بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduation Studies

MSc Diagnostic Radiologic Technology

Characterization of Cervical Vertebral Foramen in Sudanese Patients using Computerized Tomography

توصيف الثقبة الفقرية العنقيه في المرضى السودانيين باستخدام التصوير المقطعي المحوسب

Thesis Submitted for Partial fulfillment of M.Sc Degree in Diagnostic Radiological Technology

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الآية

بسم الله الرحمن الرحيم

قال تعالى:

(هَلْ أَتَى عَلَى الإِنسَانِ حِينٌ مِّنَ الدَّهْرِ لَمْ يَكُن شَيْئًا مَّذْكُورًا (1) إِنَّا خَلَقْنَا الإِنسَان مِن نُّطْفَةٍ أَمْشَاجٍ نَّبْتَلِيهِ فَجَعَلْنَاهُ سَمِيعًا بَصِيرًا (2) إِنَّا هَدَيْنَاهُ السَّبِيلَ إِمَّا شَاكِرًا وَإِمَّا كَفُورًا (3))

صدق الله العظيم

سورة الانسان الآية (1_3)

Dedication

To my parents, whose words of encouragement and push for tenacity ring in my ears

To my family

To all whom aid me to complete this work…

Acknowledgement

Praise and thanks are to Allah the lord and creator of the world.

I would like to specify my acknowledgement to my supervisor Dr. Caroline Edward Ayad for sincere supervision and guidance. My thanks extend also to all the technicians staff in hospitals whom help me in this research.

Abstract

The vertebral foramen is opening formed by the union of the vertebral arch with the body; All the vertebral foramina together form the vertebral canal, which houses the spinal cord. {Gray's Anatomy (1918)}.

This study was executed to demonstrate variation in cevical vertebral foramen measurements .the study was conducted at CT department inAl-Ribat teaching Hospital ,Al-ZytounaHospital,Al-Amal National Hospital and Ebrahim Malik Hospital. This was expandedfrom March 2016 up to May2016 .

52 patients referred to CT department for normal cevical vertebral examination, both genders were included ,40were males and 12were females.

The measurements ofvertebral foramenwere taken at the levels of C1up to C7 in cms for both ganders.

The results showed that the means of (mm length and mm width) of (C1, C2, C3, C4, C5, C6 and C7) which were compared between males and female with corresponding significance values of t-tests (0.385, 0.613), (0.128, 0.442), (0.650, 0.869), (0.786, 0.909), (0.537, 0.070), (0.782, 0.047) and (0.878, 0.121), respectively for (C1, C2, C3, C4, C5, C6 and C7) (all of Sig. more than or equal to 0.05) which implies that, there were nostatistically significantdifferences between two groups (males and females).the means of (mm length and mm width) of (C1, C2, C3, C4, C5, C6 and C7) which compared between different age groups (15-25), (26-35), (36-45), (46-55), (56-65) and (more than 65 years) with corresponding significance values of F-tests (0.711, 0.952), (0.64, 0.332), (0.575, 0.357), (0.494, 0.361), (0.859, 0.519), (0.771, 0.914) and (0.721, 0.859), respectively for (C1, C2, C3, C4, C5, C6 and C7) (all of Sig. more than 0.05) which implies that, there were nostatisticallysignificants differences between age groups (in all Cs Size).

Multi detector computed tomography is modality of choice to Characterize cervical vertebral foramen in the studded area .

ملخص الدراسه

الثقبهالفقريه هي عباره عن فتحه مكونه من اتحاد القوس الفقري والجسم ، والتي تشكل معا قناة العمود الفقري الذي يضم الحبل الشوكي .

اجريت هذه الدراسه لمعرفة الاختلافات التشريحيه لقياسات الثقب الفقريهالعنقيه وذلك في اقسام الاشعهالمقطعيه بمستشفى الرباط الجامعي ومستشفى الزيتونه ومستشفى الامل الوطني ومستشفى ابراهيم مالك، وذلك ف الفترهمابينمارس 2016 الى مايو 2016 .

اثنين وخمسون مريض تم تحويلهم الى قسم الاشعهالمقطعيه بطلب فحص اشعه مقطعيه للفقرات العنقيه (40 من الرجال و12 من النساء) من مختلف الاعمار ؛وقد خضع جميع المرضى لاجراءالفحص وذلك لقياس الثقب الفقريهالعنقيه.

تم قياس الثقبهالعنقيه من مستوى الفقرة العنقيه الاولى الى الفقرة العنقيهالسابعه بالمليمترات للذكور والاناث.

اوضحت النتائج ان متوسطات الطول والعرض للثقب العنقيه من مستوى الفقرة العنقيه الاولى الى الفقرة العنقيهالسابعه بالمليمترات للذكور والاناث وفقا لقيم ال T تيست على التوالي هي (0.385 ، 0.613) و (0.128 ، 0.442) و (0.650 ، 0.869) و (0.786 ، 0.909) و (0.537 ، 0.070) و (0.782 ، 0.047) و (0.878 ، 0.121) .كما اوضحت ان متوسات الطول والعرض للثقبالعنقيه من مستوى الفقرة العنقيه الاولى الى الفقرة العنقيهالسابعه بالمليمترات لمختلف الفئات العمرية وفقا لقيم ال F تيست على التوالي هي (0.711 ، 0.952) و(0.64 ، 0.332) و(0.575 ، 0.357) و (0.494 ، 0.361) و (0.859 ، 0.519) و (0.771 ، 0.914) و (0.721 ، 0.859) مما يعني أنه لم تكن هناك فروق ذات دلالة إحصائية بين مجموعتين (ذكور وإناث) وبين الفئات العمريه .

اوضحت الدراسه ان الاشعهالمقطعيه متعددة المجسات هي الخيار الامثل لتوصيف قياسات الثقب الفقريهالعنقيه في منطقة الدراسه.

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Chapter one

1.1 Introduction :

cervicalvertebræ are the smallest of the true vertebræ, and can be readily distinguished from those of the thoracic or lumbar regions by the presence of a foramen in each transverse process. The first, second, and seventh present exceptional features and must be separately described; the following characteristics are common to the remaining four.{Gray's Anatomy (1918)}.

The body is small, and broader from side to side than from before backward. The anterior and posterior surfaces are flattened and of equal depth; the former is placed on a lower level than the latter, and its inferior border is prolonged downward, so as to overlap the upper and forepart of the vertebra below. The upper surface is concave transversely, and presents a projecting lip on either side; the lower surface is concave from before backward, convex from side to side, and presents laterally shallow concavities which receive the corresponding projecting lips of the subjacent vertebra.{Gray's Anatomy (1918)}.

