motion, whether breathing or body movements, can lead to *artifacts* on the images. This loss of image quality can resemble the blurring seen on a photograph taken of a moving object. Axial scan started from the base of skull to mental proteburance with slice thickness (3 – 5)mm and interval space (1 – 3)mm.

When CT scanning, numerous x-ray beams and a set of electronic x-ray detectors was rotated around the patient, measuring the amount of radiation being absorbed throughout his or her body. the examination table will move during the scan, so that the x-ray beam follows a spiral path. Refinements in detector technology was allowed to obtain multiple slices in a single rotation, thinner slices so, obtaining in a shorter period of time, resulting in more detail and additional view capabilities.

A special computer program processes was applied to large volume of data to create two-dimensional cross-sectional images and was reconstructed to three dimensional with sagittal ,axial and coronal plane, which are then was displayed on a monitor or sending in CD, DVD and DICOM. Scan time is taken less than a minute and the entire process is usually completed within 10 minutes.

Chapter Four

Results

Chapter 4

Results

Tables and graphics:

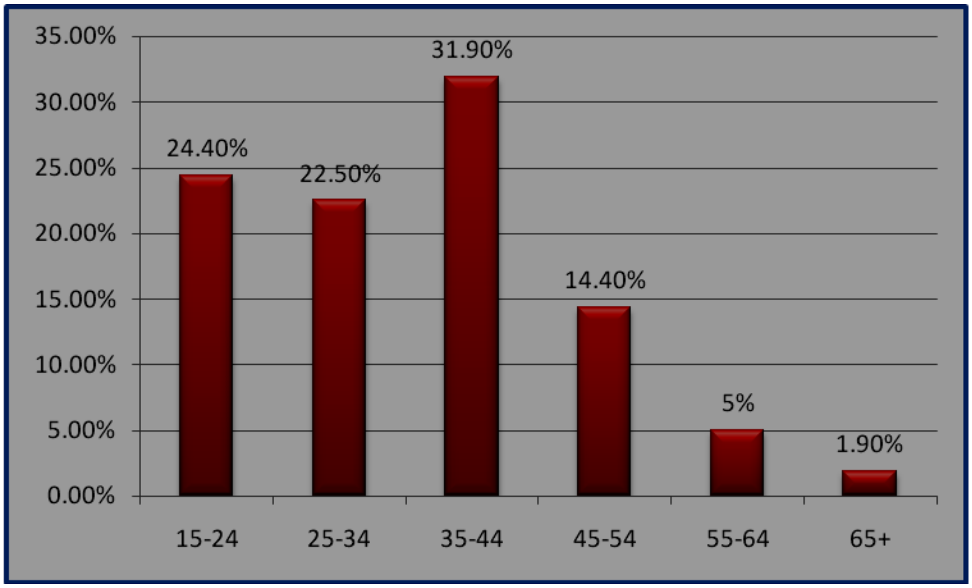

Figure 4 – 1: Distribution of the sample according to age classes, presented in percentages

Table4 - 1: Descriptive statistics of the mandible compartments mean, standard deviation, maximum and minimum value:.

	Bicondylar breadth*	**Bigonial breadth ***	**Mandibular body length***	**Mandibular symphysis height***	**Corpus width ***	**Right Ramus height ***	**Left Ramus breadth ***
***Mean**	112.9	93.8	85.6	34.9	8.9	60.9	33.5
Std. Deviation	7.6	9.9	7.5	1.9	6.6	42.6	2.3
Minimum	98.0	79.0	74.9	31.1	7.0	46.0	28.5
Maximum	131.9	116.0	106.1	43.1	92.0	594.0	43.2

Measurements were taken in (mm)

Table 4 - 2: Independent samples test shows the mandible compartment in both genders and p value:

	Gender	N	Mean	Std. Deviation	P-value
Bicondylar breadth	Male	92	115.24	7.013	0.000
	Female	68	109.81	7.35	
Bigonial breadth	Male	92	99.87	8.35	0.000
	Female	68	85.63	4.58	
Mandibular body length	Male	92	90.14	6.20	0.000
	Female	68	79.40	3.86	
Mandibular symphysis height	Male	92	34.30	1.98	0.000
	Female	68	35.76	1.60	
Corpus width	Male	92	9.57	8.71	0.126
	Female	68	7.94	.48	
Right Ramus height	Male	92	62.62	56.21	0.545
	Female	68	58.48	1.43	
Left Ramus breadth	Male	92	33.31	2.84	0.187
	Female	68	33.79	.99	

Table4 - 3: Independent samples test shows the mandible compartment classified according to different age

Anatomical Structure and age class		N	Mean	Std. Deviation	Minimum	Maximum	p-value
Bicondylar breadth	15-24	39	103.8410	6.75927	98.00	117.60	0.000
	25-34	36	114.2861	8.61109	102.00	131.90	
	35-44	51	116.3059	2.65024	110.90	120.00	
	45-54	23	116.0130	1.77157	113.30	118.40	
	55-64	8	118.1375	2.13404	115.50	120.00	
	>65	3	120.2667	.05774	120.20	120.30	
	Total	160	112.9369	7.62723	98.00	131.90	
Bigonial breadth	15-24	39	88.2667	10.90192	79.00	116.00	0.000
	25-34	36	99.3222	12.69457	81.30	115.30	
	35-44	51	94.9176	5.37206	87.70	103.10	
	45-54	23	93.6652	7.69702	85.80	105.20	

	55-64	8	87.4875	1.22058	86.20	89.80	
	>65	3	99.5000	.20000	99.30	99.70	
	Total	160	93.8219	9.93239	79.00	116.00	
Mandibular body length	15-24	39	84.1487	10.08007	74.90	106.10	0.005
	25-34	36	88.6222	7.71689	77.20	105.00	
	35-44	51	86.5314	4.68651	77.50	94.30	
	45-54	23	83.2522	6.90987	77.10	95.50	
	55-64	8	79.1250	.44320	78.60	79.70	
	>65	3	86.6333	.11547	86.50	86.70	
	Total	160	85.5813	7.53018	74.90	106.10	
Mandibular symphysis height	15-24	39	34.9179	1.85527	31.80	37.00	0.122
	25-34	36	35.4139	2.73236	31.10	43.10	
	35-44	51	34.3490	1.42610	32.10	36.70	
	45-54	23	35.3087	1.82680	32.30	37.50	
	55-64	8	34.9375	1.32011	33.60	37.50	
	>65	3	36.1333	.15275	36.00	36.30	
	Total	160	34.9281	1.96309	31.10	43.10	
Corpus width	15-24	39	10.3231	13.43280	7.50	92.00	0.768
	25-34	36	8.7944	.82978	7.50	10.50	
	35-44	51	8.2118	.64549	7.00	9.50	
	45-54	23	8.3435	.50975	7.40	9.10	
	55-64	8	8.2750	.38822	7.80	8.80	
	>65	3	8.4000	.10000	8.30	8.50	
	Total	160	8.8831	6.64601	7.00	92.00	
Cont.							
Anatomical Structure and age class		N	Mean	Std. Deviation	Minimum	Maximum	
Right Ramus height	15-24	39	70.3872	86.28324	46.00	594.00	0.766
	25-34	36	57.9417	3.18159	53.40	68.70	
	35-44	51	58.1490	2.12559	52.90	63.80	
	45-54	23	56.4870	2.34100	51.70	60.00	
	55-64	8	58.2625	.26693	57.70	58.50	

	>65	3	58.9000	.10000	58.80	59.00	
	Total	160	60.8663	42.58401	46.00	594.00	
Left Ramus breadth	15-24	39	32.5590	2.99848	28.50	38.50	0.001
	25-34	36	34.8306	1.87095	32.90	43.20	
	35-44	51	33.5118	1.93366	31.30	37.90	
	45-54	23	33.4957	1.40178	31.90	35.70	
	55-64	8	32.6875	1.34104	31.80	35.90	
	>65	3	32.7333	.05774	32.70	32.80	
	Total	160	33.5181	2.26015	28.50	43.20	

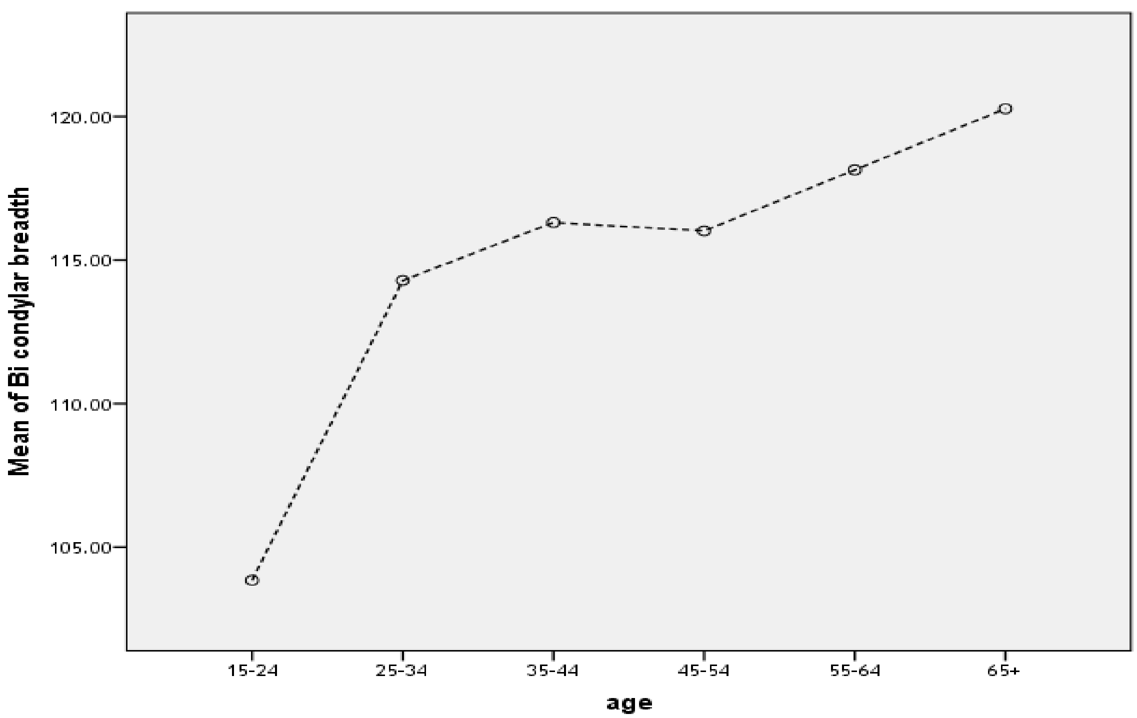

***Figure 4 - 2: Correlation coefficient shows the relation between the patient's age and Bi condylar breadth* (R^2=0.360)**

Table 4 - 4: The New established equations For Sudanese considering the Bi condylar breadth and patients ages .

Coefficients				
Model		Un standardized Coefficients	t	Sig.
		B		
	(Constant)	99.845	67.933	.000
	Age	.371	9.433	.000

Dependent Variable: Bi condylar breadth

The New established equations For Sudanese are as follows

Bi condylar bread = 4.99.84+ (Age X 0.371).

Table 4 - 5 shows the classification of age classes presented in frequency and percentages

age classes	Frequency	Percentages (%)
15-24	39	24.4
25-34	36	22.5
35-44	51	31.9
45-54	23	14.4
55-64	8	5.0
65+	3	1.9
Total	160	100 %

Table 4 - 6 shows the mean and standard deviation of patients ages, Right and left Foramen Width/(MM)

Statistics	**Age/Years**	**Right Foramen Width/(MM)**	**Left Foramen Width(MM)**
Mean	35.2625	4.2881	3.5338
Std. Deviation	12.33112	2.30409	.57263
Minimum	15.00	3.10	2.40
Maximum	75.00	5.10	5.20

Table 4 – 7: Independent Samples Test shows the difference between the genders for both right and left foramen width

Group Statistics					
	Gender	N	Mean	Std. Deviation	P-value
Right Foramen Width	Male	92	4.2348	.62025	0.035
	Female	68	4.3603	3.47375	
Left Foramen Width	Male	92	3.6337	.57480	0.010
	Female	68	3.3985	.54513	

Table 4- 8: Descriptive Statistics both right and left foramen width classified according to age groups

		N	Mean	Std. Deviation	Minimum	Maximum	P-value
Right Foramen Width	15-24	39	4.3718	.41292	3.70	5.70	.028
	25-34	36	4.5333	.67146	3.10	5.80	
	35-44	51	3.8039	.38934	3.30	4.80	
	45-54	23	5.0957	5.95792	3.20	32.40	
	55-64	8	3.6500	.24495	3.40	4.20	
	65+	3	4.0000	.10000	3.90	4.10	
	Total	160	4.2881	2.30409	3.10	32.40	
Left Foramen Width	15-24	39	3.6308	.38468	3.10	4.50	.000
	25-34	36	4.0500	.75043	2.40	5.20	
	35-44	51	3.2745	.38306	2.50	4.20	
	45-54	23	3.2391	.35896	2.40	3.70	
	55-64	8	3.2000	.21381	2.90	3.60	
	65+	3	3.6333	.05774	3.60	3.70	
	Total	160	3.5338	.57263	2.40	5.20	

Table 4 - 9: Correlation coefficient between the right mandibular foramen width with age .Significant at p≤0.005

	Correlations		
Model	Un standardized Coefficients B	t	Sig.
(Constant)	4.343	7.824	.000
Age	-.002	-.105	.017

The New Established Equation to predict the right mandibular foramen width for Sudanese with known age.R^2=0.084
Right mandibular foramen width= 4.343+(AgeX-0.002)

Table 4 – 10: Correlation coefficient between the left mandibular foramen width with age .Significant at p≤0.005

	Correlations		
Model	Un standardized Coefficients B	t	Sig.
(Constant)	4.025	30.583	.000
Age	-.014	-3.953	.000

The New Established Equation to predict the left mandibular foramen width for Sudanese with known age.R^2=0.090
Left mandibular foramen width=4.025+(AgeX-0.014)

Chapter Five

Discussion, Conclusion and Recommendation

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

5.1.1 Mandible structures:

The mandible is the largest and hardest facial bone and retains its shape better than other bones in the forensic and physical anthropologic field. The mandible can be used to distinguish among ethnic groups and between genders. (James D. Raj et al: 2013).

The study used the three dimensional CT images, since these images allow for more accuracy in the obtained measurements compared with the previous studies. (Roshanak Ghaffari et al: 2013).

Distribution of the sample according to age classes was presented in percentages (Figure :4 -1) and the most frequently presented age group was the group of age between 35-44years old. The mean measurements of the Sudanese mandible components were presented in (Table 4 - 1).

The current study showed that the measurements in both male and female subjects were statistically differ in bicondylar breadth, bigonial breadth, and mandibular body length. The males have greater measurements than females and the difference was significant at $p \leq 0.000$. The mandibular symphysis height was statistically greater in females than males (Table:4-2), similar findings was mentioned by Roshanak et al; 2013. In each three studies; the mean of bigonial width in men was greater than in women. (James D. Raj etal: 2013, Pessa JE:2008, Shaw RB Jr etal: 2010).

In another study run by (Pecora et al., 2008),it was found that women had a downward and backward rotation in mandible but men had a forward rotation in mandible. Hence, the increase in mandibular angle in females is more than in men. this may be the cause of the difference between the two genders.

Studies mentioned that mandibular ramus can differentiate between genders, as the stages of mandibular development, growth rates, and duration are distinctly different in both genders. In addition, masticatory forces exerted are different for males and females, which influences the shape of the mandibular ramus. (James D. Raj etal: 2013). Study done by (Steyn et al:1998) showed bigonial breadth was the most dimorphic of the measurements taken .No significant difference was observed in mandibular angle in sex determination in the young Lebanese population aged between 17 and 26 years. (Ayoub F, et al: 2009).

Various parameters have been used for sexing the mandible. Studies done by Loth et al, on their nonmetric examination on South African sub adult samples claimed that, shape differences in the symphyseal region and anterior body of the mandible can be used to predict sex with above 80% accuracy. In a blind test of that technique, however, Scheuer showed that when applied to different population samples, sex classification accuracy declined considerably to 64%. The most accurate single indicators among cranial methods were the robustness of the mandible with accuracy of 70.93% (Duric, M,etal: 2005).

Many variables showed significant differences which includes: bicondylar breadth, gonial angle and minimum ramus breadth according to study done by Kharoshah et al. (Kharoshah Ma, et al: 2010).

In Sudanese population, the mean bi bicondylar breadth, bigonial bridth mandibular body length and left ramus breadth changed significantly with increasing age (Table :4-3). Comparing with other populations; one study showed that, the mean of bigonial width did not change significantly with increasing age. (Roshanak Ghaffari etal:2013)In a similar study by Shaw et al. (Shaw RB Jr,etal: 2010) . on 3D CT images, also the mean of bigonial width did not change significantly with increasing age. Sudanese measurements were differ from other populations.

Results of (Roshanak Ghaffari etal:2013) and (Shaw RB Jr,etal: 2010)were different from that of (Pessa et al: 2008) , Pessa Je et al:. evaluated the frontal radiographs and reported that there was an increase in mandible width and height with increasing age. The current results mentioned that mandibular body length, left ramus breadth were significantly increased in measurements as the age increases at $p \leq 0.005$ and $p \leq 0.001$.The changes in measurements may be due to the fact that some areas continued to grow faster than other areas. The measurements starts to increased during the ages starting from 15-24 years, 25-34years then decreased after the age of 45-54years and 55-64 years .Similar study has mentioned that the changes were in maturity period (Pessa et al: 2008)

Correlation coefficient shows the relation between the patient's age and bi condylar breadth ($R^2=0.360$) the contribution of the age to do changes in bi condylar breath is 36%. As the age increases the bicondylar breadth will also be increased significantly at $p \leq 0.000$. These were presented in (Table:4 - 4) and (Figure: 4 - 2).