The pedicles are directed lateralward and backward, and are attached to the body midway between its upper and lower borders, so that the superior vertebral notch is as deep as the inferior, but it is, at the same time, narrower. The laminæ are narrow, and thinner above than below.{Gray's Anatomy (1918)}.

the vertebral foramen is large, and of a triangular form. The spinous process is short and bifid, the two divisions being often of unequal size. The superior and inferior articular processes on either side are fused to form an articular pillar, which projects lateralward from the junction of the pedicle and lamina. The articular facets are flat and of an oval form: the superior look backward, upward, and slightly medialward: the inferior forward, downward, and slightly lateralward. The transverse processes are each pierced by the foramen transversarium, which, in the upper six vertebræ, gives passage to the vertebral artery and vein and a plexus of sympathetic nerves. Each process consists of an anterior and a posterior part. {Gray's Anatomy (1918)}.

The anterior portion is the homologue of the rib in the thoracic region, and is therefore named the costal process or costal element: it arises from the side of the body, is directed lateralward in front of the foramen, and ends in a tubercle, the anterior tubercle. The posterior part, the true transverse process, springs from the vertebral arch behind the foramen, and is directed forward and lateralward; it ends in a flattened vertical tubercle, the posterior tubercle. These two parts are joined,

outside the foramen, by a bar of bone which exhibits a deep sulcus on its upper surface for the passage of the corresponding spinal nerve.{Gray's Anatomy (1918)}.

X-ray is the easiest means to image the spine. X-ray reveals alignment and degenerative changes of the bones. The spaces for the discs are seen as well, but no pictures are seen of the spinal cord, nerves or actual disc material. Unsuspected bony pathology, such as fractures, dislocations and cancer metastases, are quickly identified with x-ray.

Computed tomography (CT scan) is a noninvasive diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce horizontal, or axial, images (often called slices) of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat, organs, and blood vessels. CT scans are more detailed than standard X-rays.CT Scan is useful for cross-sectional imaging of the spine and increased image detail of the spinal cord, nerves and discs, but less so than MRI imaging.

MRI is currently the best means of visualizing all of the important structures of the cervical spine. With a good MRI study, considerable detail is available of the bones, discs, spinal cord, ligaments and even the nerves. MRI studies are most likely the major determinant of the pathology causing the cervical spine difficulties, whatever their nature.

1.2 problem of the study :

Knowlodge of the normal diameter of cervical vertebral foramen throughout the body so that clinicians are able to determine when the foramina is variable due to placement, spinal loading, posture, or pathology.

1.3 research objectives:

1.3.1 General objective:

The general objective of this study is tocharacterize of cervical vertebral foramen in Sudanese patients using computed tomography.

1.3.2 Specific objective:

- To measure the normal foramina diameter from C1-C7 in Sudanese.
- To correlate the measurements of normal foramina diameter with the age, gender.
- To determine common variations in Sudanese.
- To establish an index for normal Sudanese

1.4 significance of study:

This study will improve the knowledge about normal appearance of cervical vertebral foramen in Sudanese toshow the reasons of foramina variation in individuals and reach the quick diagnosis and treatment.

1.5 overview of study:

This study consisted of five chapters. Chapter One will be an introduction which includes problem of study, general, specific objectives and significant of study,Chapter Two will includes literatures review and reconstruction, chapter three will inclides the materials and methods, chapter four will include the results and chapter five will include the discussion ,conclusion and recommendations.

Chapter two

Literature review

2.1 cervical anatomy and physiology:

The cervical spine is made up of 7 vertebrae. The first 2, C1 and C2, are highly specialized and are given unique names: atlas and axis, respectively. C3-C7 are more classic vertebrae, having a body, pedicles, laminae, spinous processes, and facet joints.{Robert E Windsor et al, 2013}.

C1 and C2 form a unique set of articulations that provide a great degree of mobility for the skull. C1 serves as a ring or washer that the skull rests upon and articulates in a pivot joint with the dens or odontoid process of C2. Approximately 50% of flexion extension of the neck happens between the occiput and C1; 50% of the rotation of the neck happens between C1 and C2.The cervical spine is much more mobile than the thoracic or lumbar regions of the spine. Unlike the other parts of the spine, the cervical spine has transverse foramina in each vertebra for the vertebral arteries that supply blood to the brain. The cervical spine is made up of the first 7 vertebrae, referred to as C1-7. It functions to provide mobility and stability to the head while connecting it to the relatively immobile thoracic spine.

{Robert E Windsor et al, 2013}.

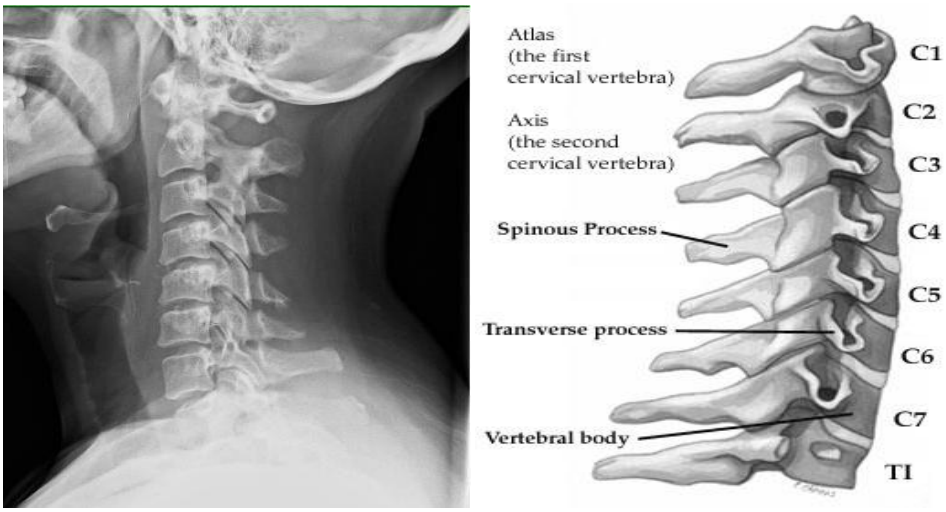


Figure 2.1: Show Lateral of cervical spine showing all 7 vertebrae.{Robert E Windsor 2013}.

2.1.1The cervical spine may be divided into 2 parts: upper and lower.

2-1-1-1Upper cervical spine

The upper cervical spine consists of the atlas (C1) and the axis (C2).These first 2 vertebrae are quite different from the rest of the cervical spine (see the image below). The atlas articulates superiorly with the occiput (the atlanto-occipital joint) and inferiorly with the axis (the atlantoaxial joint). The atlantoaxial joint is responsible for 50% of all cervical rotation; the atlanto-occipital joint is responsible for 50% of flexion and extension. {Bogduk et al,1991}.