5.1.2 Mental foramen (MF):

When reviewing the literature regarding morphometric analysis of the MF based on multi-slice computed tomography, no detailed data has been found. The current study provides new data on the width of the MF in a Sudanese population. When practicing dental surgery, orthodontic treatments, maxillofacial trauma, and ortho gnathic procedures such as a mandibular body osteotomy, in order not to cut or damage the mental nerve, it is important for the operator to know exactly the morphology of MF.(Anesth Prog :1989).Tables:(4 -5) and(4-6) show the classification of age classes presented in frequency and percentages as well as the mean values of the right and left MF width measured for Sudanese.

Radiography is the non-invasive method for diagnosis and treatment planning of major surgical procedures of the mandible. (Kaffe. I, etal: 1994). Panoramic radiographs usually are limited due to horizontal overlap of teeth (Yosue. T, et al: 1989) distortion and magnification in orthopantomogram techniques cannot be eliminated, in addition, as the bone density increases, the foramen becomes more difficult to identify and may not be seen clearly. CT has been the first option for diagnosis, surgical planning, and treatment of osseous trauma injuries due to its high specificity and sensitivity.(Utumi ER,etal:2009).As a result of recent advances in computer hardware and software; 3D imaging by CT scans of craniofacial anomalies is routinely used by most medical centers to define the unique individual aspects of complex anatomy, plan interventions and follow results(Cavalcanti MG,etal:1998).

Therefore, we utilized CT images because they have certain advantages in diagnostic medicine. In our series of 160 CT images, the width of the MF has been measured; it was found that there is a significant difference between the males and females for both right and left MF width at $p \leq 0.035$ and 0.010 respectively (Table:4 -7).

Studies have mentioned that the MF morphology, varies not only according to age(A. Gershenson H,etal: 1986)gender (Souaga K, et al: 2004, Danny R, et al: 1998) and ethnicity;(Zivanovic S,etal:1970, Santini A,etal:1990)but even within the same race; in different geographic regions

(Phillips JL,etal:1992, Weller RN,etal;1992, Lindh C, etal:1995)and within the inhabitants of the same geographic area (Ari I Kafa IM,etal:2005).

Age difference was also been evaluated and it was found that the age can affected significantly the measurements of MF width (Table :4 - 4) One of the most striking characteristics of The Sudan is the diversity of its people. The Sudanese are divided into multiple ethnic groups and subgroups. identifying ethnic groups in Sudan was made more complicated by the multifaceted character of internal divisions. Largest ethnic category comprises those considering themselves Arabs, but category internally split by regional and tribal loyalties and affiliation to various groups. Major groups are Nubians and nomadic Beja dwelling in parts of North Africa, and Fur in west. Southern groups include Dinka form the largest portion of the national population (Black), Nuer, and numerous smaller Nilotic and other ethnic groups. Therefore characterization of MF for each tribe is essential. However we characterize MF for Sudanese living in Khartoum State and not considering their origin or tribe which may consider as limitation in our study.

A new equation to predict the right mandibular foramen width for Sudanese living in central Sudan at the capital (Khartoum) with known age was established.

Right mandibular foramen width= 4.343+ (AgeX-0.002), $R2=0.084$. For the left mandibular foramen width: Left mandibular foramen width=4.025+ (AgeX-0.014), $R2=0.090$, these are presented in (tables:4-9 and 4-10).

The measurements of Sudanese differ from other populations. Data from various ethnic groups including Tanzanian, Thai, Chinese, British, Saudi Arabian vary regarding the characterization of MF.A review by

(Green (1987) demonstrated a clear racial trend in the characterization of the MF [34] According to (Mbajiorgu et al:1998),in 32 mandibles of black adults from Zimbabwe had mentioned that MF was either round or oval. The study suggest that this may be a factor that may change the MF width. (Oliveira Junior et al:2009) reported that the shape was found to be oval with Larger diameter in the horizontal direction. Regarding the size of the mental foramen and according to (Chung et al:1995); horizontal opening of MF was 2.4 mm and (Apinhasmit et al:2006)reported the average horizontal opening was 2.8mm. (Oguz O,etal:2002) did measurements in 34 dry mandibles of people from Turkey. The horizontal dimension of MF was 2.93mm on right side and 3.14 mm on left side. (Souaga K, et al :2004) studied 61 dry mandibles. The average sizes of the short axes of foramina were 3.97 mm for males while dimensions of female mandibles was 3.87 mm. The present observations brought out average horizontal dimension of MF to be 4.29 mm on right side and 3.53 mm on the left side. This was considered to be greater than other previously studied populations.

5.2 Conclusion:

- The anatomy of the mandible structures is of interest to many radiological field and they should have acknowledge of normal mandible morphology so as to determine the presence of abnormality and to help in surgical planning. This study presents a new morphologic indicator of age and gender in the human mandible.
- Regarding to morphmetry of mandibular structures, the current study predict that the bi condylar width for Sudanese if their ages were known, A new equation was established in order to standardize a local reference or measurements for Sudanese mandibles.
- Regarding to the mental foramen (MF),The present analysis revealed variations in width of MF of Sudanese from other populations. The MF width differ according to age and gender.

5.3 Recommendations:

- The dentist, surgeon, radiological technologist and radiologist should be familiar with the anatomical structures variations of mandible to achieve the widest exposure with the best surgical outcome.
- The current study covered just measuring the right ramus height and left ramus breadth, so the future studies can continues in both right and left of them.
- Future studies are needed to further confirm the result acquired with this study for mandible and petro us bone.
- Future studies are recommended for mandible structures measurement in different Sudanese state and tribe since Sudan rich with ethnic diversity.
- Future studies is recommended to measure both mental foramen width and length in Sudanese and compare it with other population

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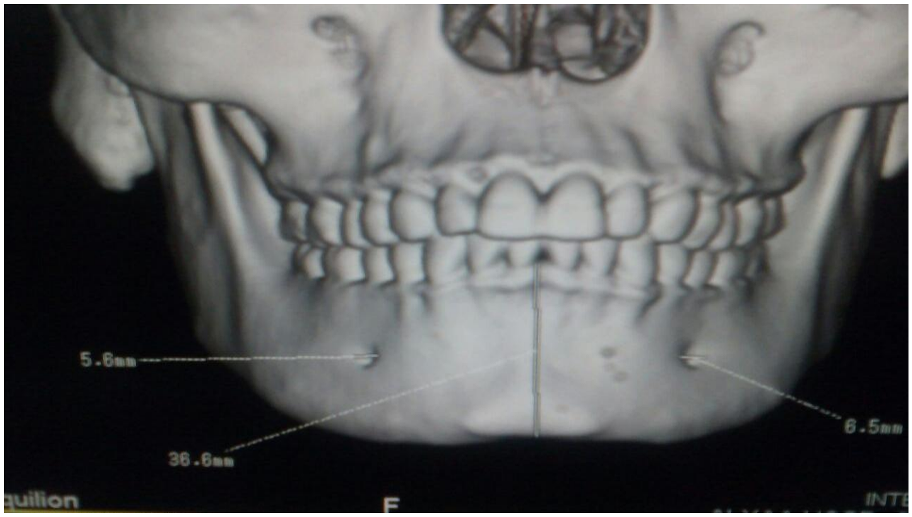
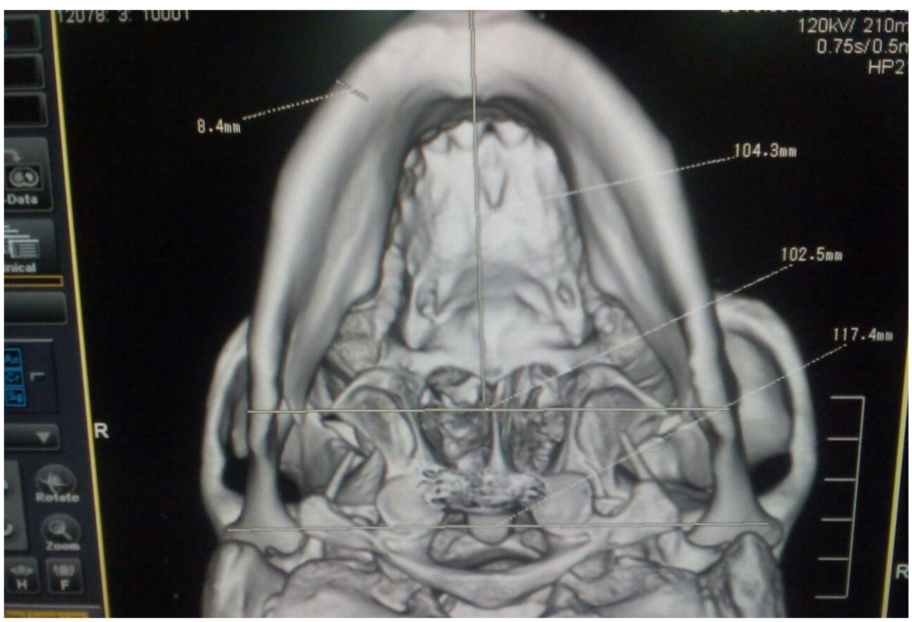
Appendixes

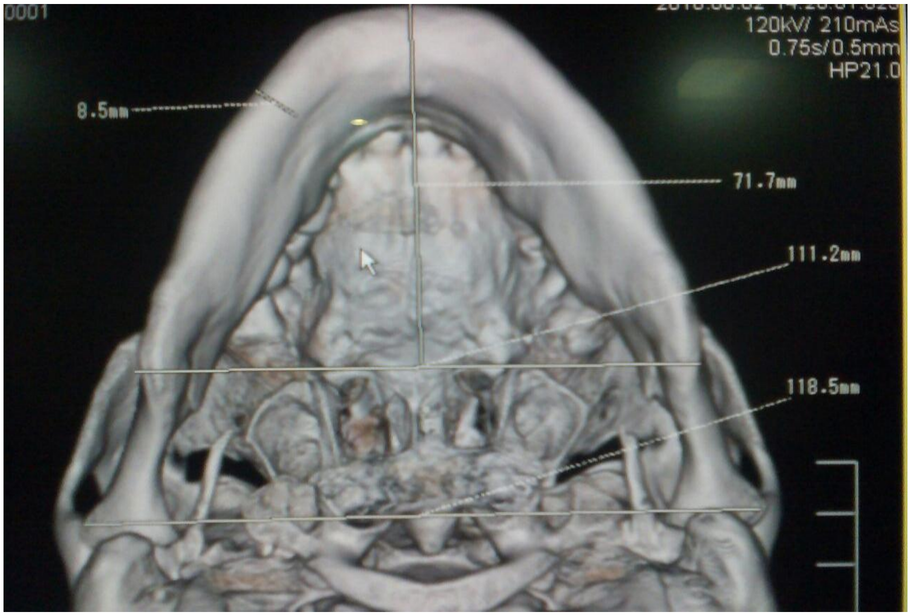
Appendix



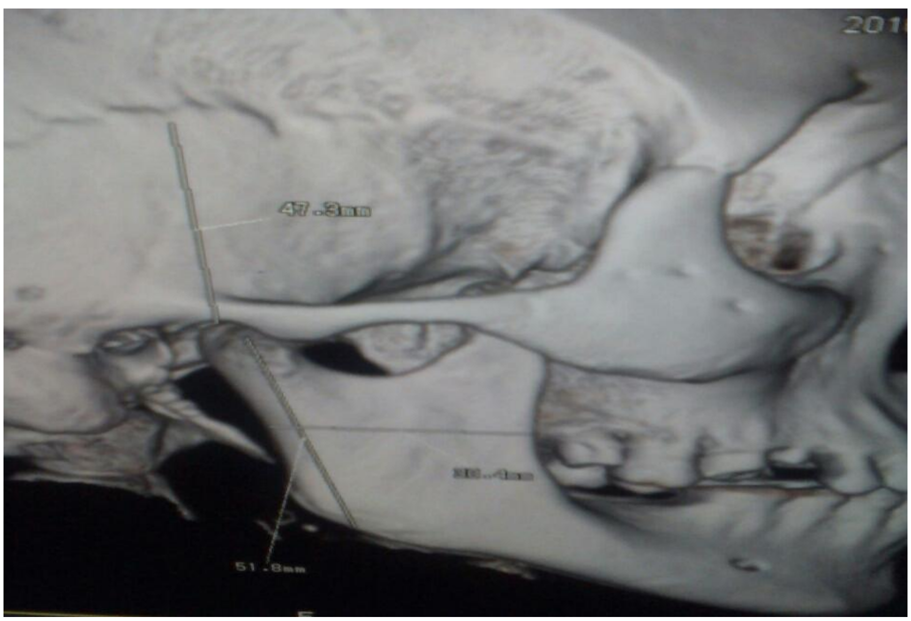
Appendix (1): CT mandible 3D reconstruction measurement for male patient 40 years old with Rt mental foramen(5.6 mm), Lt mental foramenwidth (6.5 mm)and mndibular symphasis height (36.6 mm).



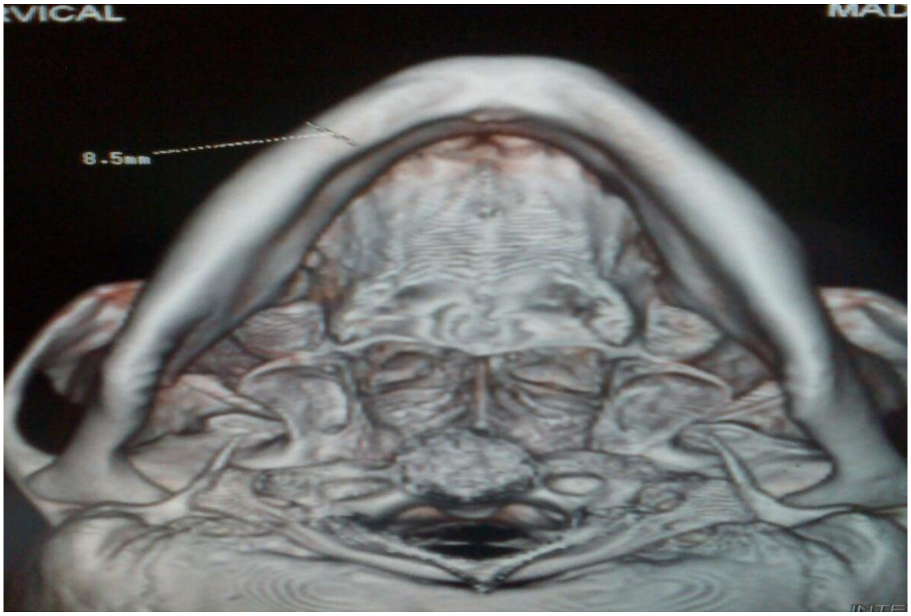
Appendix (2): CT mandible 3D reconstruction measurement for male patient 22 years old with mandibular body length (104.3 mm), bigonial breadth (102.5 mm), bicondylar breadth (117.4 mm) and corpus width (8.4 mm).



Appendix (3): CT mandible 3D reconstruction measurement for 22 years old female patient with mandibular body length (71.7mm), bigonial breadth (111mm), bicondylar breadth (118 mm) and corpus width (8.5 mm).

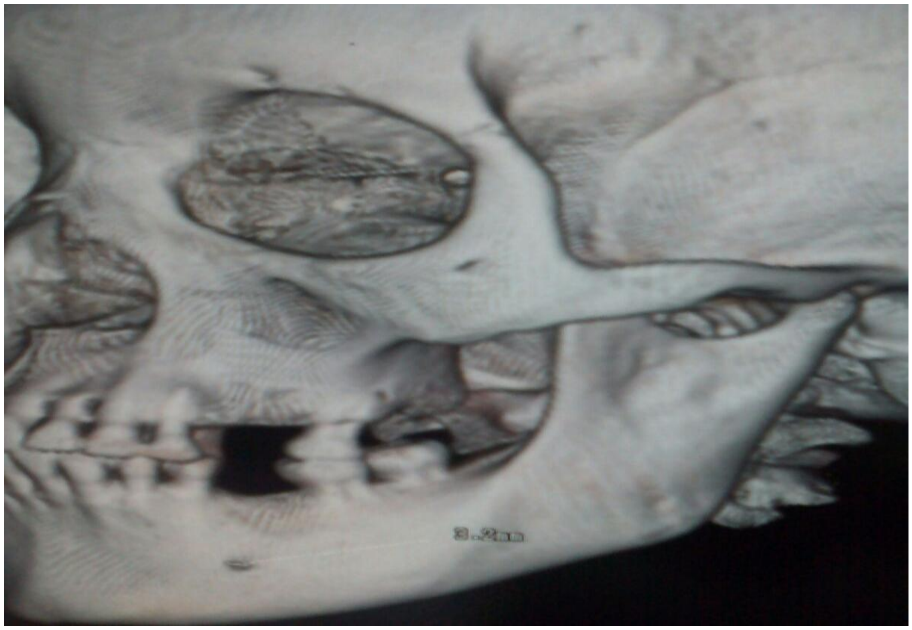


Appendix(4): CT mandible 3D reconstruction measurement for male patient 55 years old with Ramus height (51.8 mm), ramus breadth (30.4 mm)and pterous bone length (47.3 mm).