2-1.1.1.1 Atlas (C1)

The atlas is ring-shaped and does not have a body, unlike the rest of the vertebrae. Fused remnants of the atlas body have become part of C2, where they are called the odontoid process, or dens. The odontoid process is held in tight proximity to the posterior aspect of the anterior arch of the atlas by the transverse ligament, which stabilizes the atlantoaxial joint. The apical, alar, and transverse ligaments, by allowing spinal column rotation, provide further stabilization and prevent posterior displacement of the dens in relation to the atlas. The atlas is made up of a thick anterior arch, a thin posterior arch, 2 prominent lateral masses, and 2 transverse processes. The transverse foramen, through which the vertebral artery passes, is enclosed by the transverse process.{Bogduk et al,1991}.

On each lateral mass is a superior and inferior facet (zygapophyseal) joint. The superior articular facets are kidney-shaped, concave, and face upward and inward. These superior facets articulate with the occipital condyles, which face downward and outward. The relatively flat inferior articular facets face downward and inward to articulate with the superior facets of the axis.According to Steele's rule of thirds, at the level of the atlas, the odontoid process, the subarachnoid space, and spinal cord each occupy one third of the area of the spinal canal.{Bogduk et al,1991}.

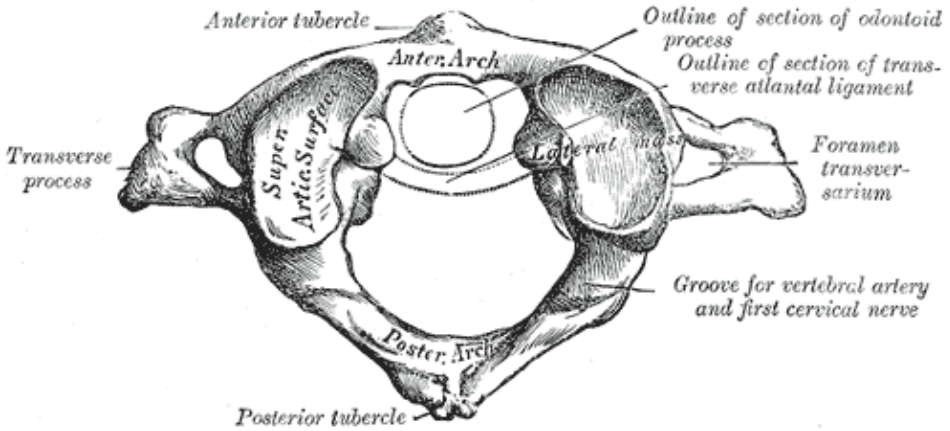


Figure 2.2: Show First cervical vertebra, or Atlas{Gray's Anatomy (1918)}

2.1.1.1.2Axis (C2)

The axis has a large vertebral body, which contains the odontoid process (dens). The odontoid process articulates with the anterior arch of the atlas via its anterior articular facet and is held in place by the transverse ligament. The axis is composed of a vertebral body, heavy pedicles, laminae, and transverse processes, which serve as attachment points for muscles. The axis articulates with the atlas via its superior articular facets, which are convex and face upward and outward.{Malanga , 1997}.

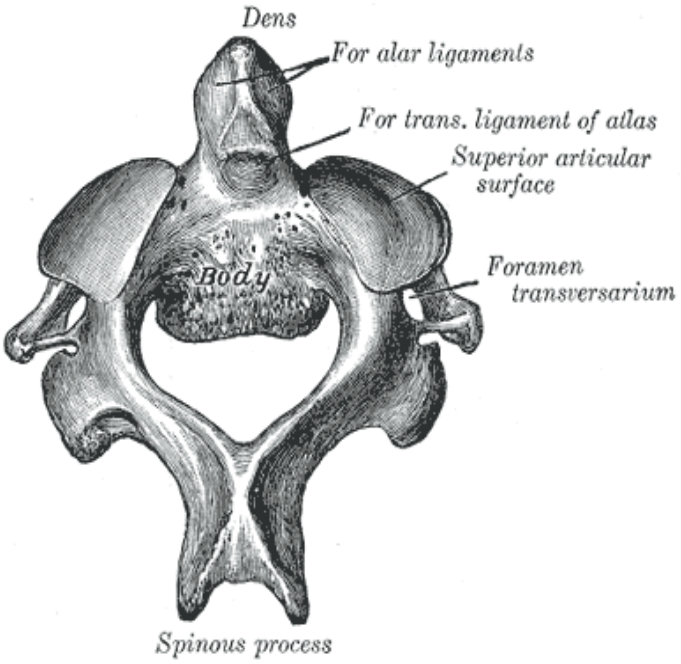


Figure 2.3: Show Second cervical vertebra, or axis{Gray's Anatomy (1918)}

2.1.1.2 Lower cervical spine:

The 5 cervical vertebrae that make up the lower cervical spine, C3-C7, are similar to each other but very different from C1 and C2. Each has a vertebral body that is concave on its superior surface and convex on its inferior surface (see the image below). On the superior surfaces of the bodies are raised processes or hooks called uncinate processes, each of which articulates with a depressed area on the inferior lateral aspect of the superior vertebral body, called the echancrure or anvil.{ Johnson , 1991}.