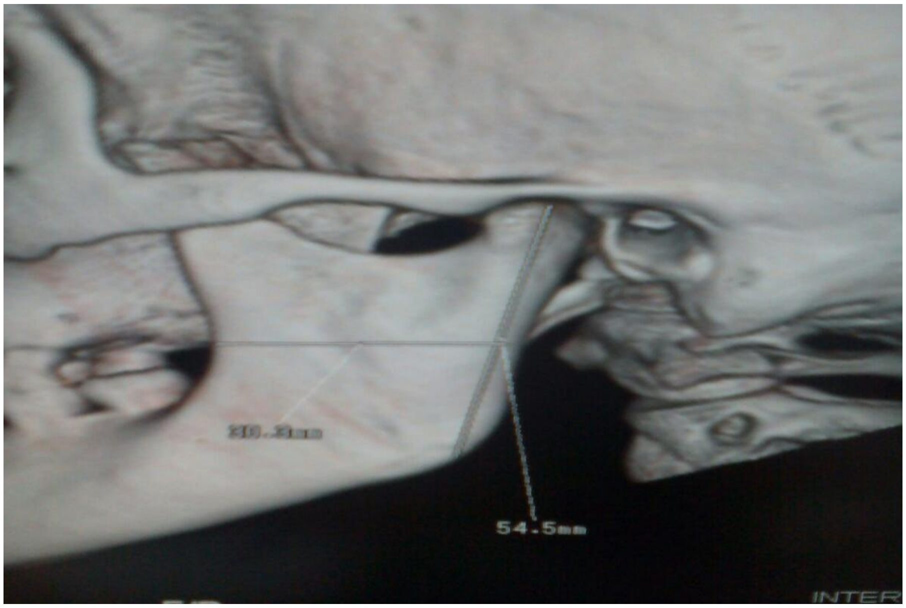
Appendix (5): CT mandible 3D reconstruction measurement for female patient 37 years old with corpus width (8.5 mm).

Appendix (6): CT mandible 3D reconstruction measurement for female patient 18 years old with mandibular symphasis height (37.1 mm).

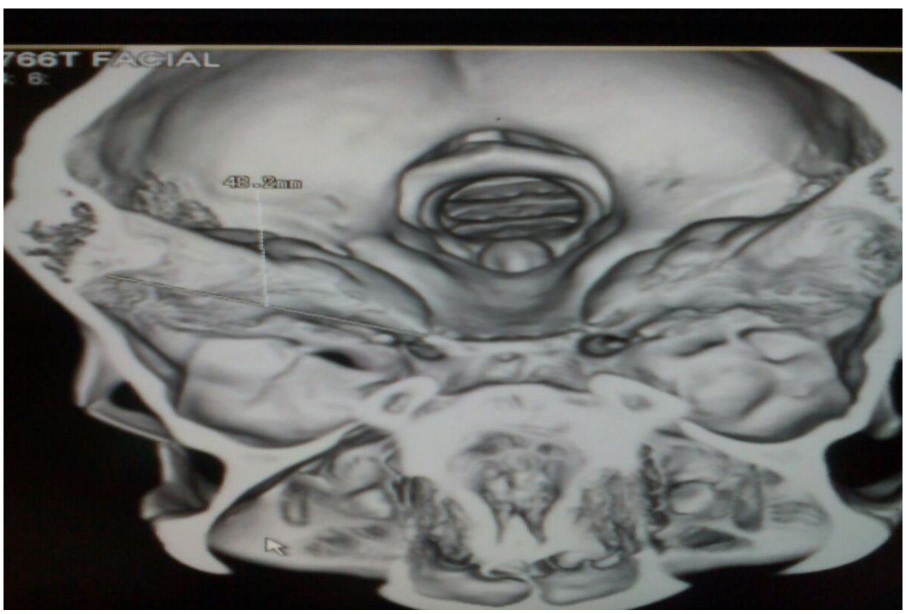


Appendix (7): CT mandible 3D reconstruction measurement for female patient 53 years old with Lt mental foramen width (3.2 mm).

Appendix (8): CT mandible 3D reconstruction measurement for male patient 35years old with mandibular body length (88.6 mm), bigonial breadth (93.1mm), bicondylar breadth (116.3 mm).



Appendix(9): CT mandible 3D reconstruction measurement for male patient 60 years old with Ramus height (54.5mm), ramus breadth (30.3 mm).



Appendix(10): CT mandible 3D reconstruction measurement for female 48 years oldpatient with petrous bone length (48.2 mm).

Date collection sheet

No	Patient information		Mandible Structures								
	Age	Gender	Bi condylar breadth	Bi gonial width	Mandibular Body length	Mandibular symphasis Breadth	Corpus width	Rt Ramus height	Lt Ramus breadth	Mental foramen (Lt/Rt)	Petrous bone length

Normative Morphometry of adult Sudanese mandible: A 3D Computerized Tomography based Study

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Abstract :
Mandible being largest and strongest bone of skull, having various morphological features may show changes with reference to age, gender and race. The aim of this study is to characterize the mandible and to find out if there is age /gender related deference and was designed to establish a local reference for the Sudanese mandible measurement

In this descriptive study, the facial CT scans were obtained from 160 subjects (92males and 68 females .The population of the study was categorized in six ages (15to24, 25to34, 35to44, 45to54, 55to64 and ages> 65 years old). Volume rendering three-dimensional reconstruction by using the three dimensional analysis software volume viewer was used. The specific parts of mandible were measured and the data were analyzed using SPSS program version 16.Results showed that the Bicondylar breadth, Bigonial breadth, Mandibular body length and Mandibular symphysis height, differ significantly between the two genders at $p \leq 0.000$, Correlation coefficient shows a significant relation between the patient's age and Bi condylar breadth (R2=0.360).A New established equation and a local reference for Sudanese regarding the Bicondylar breadth measurement was established.

This study presents a new morphologic indicator of age in the human mandible for Sudanese.

Keywords - Age; 3D Computerized Tomography; Mandible

I. Introduction

The mandible is the strongest bone of facial skeleton and the best preserved after death. [1].The sex differences are well marked in the bony pelvis and skull. Sex determination from a given bone of an individual is of great value for medical jurist who often gives expert opinion from the available skeletal remains. Skull is the most dimorphic and easily sexed portion of skeleton after pelvis. [1] As a component of the skull, mandible shares the character. The study of identification of sex for a single bone is important medico legally and anthropologically. If the mandible alone is available; besides gender, age and race also can be determined. Mandible, maxilla and teeth are best preserved parts of the body after death. The mandible has been extensively in ancient studied (Martin 1936, Morant 1936, Stewart 1954 [2,3,4]. Their work was based on biometric study, mathematical methods. Studies took into account that males differ than females, Diwan (1987) [5] Facial aging is a dynamic process involving bony structures. The age related changes of bony morphology are not well defined.[6] Previous researches focused on changes in soft tissue and skin with aging but changes in bones and facial skeleton significantly affected the aging face [7] Any kind of changes in the mandibular projection, width, or height can affect the overall aesthetics.[8] Reshaping of the face with ageing is the result of volume changes and loss of support.[9]

The ability of CT imaging to display fine bone details, makes it an ideal modality for lesions that involve bone. The three-dimensional CT has been applied to trauma and craniofacial reconstructive surgery, and has been used for treatment of congenital and acquired deformities.[10] Early literature analyzing facial bone aging, focused on the orbit and mid face. It was believed that the bony face continued to grow with age, particularly with the increase in facial width and depth. In contrast, many recent studies suggest that the bone aging of the facial bone is a process primarily of contraction and morphologic changes. [7, 8, 11]In a study which was carried out by Shaw et al. on 3D CT images, it was revealed that there were no significant changes in bigonial width and ramus breadth across ages in both genders. Ramus height, mandibular body height and mandibular body length decreased with age for both genders and mandibular angle increased in both genders across ages.[7]

Raising the knowledge of mandible changes with age has been highly essential due to an increasing demand for facial treatment. The aim of this study is to characterize the mandible and to find out the norms and to study if there are age and/ or gender related deference. To the best of our knowledge no studies have been published in the open literature regarding the characteristics of the mandible in Sudanese population using 3DCT.Therefore this study was designed to establish a local reference for the Sudanese norms of the mandible compartments measurements.

Equipment:-

The equipment required is CT Toshiba Aquilion(64slices) and three dimensional reconstruction system with parameters is used as below: Kv=120 ,mA=300, Time =0.75sec ,mAs =225 ,Slice thickness=3mm-5mm.

Methods of data measurement:-

This is a descriptive analytical study that deals with scanning patients head (brain and facial structures).The study selected 160 patients (males and females) with CT (64slices). Axial projection was applied with brain protocols as well as sagittal views for facial protocols. All of these protocols used two dimensional as localizer and Digital Imaging and Communications in Medicine (DICOM) files were rendered into three-dimensional reconstruction using Anatomize Invivo5 software.The mandible was measured by selecting, right ramus height, left ramus breadth, bicondylar breadth, bigonial breadth, Mandibular body length, mandibular symphysis height, Corpus width and left petrous bone length. All of these following mandibular land marks are measured as distance between two points in each of them as below:

Bicondylar breadth: Distance between most lateral points on the two condyles.

Bigonial breadth: Distance between right and left gonia (outer point on either side of the lower jaw at which the jawbone angles upward).

Mandibular body length: Distance between most anterior margin of the chin to a line connecting right and left gonions.

Mandibular symphysis height: Distance between infradentale(apex of the septum between the mandibular central incisors) tognathion (most inferior point of the mandible in the midline).

Corpus width: Width measured at the region at the mental foramen..

Ramus height: Distance between highest point of mandibular condyle to gonion.

Ramus breadth: Minimum width of mandibular ramus from anterior to posterior.

Petrous bone length:Distance between lateral border of petrous bone and base of the skull

Study Population:-

The study population was composed of both genders presenting to the CT unit of Military Hospital in Khartoum during the period from December 2013 to June 2016.The sample size consisted of 160 patientswith different age, sex (92males and 68 females)The radiographs that were clinically diagnosed as normal mandible were included. Any abnormality of mandible for example: fractures, infection, tumors and other mandible diseases were excludes.

Technique:

The patients were positioned supine on the CT examination table and head is rested on head holder while removing all metallic and jewelry, straps and pillow were used to help in maintaining the correct positioning , the scan started from base of the skull and end inferior to mental protuberance as well as image were produced in axial projection. Three dimensional volume rendering technique was applied to reconstruct the image data of patients (analytical software) uses several types of reconstruction algorithm with different planes .

Ethical consideration:-

-No identification or individual details were published.

-No information or patient details were disclosed or used for reasons other than the study.

II. Results

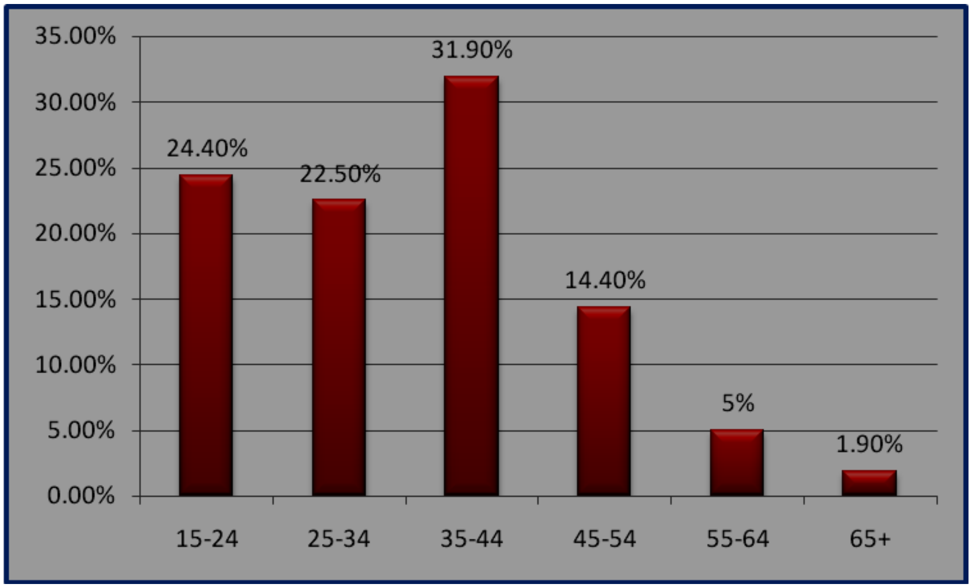

Figure (1): Distribution of the sample according to age classes, presented in percentages.

Table (1): Descriptive statistics of the mandible compartments mean, standard deviation, maximum and minimum values.

	Bicondylar breadth*	**Bigonial breadth***	**Mandibular body length***	**Mandibular symphysis height***	**Corpus width***	**Right Ramus height***	**Left Ramus breadth***
***Mean**	112.9	93.8	85.6	34.9	8.9	60.9	33.5
Std. Deviation	7.6	9.9	7.5	1.9	6.6	42.6	2.3
Minimum	98.0	79.0	74.9	31.1	7.0	46.0	28.5
Maximum	131.9	116.0	106.1	43.1	92.0	594.0	43.2

Measurements were taken in (mm)

Table (2): Independent samples test shows the mandible compartment in both genders and p value

	Gender	N	Mean	Std. Deviation	P-value
Bicondylar breadth	**Male**	**92**	**115.24**	**7.013**	**0.000**
	Female	**68**	**109.81**	**7.35**	
Bigonial breadth	**Male**	**92**	**99.87**	**8.35**	**0.000**
	Female	**68**	**85.63**	**4.58**	
Mandibular body length	**Male**	**92**	**90.14**	**6.20**	**0.000**
	Female	**68**	**79.40**	**3.86**	
Mandibular symphysis height	**Male**	**92**	**34.30**	**1.98**	**0.000**
	Female	**68**	**35.76**	**1.60**	
Corpus width	**Male**	**92**	**9.57**	**8.71**	**0.126**
	Female	**68**	**7.94**	**.48**	
Right Ramus height	**Male**	**92**	**62.62**	**56.21**	**0.545**
	Female	**68**	**58.48**	**1.43**	
Left Ramus breadth	**Male**	**92**	**33.31**	**2.84**	**0.187**
	Female	**68**	**33.79**	**.99**	

Table (3): Independent samples test shows the mandible compartment classified according to different age

Anatomical Structure and age class		N	Mean	Std. Deviation	Minimum	Maximum	p-value
Bicondylar breadth	15-24	39	103.8410	6.75927	98.00	117.60	0.000
	25-34	36	114.2861	8.61109	102.00	131.90	
	35-44	51	116.3059	2.65024	110.90	120.00	
	45-54	23	116.0130	1.77157	113.30	118.40	
	55-64	8	118.1375	2.13404	115.50	120.00	
	> 65	3	120.2667	.05774	120.20	120.30	
	Total	160	112.9369	7.62723	98.00	131.90	
Bigonial breadth	15-24	39	88.2667	10.90192	79.00	116.00	0.000
	25-34	36	99.3222	12.69457	81.30	115.30	
	35-44	51	94.9176	5.37206	87.70	103.10	
	45-54	23	93.6652	7.69702	85.80	105.20	
	55-64	8	87.4875	1.22058	86.20	89.80	
	> 65	3	99.5000	.20000	99.30	99.70	
	Total	160	93.8219	9.93239	79.00	116.00	
Mandibular body length	15-24	39	84.1487	10.08007	74.90	106.10	0.005
	25-34	36	88.6222	7.71689	77.20	105.00	
	35-44	51	86.5314	4.68651	77.50	94.30	
	45-54	23	83.2522	6.90987	77.10	95.50	
	55-64	8	79.1250	.44320	78.60	79.70	
	> 65	3	86.6333	.11547	86.50	86.70	
	Total	160	85.5813	7.53018	74.90	106.10	
Mandibular symphysis height	15-24	39	34.9179	1.85527	31.80	37.00	0.122
	25-34	36	35.4139	2.73236	31.10	43.10	
	35-44	51	34.3490	1.42610	32.10	36.70	
	45-54	23	35.3087	1.82680	32.30	37.50	
	55-64	8	34.9375	1.32011	33.60	37.50	
	> 65	3	36.1333	.15275	36.00	36.30	
	Total	160	34.9281	1.96309	31.10	43.10	
Corpus width	15-24	39	10.3231	13.43280	7.50	92.00	0.768
	25-34	36	8.7944	.82978	7.50	10.50	
	35-44	51	8.2118	.64549	7.00	9.50	
	45-54	23	8.3435	.50975	7.40	9.10	
	55-64	8	8.2750	.38822	7.80	8.80	
	> 65	3	8.4000	.10000	8.30	8.50	
	Total	160	8.8831	6.64601	7.00	92.00	
Cont.							
Anatomical Structure and age class		N	Mean	Std. Deviation	Minimum	Maximum	
Right Ramus height	15-24	39	70.3872	86.28324	46.00	594.00	0.766
	25-34	36	57.9417	3.18159	53.40	68.70	
	35-44	51	58.1490	2.12559	52.90	63.80	
	45-54	23	56.4870	2.34100	51.70	60.00	
	55-64	8	58.2625	.26693	57.70	58.50	
	> 65	3	58.9000	.10000	58.80	59.00	
	Total	160	60.8663	42.58401	46.00	594.00	
Left Ramus breadth	15-24	39	32.5590	2.99848	28.50	38.50	0.001
	25-34	36	34.8306	1.87095	32.90	43.20	
	35-44	51	33.5118	1.93366	31.30	37.90	
	45-54	23	33.4957	1.40178	31.90	35.70	
	55-64	8	32.6875	1.34104	31.80	35.90	
	> 65	3	32.7333	.05774	32.70	32.80	
	Total	160	33.5181	2.26015	28.50	43.20	