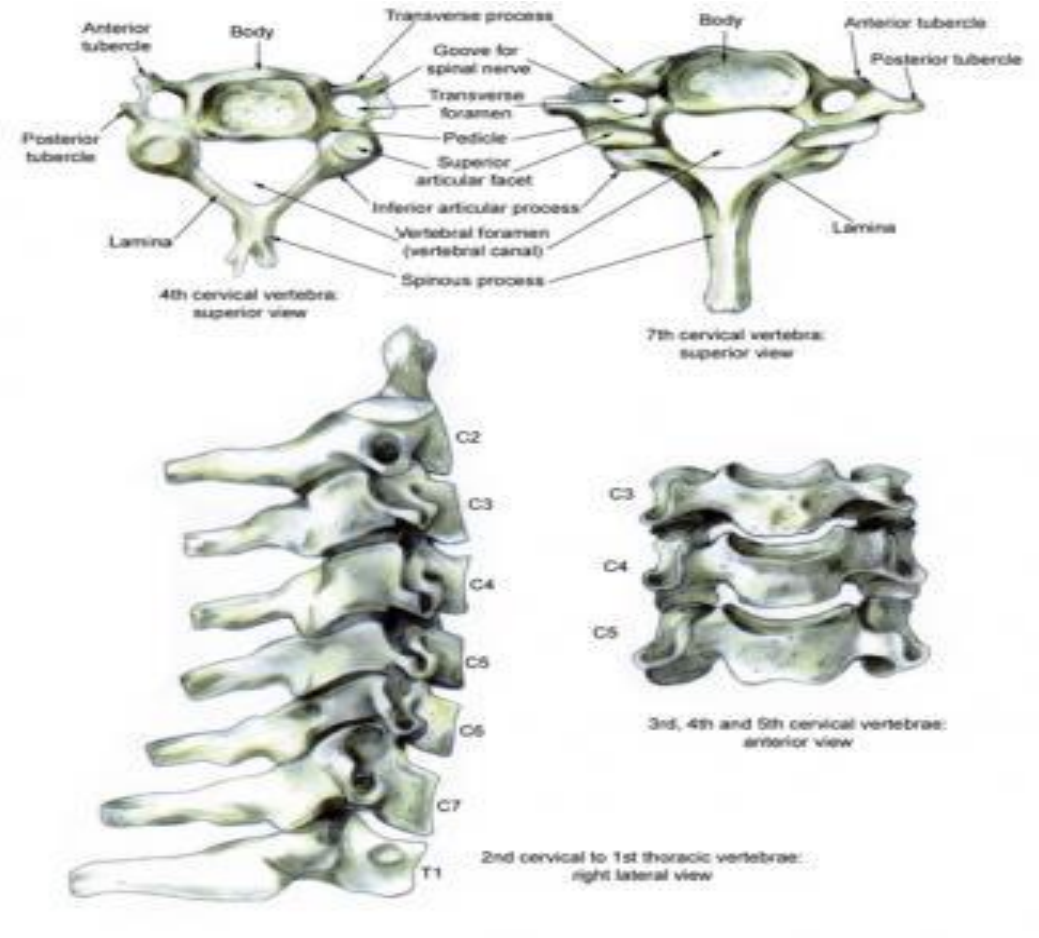


Figure 2.4: Show Normal anatomy of lower cervical spine.{ Johnson , 1991}

2.1.2 Vertebra:

In the vertebrate spinal column, each vertebra is an irregular bone with a complex structure composed of bone and some hyaline cartilage, the proportions of which vary according to the segment of the backbone and the species of vertebrate. Vertebrae take their names from the regions of the vertebral column that they occupy. There are thirty-three vertebrae in the human vertebral column—seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, five fused sacral vertebrae forming the sacrum and three to five coccygeal vertebrae, forming the coccyx. The regional vertebrae increase in size as they progress downwards but become smaller in the coccyx.{ Drake et al, 2010}.

There are seven cervical vertebrae (but eight cervical spinal nerves), designated C1 through C7. These bones are, in general, small and delicate. Their spinous processes are short (with the exception of C2 and C7, which have palpable spinous processes). C1 is also called the atlas, and C2 is also called the axis. The structure

of these vertebrae is the reason why the neck and head have a large range of motion. The atlanto-occipital joint allows the skull to move up and down, while the atlanto-axial joint allows the upper neck to twist left and right. The axis also sits upon the first intervertebral disc of the spinal column.Cervical vertebrae possess transverse foramina to allow for the vertebral arteries to pass through on their way to the foramen magnum to end in the circle of Willis. These are the smallest, lightest vertebrae and the vertebral foramina are triangular in shape. The spinous processes are short and often bifurcated (the spinous process of C7, however, is not bifurcated, and is substantially longer than that of the other cervical spinous processes).{ Drake et al, 2010}.

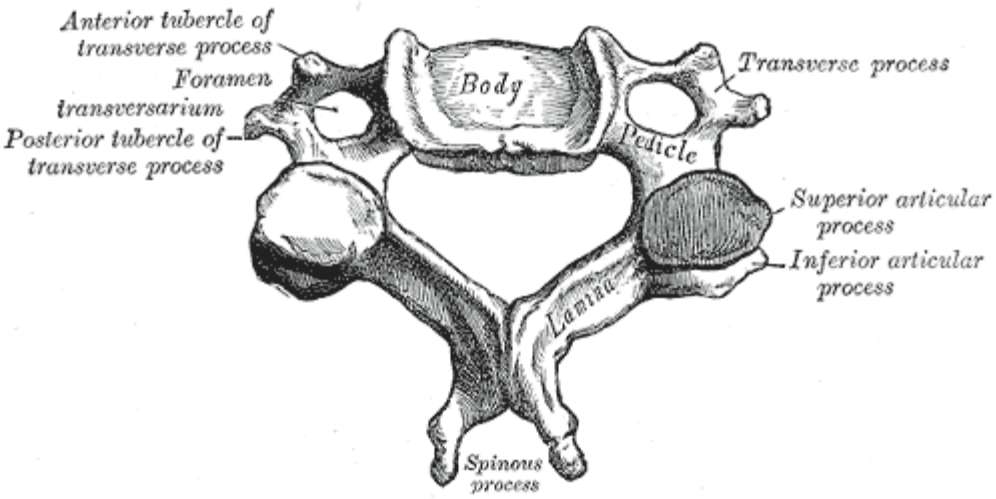


Figure 2.5: Show A cervical vertebra. {Gray's Anatomy (1918)}

2.1.3 Intervertebral foramina:

The intervertebral foramen (also called neural foramina, and often abbreviated as IV foramina or IVF), is a foramen between two spinal vertebrae. Cervical, thoracic, and lumbar vertebrae all have intervertebral foramina.The foramina, or openings, are present between every pair of vertebrae in these areas. A number of structures pass through the foramen. These are the root of each spinal nerve, dorsal root ganglion, the spinal artery of the segmental artery, communicating veins between the internal and external plexuses, recurrent meningeal (sinu-vertebral) nerves, and transforaminal ligaments..{ Gray's Anatomy (1918)}.

When the spinal vertebrae are articulated with each other the bodies form a strong pillar for the support of the head and trunk, and the vertebral foramen constitutes a canal for the protection of the medulla spinalis (spinal cord).The size of the foramina is variable due to placement, pathology, spinal loading, and posture.Foramina can be occluded by arthritic degenerative changes and space-

occupying lesions like tumors, metastases and spinal disc herniations.Specifically the intervertebral foramen is bound by, The Superior Notch of the adjacent vertebra, The Inferior Notch of the vertebra, The body of the vertebral body, Facet joints on the transverse process of the vertebra.{ Gray's Anatomy (1918)}.