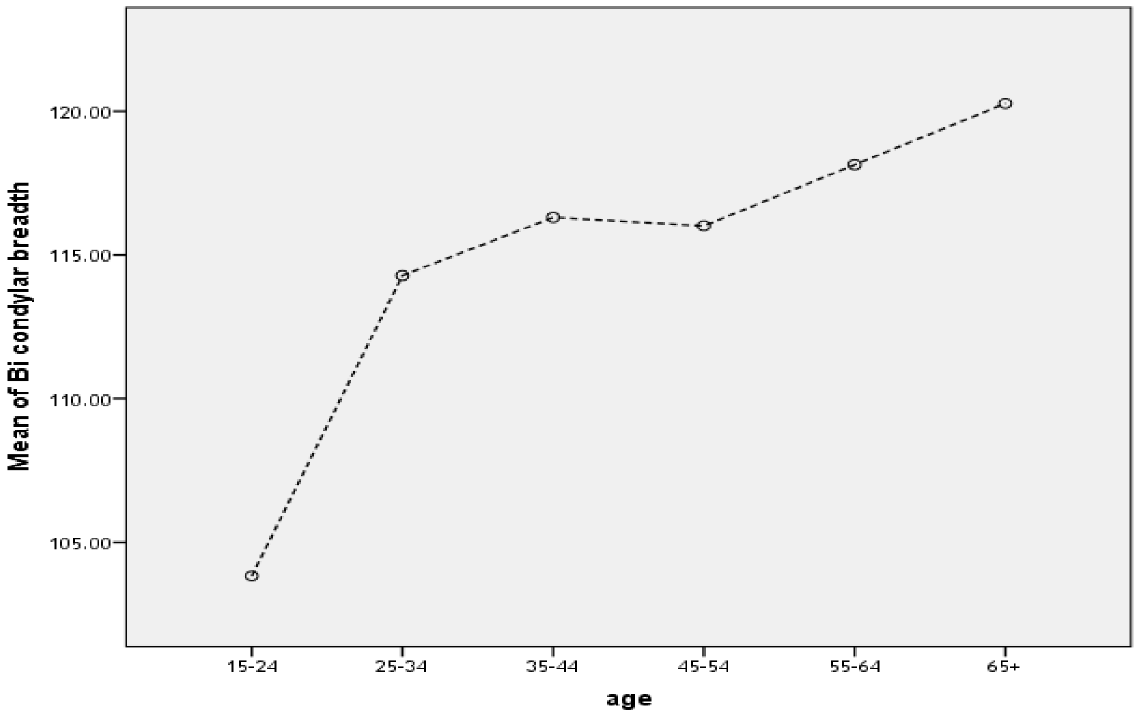

Figure (2): Correlation coefficient shows the relation between the patient's age and Bi condylar breadth **(R^2=0.360)**

Table (4): **The New established equations For Sudanese considering the Bi condylar breadth and patients ages .**

Coefficients				
Model		Unstandardized Coefficients B	t	Sig.
	(Constant)	99.845	67.933	.000
	Age	.371	9.433	.000

Dependent Variable: Bi condylar breadth

The New established equations For Sudanese are as follows
Bi condylar breadth = 4.99.84+ (Age X 0.371).

III. Discussion

The mandible is the largest and hardest facial bone and retains its shape better than other bones in the forensic and physical anthropologic field. The mandible can be used to distinguish among ethnic groups and between genders.[12]

We used the three dimensional CT images, since these images allow for more accuracy in the obtained measurements compared with the previous studies. [13]

Distribution of the sample according to age classes was presented in percentages (Figure1) and the most frequently presented age group was the group of age between 35-44years old. The mean measurements of the Sudanese mandible components were presented in (Table1)

The current study showed that the measurements in both male and female subjects were statistically differ in bicondylar breadth, bigonial breadth,and mandibular body length. The males have greater measurements than females and the difference was significant at $p \leq 0.000$. The mandibular symphysis height was statistically greater in females than males (Table 2), similar findings was mentioned by Roshanak et al; 2013. [13] In each three studies; the mean of bigonial width in men was greater than in women. [13, 14, 15]

In another study run by Pecora et al., 2008 [16] it was found that women had a downward and backward rotation in mandible but men had a forward rotation in mandible. Hence, the increase in mandibular angle in females is more than in men.[16] this may be the cause of the difference between the two genders .

Studies mentioned that mandibular ramus can differentiate between genders, as the stages of mandibular development, growth rates, and duration are distinctly different in both genders. In addition, masticatory forces exerted are different for males and females, which influences the shape of the mandibular ramus.[12] Study done by Steyn et al [17]showed bigonial breadth was the most dimorphic of the measurements taken .No significant difference was observed in mandibular angle in sex determination in the young Lebanese population aged between 17 and 26 years . [18]

Various parameters have been used for sexing the mandible. Studies done by Loth et al, on their nonmetric examination on South African sub adult samples claimed that, shape differences in the symphyseal region and anterior body of the mandible can be used to predict sex with above 80% accuracy. In a blind test of that technique, however, Scheuer showed that when applied to different population samples, sex classification accuracy declined considerably to 64%. The most accurate single indicators among cranial methods were the robustness of the mandible with accuracy of 70.93% [19]

Many variables showed significant differences which includes: bicondylar breadth, gonial angle and minimum ramus breadth according to study done by Kharoshah et al.[20]

In Sudanese population, the mean bi bicondylar breadth, bigonial bridth mandibular body length and left ramus breadth changed significantly with increasing age (Table3). Comparing with other populations; one study showed that, the mean of bigonial width did not change significantly with increasing age. [13] In a similar study by Shaw et al. [15] on 3D CT images, also the mean of bigonial width did not change significantly with increasing age. Sudanese measurements were differ from other populations.

Results of Roshanak et al [13] and Shaw et al [15]were different from that of Pessa et al. [14] Pessa et al. evaluated the frontal radiographs and reported that there was an increase in mandible width and height with increasing age. The current results mentioned that mandibular body length, left ramus breadth were significantly increased in measurements as the age increases at $p\leq0.005$ and $p\leq0.001$.The changes in measurements may be due to the fact that some areas continued to grow faster than other areas. The measurements starts to increased during the ages starting from 15-24 years, 25-34years then decreased after the age of 45-54years and 55-64 years .Similar study has mentioned that the changes were in maturity period [14]

Correlation coefficient shows the relation between the patient's age and bi condylar breadth (R^2=0.360) the contribution of the age to do changes in bi condylar breath is 36%. As the age increases the bicondylar breadth will also be increased significantly at $p\leq0.000$. These were presented in (Table4) and (Figure2).

IV. Conclusion

We can predict the bi condyler width for Sudanese if their ages were known. A new equation was established in order to standardize a local reference or measurements for Sudanese mandibles. This study presents a new morphologic indicator of age in the human mandible.

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A Local Reference value for the Mental Foramen in adult Sudanese: A 3D Computerized Tomography based study

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Abstract :
The mental foramen (MF) is located on the anterior surface of the mandible. It permits passage of the mental nerve and vessels. Studying the morphological variation of (MF); helps to localize the mental nerve to prevent complications during surgery. (MF) character varied considerably among ethnic groups, although, determination the norms is essential, however no study was conducted in Sudanese. The aims of this study are to establish local reference for (MF) width for Sudanese as well as to study the age and gender related difference and to compare the measurements with other populations.
The present study was carried out in the Radiology department-Military Hospital, Khartoum –Sudan on 160 Adult Sudanese with mean age is 35.26years old. Three dimensional computerized tomography was obtained for the facial bone .The Mandibles were observed for the right and left of (MF) width.
In our study we observed that the (MF) mean width were 4.28 and 3.53 mm for right and left sides. The (MF) differs between the two genders significantly at p≤ 0.035 and 0.010 for right and left sides in respectively .A significant changes in (MF) width were detected in different age groups for both right and left sides. New equations were established to identify the (MF) width as local reference for Sudanese population of known age. the present analysis revealed variations in width of MF of Sudanese from other populations. The MF width differs according to age and gender .

Keywords - *Mental foramen, Morphometry, Computerized Tomography*

V. Introduction

Anatomically, there is one mental foramen (MF) on each side of the mandible through which passes the mental artery, vein and the mental nerves, the larger of the two terminal branches of the inferior alveolar nerve. The number of mental nerves can vary in individuals and in different races. [1,2]

The (MF) is a strategically important landmark during osteotomy procedures, anesthetic nerve blocks and prevention of neurovascular complications after invasive procedures on the lower jaw. Its anatomy is important for evaluating the morphometry of the (MF) in different populations.[3]

Different studies were obtained regarding the morphometric characteristics of the (MF); in so doing depicting variable racial tendency. [4]In Africans; the (MF) was observed to exhibit dimorphism; the average size of the short axis of the foramen was 3.97mm in the male 3.87 mm in the female mandibles.[5] These measurements were statistically similar to another study on mandibles from Alagoas state.[6].In Asian /Japanese population the (MF) was observed to have largest horizontal diameter ranged between 3.25-3.32mm [6] In Sri Lankans; the mean transverse diameters of the foramen were 3.31mm [7] while in Israelis; the (MF) average diameter was of 2.37 mm.[8]In Turkish; the horizontal diameter of the (MF) was 2.93 mm on the right side and 3.14 mm on the left side. [6]

Racial variances in mandibular dimensions have been studied among several Caucasian, African, Asian, and Arab populations.[9-12] An important landmark in carrying out the mental or incisive nerve block is the mental foramen [13] The position of this foramen has also been studied, with racial differences again being found [14-19] What is not known, is whether there are significant variations on these mandibular landmarks(MF) in Sudanese patients compared with those already reported. There are no apparent published reports on its relative short axis in Sudanese populations.Although the variations appears according to the ethnic groups, this study aims to measure the MF width and to find out the variations related to age and gender using 3D CT done for adult Sudanese population as well as to compare the findings with other populations and to establish a local reference for Sudanese regarding the MF width.