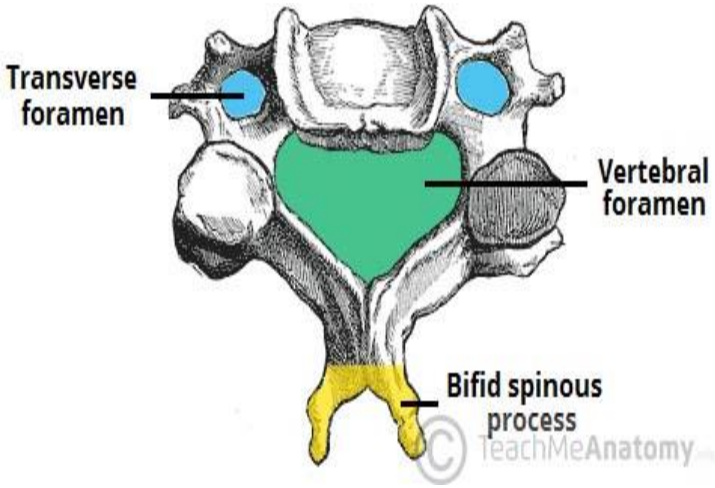


Figure 2.6: Show Characteristic features of a cervical vertebrae.{ Gray's Anatomy (1918)}

2.1.4 Intervertebral Disc:

Intervertebral discs are located between the vertebral bodies of C2-C7. Intervertebral disks are located between each vertebral body caudad to the axis. These disks are composed of 4 parts: the nucleus pulposus in the middle, the annulus fibrosis surrounding the nucleus, and 2 end plates that are attached to the adjacent vertebral bodies. They serve as force dissipators, transmitting compressive loads throughout a range of motion. The disks are thicker anteriorly and therefore contribute to normal cervical lordosis.{Bogduk et al,1991}.

The intervertebral disks are involved in cervical spine motion, stability, and weight-bearing. The annular fibers are composed of collagenous sheets (lamellae) that are oriented at a 65-70° angle from the vertical and alternate in direction with each successive sheet. As a result, they are vulnerable to injury by rotation forces because only one half of the lamellae are oriented to withstand force applied in this direction. The middle and outer one third of the annulus is innervated by nociceptors. Phospholipase A2 has been found in the disc and may be an inflammatory mediator.{Bogduk et al,1991}.

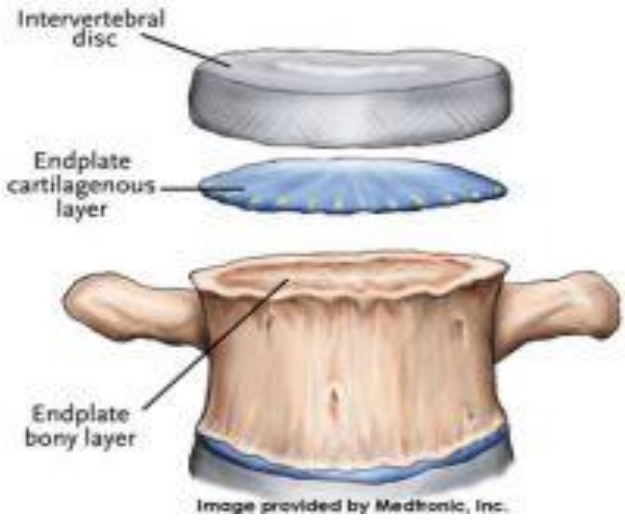


Figure 2.7: Show Intervertebral disk.{spinemd.com}

2.1.5 Joints :

The joints of the vertebral column include the joints between the bodies of adjacent vertebrae and joints between the adjacent vertebral arches. Two types of joints in the neck are given special attention because they're different from other joints: the atlanto-occipital joints and the atlanto-axial joints in the upper cervical region. These joints between the first two cervical vertebrae and the cranium permit a greater degree of movement than the rest of the vertebral column. The vertebrae also articulate with the ribs and the hip bones.{ David Terfera et al,2010}.

2.1.5.1 Atlanto-occipital joints: Joining the head and the atlas:

Atlanto-occipital joints are synovial joints located between the occipital condyles and the superior articular surfaces of the lateral masses of the atlas. You have two atlanto-occipital joints, which allow you to nod your head. They're held in place by the anterior and posterior atlanto-occipital membranes, which help prevent excessive movement of the joints.{ David Terfera et al,2010}.

2.1.5.2 Atlanto-axial joints: Joining the atlas and axis:

The three atlanto-axial joints are also synovial joints. One is found between the dens (odontoid process) of the axis (2nd cervical vertebra) and the anterior arch of the atlas (1st cervical vertebra), and two are located between the lateral masses of the 1st cervical vertebra and the superior articular facets of the 2nd cervical vertebra.{ David Terfera et al,2010}.

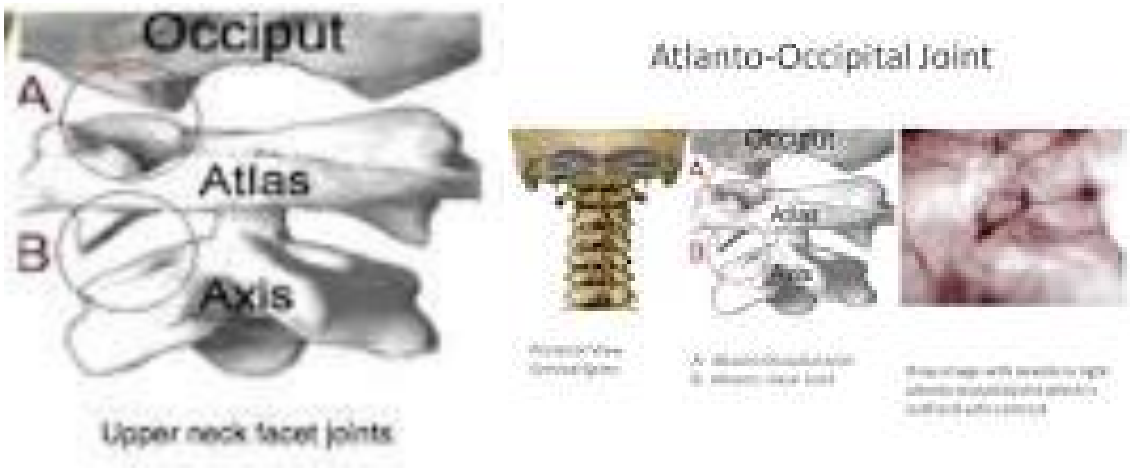


Figure 2.8: Show atlanto-occipital and atlanto-axial joint{annabellelearnsortho.blogspot.com}

2.1.6 Ligaments:

There are six major ligaments to consider in the cervical spine. The majority of these ligaments are present throughout the entire vertebral column.

2.1.6.1 Present throughout Vertebral Column:

Anterior and posterior longitudinal ligaments: Long ligaments that run the length of the vertebral column, covering the vertebral bodies and intervertebral discs.

Ligamentumflavum: Connects the laminae of adjacent vertebrae.

Interspinous ligament: Connects the spinous processes of adjacent vertebrae.

2.1.6.2 Unique to Cervical Spine:

Nuchal ligament: A continuation of the supraspinous ligament. It attaches to the tips of the spinous processes from C1-C7, and also provides the proximal attachment for the rhomboids and trapezius.Transverse ligament of the atlas: Connects the lateral masses of the atlas, and in doing so anchors the dens in place. {http://teachmeanatomy.info/neck/bones/cervical-spine/}.

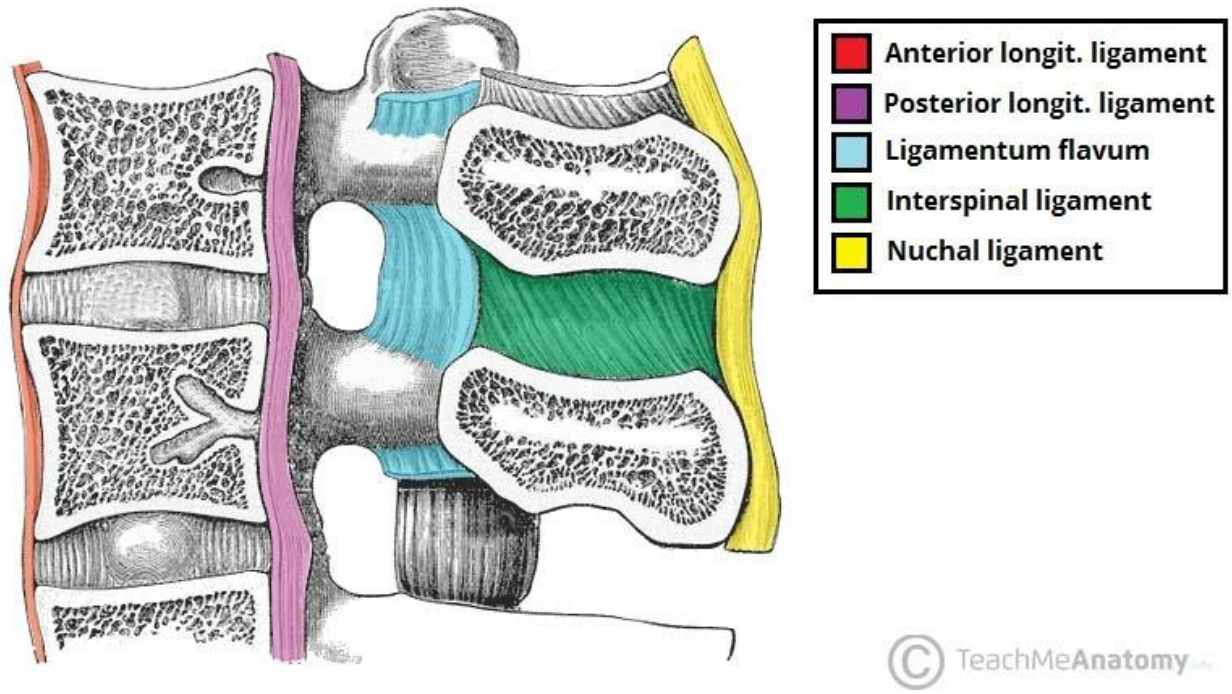


Figure 2.9: Show Ligaments of the cervical spine {http://teachmeanatomy.info/neck/bones/cervical-spine/}

2.1.7 Muscles:

2.1.7.1- Trapezius:

the trapezius is one of two large superficial muscles that extend longitudinally from the occipital bone to the lower thoracic vertebrae and laterally to the spine of the scapula (shoulder blade). Its functions are to move the scapulae and support the arm.The trapezius has three functional regions: the superior region (descending part), which supports the weight of the arm; the intermediate region (transverse part), which retracts the scapulae; and the inferior region (ascending part), which medially rotates and depresses the scapulae.{Dalley, 2010} .

Contraction of the trapezius muscle can have two effects: movement of the scapulae when the spinal origins are stable, and movement of the spine when the scapulae are stable. Its main function is to stabilize and move the scapula.{Dalley, 2010}.

Figure 2.10: ShowTrapeziusmuscle{somastruct.com}

2.1.7.2-Sternocleidomastoid (SCM):

thesternocleidomastoid muscle, also known as sternomastoid and commonly abbreviated as SCM, is a paired muscle in the superficial layers of the side of the neck. It is one of the largest and most superficial cervical muscles. The primary actions of the muscle are rotation of the head to the opposite side and flexion of the neck. The sternocleidomastoid is innervated by the accessory nerve.It is given the name sternocleidomastoid because it originates at the manubrium of the sternum (sterno-) and the clavicle (cleido-), and has an insertion at the mastoid process of the temporal bone of the skull.{ Merriam-Webster Dictionary,2016}.

The function of this muscle is to rotate the head to the opposite side or obliquely rotate the head. It also flexes the neck. When both sides of the muscle act together, it flexes the neck and extends the head. When one side acts alone, it causes the head to rotate to the opposite side and flexes laterally to the same side (ipsilaterally).It also acts as an accessory muscle of respiration, along with the scalene muscles of the neck.{ Merriam-Webster Dictionary,2016}.

Figure 2.11: Show sternocleidomastoid muscle{en.wikipedia.org}

2.1.7.3-Levator scapulae:

thelevator scapulae is a skeletal muscle situated at the back and side of the neck. As the Latin name suggests, its main function is to lift the scapula.The levator scapulae originates from the posterior tubercle of the transverse process of cervical vertebrae one to four. The muscle is inserted into medial border of the scapula extending from superior angle to junction of spine and medial border of scapula. {Platzer,2004}.

The levator scapulae may lie deep to the sternocleidomastoideus at its origin, deep or adjacent to the splenius capitis at its origin and mid-portion, and deep to the trapezius in its lower portion. When the spine is fixed, levator scapulae elevates the scapula and rotates its inferior angle medially.It often works in combination with other muscles like the rhomboids and pectoralis minor to rotate down.When the shoulder is fixed, levator scapula rotates and flexes the cervical spine laterally.When both shoulders are fixed, a simultaneous co-contraction of both levator scapulae muscles in equal amounts would not produce lateral flexion or rotation, and may produce straight flexion or extension of the cervical spine.{Platzer,2004}.

Figure 2.12: Showlevator scapulae muscle {clearpathchiropractic.com}

2.1.7.4-Scalenes:

The scalene muscles are a group of three pairs of muscles in the lateral neck, namely the anterior scalene, middle scalene, and posterior scalene. They are innervated by the fourth, fifth, and sixth cervical spinal nerves (C4-C6). {Mosby's Medical,1994}.

The action of the anterior and middle scalene muscles is to elevate the first rib and laterally flex (bend) the neck to the same side, the action of the posterior scalene is to elevate the second rib and tilt the neck to the same side.Because they elevate the

upper ribs they also act as accessory muscles of respiration, along with the sternocleidomastoids.{Mosby's Medical,1994}.