VI. Materials and Methods

2.1 Equipment:

The equipment required is CT Toshiba Aquilion(64slices) and three dimensional reconstruction system with parameters is used as below: Kv=120 ,mA=300, Time =0.75sec ,mAs =225 ,Slice thickness=3mm-5mm

2.2 Methods of data measurement:

This is a descriptive analytical study that deals with scanning patients head (brain and facial structures).The study selected 160 patients (males and females) with CT (64slices). Axial projection was applied with brain protocols as well as sagittal views for facial protocols. All of these protocols used two dimensional as localizer and Digital Imaging and Communications in Medicine (DICOM) files were rendered into three-dimensional reconstruction using Anatomize Invivo5 software. The width of the mandible foramen right and left were measured.

2.3 Sample.

The study population was composed of both genders presenting to the CT unit of Military Hospital in Khartoum during the period from December 2013 to June 2016.The sample size consisted of 160 patients with different age and gender (92males and 68 females)The radiographs that were clinically diagnosed as normal mandible were included. Any abnormality of mandible for example: fractures, infection, tumors and other mandible diseases were excludes

2.4 Technique:

The patients were positioned supine on the CT examination table and head is rested on head holder while removing all metallic and jewelry, straps and pillow were used to help in maintaining the correct positioning , the scan started from base of the skull and end inferior to mental protuberance as well as image were produced in axial projection. Three dimensional volume rendering technique was applied to reconstruct the image data of patients (analytical software) uses several types of reconstruction algorithm with different planes .

2.5 Ethical consideration

-No identification or individual details were published.

-No information or patient details were disclosed or used for reasons other than the study

VII. Results

Table 1 shows the classification of age classes presented in frequency and percentages

	Frequency	Percentages (%)
15-24	39	24.4
25-34	36	22.5
35-44	51	31.9
45-54	23	14.4
55-64	8	5.0
65+	3	1.9
Total	160	100 %

Table 2 shows the mean and standard deviation of patients ages, Right and left Foramen Width/(MM)

	Age/Years	Right Foramen Width/(MM)	Left Foramen Width(MM)
Mean	35.2625	4.2881	3.5338
Std. Deviation	12.33112	2.30409	.57263
Minimum	15.00	3.10	2.40
Maximum	75.00	5.10	5.20

Table 3 Independent Samples Test shows the difference between the genders for both right and left foramen width

Group Statistics					
	Gender	N	Mean	Std. Deviation	P-value
Right Foramen Width	Male	92	4.2348	.62025	0.035
	Female	68	4.3603	3.47375	
Left Foramen Width	Male	92	3.6337	.57480	0.010
	Female	68	3.3985	.54513	

Table 4 . Descriptive Statistics both right and left foramen width classified according to age groups

		N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**	**P-value**
Right Foramen Width	15-24	39	4.3718	.41292	3.70	5.70	.028
	25-34	36	4.5333	.67146	3.10	5.80	
	35-44	51	3.8039	.38934	3.30	4.80	
	45-54	23	5.0957	5.95792	3.20	32.40	
	55-64	8	3.6500	.24495	3.40	4.20	
	65+	3	4.0000	.10000	3.90	4.10	
	Total	160	4.2881	2.30409	3.10	32.40	
Left Foramen Width	15-24	39	3.6308	.38468	3.10	4.50	.000
	25-34	36	4.0500	.75043	2.40	5.20	
	35-44	51	3.2745	.38306	2.50	4.20	
	45-54	23	3.2391	.35896	2.40	3.70	
	55-64	8	3.2000	.21381	2.90	3.60	
	65+	3	3.6333	.05774	3.60	3.70	
	Total	160	3.5338	.57263	2.40	5.20	

Table 5 . Correlation coefficient between the right mandibuler foramen width with age .Significant at p≤0.005

	Correlations		
Model	Unstandardized Coefficients	t	Sig.
	B		
(Constant)	4.343	7.824	.000
Age	-.002	-.105	.017

The New Established Equation to predict the right mandibuler foramen width for Sudanese with known age.R^2=0.084
Right mandibuler foramen width= 4.343+(AgeX-0.002)

Table 6 . Correlation coefficient between the left mandibuler foramen width with age .Significant at p≤0.005

	Correlations		
Model	Unstandardized Coefficients	t	Sig.
	B		
(Constant)	4.025	30.583	.000
Age	-.014	-3.953	.000

The New Established Equation to predict the left mandibuler foramen width for Sudanese with known age.R^2=0.090

Left mandibuler foramen width=4.025+(AgeX-0.014)

VIII. Discussion

When reviewing the literature regarding morphometric analysis of the MF based on multi-slice computed tomography, no detailed data has been found. The current study provides new data on the width of the MF in a Sudanese population.When practicing dental surgery, orthodontic treatments, maxillofacial trauma, and orthognathic procedures such as a mandibular body osteotomy, in order not to cut or damage the mental nerve, it is important for the operator to know exactly the morphology of MF. [20] Tables 1 and 2 show the classification of age classes presented in frequency and percentages as well as the mean values of the right and left MF width measured for Sudanese.

Radiography is the non-invasive method for diagnosis and treatment planning of major surgical procedures of the mandible. [21]Panoramic radiographs usually are limited due to horizontal overlap of teeth [22] distortion and magnification in orthopantomogram techniques cannot be eliminated, in addition, as the bone density increases, the foramen becomes more difficult to identify and may not be seen clearly. CT has been the first option for diagnosis, surgical planning, and treatment of osseous trauma injuries due to its high specificity and sensitivity.[23] As a result of recent advances in computer hardware and software; 3D imaging by CT scans of craniofacial anomalies is routinely used by most medical centers to define the unique individual aspects of complex anatomy, plan interventions and follow results [24]

Therefore, we utilized CT images because they have certain advantages in diagnostic medicine. In our series of 160 CT images, the width of the MF has been measured; it was found that there is a significant difference between the males and females for both right and left MF width at $p \leq 0.035$ and 0.010 respectively (Table3)

Studies have mentioned that the MF morphology, varies not only according to age[25] gender [26,27]and ethnicity; [28,29] but even within the same race; in different geographic regions [30,31,32]and within the inhabitants of the same geographic area[33].

Age difference was also been evaluated and it was found that the age can affected significantly the measurements of MF width (Table 4)One of the most striking characteristics of The Sudan is the diversity of its people. The Sudanese are divided into multiple ethnic groups and subgroups. identifying ethnic groups in Sudan was made more complicated by the multifaceted character of internal divisions. Largest ethnic category comprises those considering themselves Arabs, but category internally split by regional and tribal loyalties and affiliation to various groups. Major groups are Nubians and nomadic Beja dwelling in parts of North Africa , and Fur in west. Southern groups include Dinka form the largest portion of the national population (Black), Nuer, and numerous smaller Nilotic and other ethnic groups. Therefore characterization of MF for each tribe is essential. However we characterize MF for Sudanese living in Khartoum State and not considering their origin or tribe which may consider as limitation in our study.

A new equation to predict the right mandibuler foramen width for Sudanese living in central Sudan at the capital (Khartoum) with known age was established.

Right mandibuler foramen width= 4.343+ (AgeX-0.002), R^2=0.084. For the left mandibuler foramen width: Left **mandibuler foramen width**=4.025+ (AgeX-0.014), R^2=0.090, these are presented in (tables 5 and 6).

The measurements of Sudanese differ from other populations. Data from various ethnic groups including Tanzanian, Thai, Chinese, British, Saudi Arabian vary regarding the characterization of MF.A review by Green (1987) [18] demonstrated a clear racial trend in the characterization of the MF [34] According to Mbajiorgu *et al.* (1998) [15], in 32 mandibles of black adults from Zimbabwe had mentioned that MF was either round or oval. We suggest that this may be a factor that may change the MF width. Oliveira Junior *et al*. (2009) [6] reported that the shape was found to be oval with Larger diameter in the horizontal direction. Regarding the size of the mental foramen and according to Chung *et al*.(1995)[35] ; horizontal opening of MF was 2.4 mm and Apinhasmit *et al*.[36] reported the average horizontal opening was 2.8mm. Oguz & Bozkir (2002)

[37] did measurements in 34 dry mandibles of people from Turkey. The horizontal dimension of MF was 2.93mm on right side and 3.14 mm on left side. Souaga et al. [26] studied 61 dry mandibles. The average sizes of the short axes of foramina were 3.97 mm for males while dimensions of female mandibles was 3.87 mm. The present observations brought out average horizontal dimension of MF to be 4.29 mm on right side and 3.53 mm on the left side. This was considered to be greater than other previously studied populations.

IX. Conclusion

The present analysis revealed variations in width of MF of Sudanese from other populations. The MF width differ according to age and gender

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