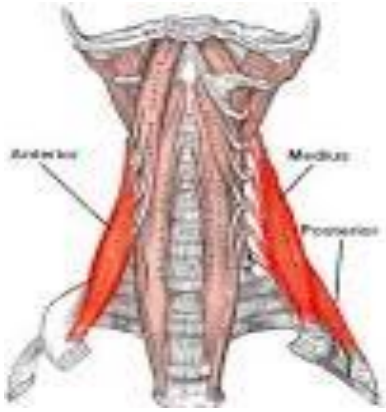


Figure 2.13: Show scalene muscles {en.wikipedia.org}

2.1.8 The spinal cord:

The vertebral column surrounds the spinal cord which travels within the spinal canal, formed from a central hole within each vertebra. The spinal cord is part of the central nervous system that supplies nerves and receives information from the peripheral nervous system within the body. The spinal cord consists of grey and white matter and a central cavity, the central canal. Adjacent to each vertebra emerge spinal nerves. The spinal nerves provide sympathetic nervous supply to the body, with nerves emerging forming the sympathetic trunk and the splanchnic nerves.The spinal canal follows the different curves of the column; it is large and triangular in those parts of the column which enjoy the greatest freedom of movement, such as the cervical and lumbar regions; and is small and rounded in the thoracic region, where motion is more limited.The spinal cord terminates in the conusmedullaris and cauda equina.{David Krogh, 2010}.

2.1.9 Cervical curve:

The cervical spine forms a lordotic curve that develops secondary to the response of an upright posture, which initially occurs when the child begins to lift the head at 3-4 months.The presence of the curve allows the head and eyes to remain oriented forward, and provides a shock-absorbing mechanism to counteract the axial compressive force produced by the weight of the head. {David Krogh, 2010}.

2.1.10 Anatomical Relationships:

The cervical spine has a close relationship with several neurovascular structures in the neck.The transverse foramina of the cervical vertebrae provide a passageway

through which the vertebral artery, vein and a plexus of sympathetic nerves can pass. There are two vertebrae where this is not the case:

C7 – the vertebral artery runs around the vertebra, instead of passing through through the transverse foramen. The vertebral vein and associated nerves are still present in the foramen.

Atlas – the vertebral artery runs along the groove for the vertebral artery instead of through the transverse foramen

The spinal nerves are intimately related to the cervical vertebrae. They extend from above their respective vertebrae, through the intervertebral foramen created by the joints at the articular processes. Again C7 is an exception. The C7 vertebra has a set of spinal nerves extending from above (C7) and below (C8) the vertebra. Therefore there are eight spinal nerves associated with seven cervical vertebra, which is a common source of confusion.{http://teachmeanatomy.info/neck/bones/cervical-spine/}

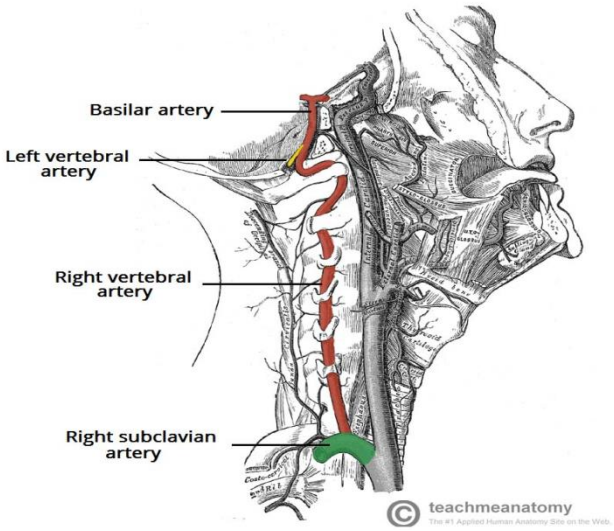


Figure 2.14: ShowThe right vertebral artery. Note its course through the transverse foramina of the cervical vertebrae.{© 2015-2016 TeachMeAnatomy.com [CC-BY-NC-ND 4.0]}

2.2 Pathology:

2.2.1 Osteophytes:

Cervical osteophytes are bone spurs that grow on any of the seven vertebrae in the cervical spine (neck), involving the spine from the base of the skull to the base of the neck (C1 - C7 vertebrae).Cervical osteophyte formation typically occurs when

ligaments and tendons around the bones and joints in the cervical spine are damaged or inflamed.{Karl ,2011}.

The inflamed or damaged tissue abnormally influences surrounding bone growth (though hard, bones are constantly renewing, like fingernails and hair). As a result, new bone cells are deposited where they would not normally grow.The inflamed or damaged tissue that stimulates cervical osteophyte growth is often caused by cervical osteoarthritis, a degradation in the neck joints that occurs in many older people. These joints include the disc spaces themselves (a modified joint) and the facet joints, and this condition of cervical osteophyte formation is referred to as cervical spondylosis.{Karl ,2011}.

Figure 2.15: ShowCervical osteophytes { bcmj.org}

2.2.2 Radiculopathy:

Cervical radiculopathy is the damage or disturbance of nerve function that results if one of the nerve roots near the cervical vertebrae is compressed. Damage to nerve roots in the cervical area can cause pain and the loss of sensation along the nerve's pathway into the arm and hand, depending on where the damaged roots are located. (dysfunction of a nerve root).{Melinda Ratini, 2015}.

It is damage can occur as a result of pressure from material from a ruptured disc, degenerative changes in bones, arthritis or other injuries that put pressure on the nerve roots. In middle-aged people, normal degenerative changes in the discs can cause pressure on nerve roots. In younger people, cervical radiculopathy tends to be the result of a ruptured disc, perhaps as a result of trauma. This disc material then compresses or inflames the nerve root, causing pain.{Melinda Ratini, 2015}.

Figure 2.16: Sagittal magnetic resonance imaging showing narrowing of the spinal canal as a result of anterior herniated discs/osteophytes and posterior buckling of hypertrophied ligamentumflavum. {Melinda Ratini, 2015}.

2.2.3 Myelopathy:

Cervical spondylotic myelopathy is the most common cause of spinal cord dysfunction in older persons. The aging process results in degenerative changes in the cervical spine that, in advanced stages, can cause compression of the spinal cord. Symptoms often develop insidiously and are characterized by neck stiffness, arm pain, numbness in the hands, and weakness of the hands and legs. The differential diagnosis includes any condition that can result in myelopathy, such as multiple sclerosis, amyotrophic lateral sclerosis and masses (such as metastatic tumors) that press on the spinal cord. The diagnosis is confirmed by magnetic resonance imaging that shows narrowing of the spinal canal caused by osteophytes, herniated discs and ligamentumflavum hypertrophy. Choice of treatment remains controversial, surgical procedures designed to decompress the spinal cord and, in some cases, stabilize the spine are successful in many patients.{WILLIAM ,2000}.

Figure 2.17: ShowCervical myelopathy {siemionow.com}

2.2.4 Spondylitis and diskitis:

Cervical spondylosis, also known as cervical osteoarthritis or neck arthritis, is a common, age-related condition that affects the joints and discs in neck. It develops from wear and tear of the cartilage and bones found incervical spine, which is in neck. While it's largely due to age, it can be caused by other factors as well. . {Amanda Delgado and Rachel Nall, 2015}.

According to the Mayo Clinic, the condition is present in more than 85 percent of people over the age of 60, although some people who have it never experience symptoms.For some, it can cause chronic, severe pain and stiffness. However, many people who have it are able to conduct normal daily activities. {Amanda Delgado and Rachel Nall, 2015}.

Figure 2.18: Showcervical spondylitis{upright-health.com}

Diskitis is an inflammation of the vertebral disk space often related to infection. Infection of the disk space must be considered with vertebral osteomyelitis; these conditions are almost always present together, and they share much of the same pathophysiology, symptoms, and treatment.{Alvin Marcovici et al,2016}.

Although diskitis and associated vertebral osteomyelitis are uncommon conditions, they are often the causes of debilitating neurologic injury. Unfortunately, morbidity can be exacerbated by a delay in diagnosis and treatment of this condition. The lumbar region is most commonly affected, followed by the cervical spine and, lastly, the thoracic spine. {Alvin Marcovici et al,2016}.

Figure 2.19: Showdiscitis {healthtap.com}

2.2.5 syringiomyelia:

Syringomyelia is a generic term referring to a disorder in which a cyst or cavity forms within the spinal cord. This cyst, called a syrinx, can expand and elongate over time, destroying the spinal cord. The damage may result in pain, paralysis, weakness, and stiffness in the back, shoulders, and extremities. Syringomyelia may also cause a loss of the ability to feel extremes of hot or cold, especially in the hands. There is also a disorder that generally leads to a cape-like pain (extreme pain, pressure, and many other painful symptoms in the area where a cape would be) and temperature sensation along the back and arms. Each patient experiences a different combination of symptoms. These symptoms typically vary depending on the extent and, often more critically, to the location of the syrinx within the spinal cord. { Merriam-Webster Dictionary,2016}.

Figure 2.20: ShowSyringomyelia {en.wikipedia.org}

2.2.6 Tumors:

A spinal tumor is an abnormal mass of tissue within or surrounding the spinal cord and spinal column, in which cells grow and multiply uncontrollably, seemingly unchecked by the mechanisms that control normal cells. Spinal tumors can be benign (non-cancerous) or malignant (cancerous). Primary tumors originate in the spine or spinal cord and metastatic or secondary tumors result from cancer spreading from another site to the spine.Spinal tumors may be referred to by the area of the spine in which they occur; These basic areas are cervical, thoracic, lumbar and sacrum. Additionally, they are also classified by their location in the spine – anterior (front) and posterior (back). Clinically, they are divided according to location into three major groups: intradural-extramedullary, intramedullary, and extradural.{http://www.centerforneuroandspine.com/conditions/spine-conditions/cervical spine-conditions/cervical-tumors/}.

Figure 2.21: ShowC2 vertebra with tumor{spineuniverse.com}

2.2.7 Cervical spine fractures:

Fractures of the cervical spine may be present in polytraumatized patients and should be suspected in patients complaining of neck pain. These fractures are more common in men approximately 30 years of age and are most often caused by automobile accidents. The cervical spine is divided into the upper cervical spine (occiput-C2) and the lower cervical spine (C3-C7), according to anatomical differences. Fractures in the upper cervical spine include fractures of the occipital condyle and the atlas, atlanto-axial dislocations, fractures of the odontoid process,and hangman's fractures in the C2 segment. These fractures are characterized based on specific classifications. In the lower cervical spine, fractures follow the same pattern as in other segments of the spine; currently, the most widely used classification is the SLIC (Subaxial Injury Classification), which predicts the prognosis of an injury based on morphology, the integrity of the disc-ligamentous complex, and the patient's neurological status. It is important to correctly classify the fracture to ensure appropriate treatment. Nerve or spinal cord injuries, pseudarthrosis or malunion, and postoperative infection are the main complications of cervical spine fractures.{Raphael MartusMarcon et al, 2015}.

(1)vertical fracture through the body of C7 (2) A fracture of the base of the dens

Figure 2.22: ShowCervical fractures {emedicine.medscape.com}

2.3 Previous studies:

ZHANG Ling et al,2012investigated the geometric parameters of normal cervical spinal canal including the sagittal and transverse diameters as well as Torg ratio. The mean sagittal diameter of cervical spinal canal at C 1 to C 7 ranges from 15.33 mm to 20.46 mm, the mean transverse diameter at the same levels ranges from 24.45 mm to 27.00 mm and the mean value of Torg ratio is 0.96. With respect to narrow cervical spinal canal, the following charaterstics are found: firstly, extension of the cervical spine results in statistically significant stenosis as compared with the flexed or neutral positions; secondly, females sustain cervical spinal canal narrowing more easily than males; finally, the consistent narrowest cervical canal level is at C 4 for all ethnicity, but there is a slight variation in the sagittal diameter of cervical spinal stenosis (?14 mm in Whites, ? 12 mm in Japanese, ?13.7 mm in Chinese. Narrow sagittal cervical canal diameter brings about an increased risk of neurological injuries in traumatic, degenerative and inflam-matory conditions and is related with extension of cervical spine, gender, as well as ethnicity. It is hoped that this re-view will be helpful in diagnosing spinal cord and neuro-logical injuries with the geometric parameters of cervical spine in the future. Key words: Spinal cord injuries; Spinal stenosis; Trauma, nervous system.{ ZHANG Ling et al,2012}.

Ebraheim NA,1996To measure the cervical nerve groove in eight linear and one angular dimensions and the intervertebral foramen in two linear diameters.Differences in dimensions of male and female specimens were not found

to be statistically significant. The average lengths of the medial zone and distances from the midline of the vertebral body to the anterior border of the medial zone for male and female specimens consistently increased from C3 to C7. The width of the medial zone was larger in C3 than that of C4, C5, and C6 in male and female specimens. The minimum width for all levels ranged 1-2 mm. The medial zone depths gradually increased from C3 (3.2 mm for male and 2.3 mm for female specimens) to C7 (4.9 mm for male and 4.4 mm for female specimens). The smallest anteroposterior distances from the posterior midpoint of the lateral mass to the posterior border of the nerve groove were found in C7 (6.7 mm for male and 6.1 mm for female specimens). The general trend of the foraminal height and width increased from the cephalad to caudal except at C2-C3.These data may enhance understanding of the important bony elements associated with the cervical spinal nerves and roots as they pass through the cervical nerve groove and the intervertebral foramen.{Ebraheim,1996}.

Kitagawa et al,2004.studiedthe morphologic changes in the neural foramen during flexion and extension of the cervical spine in vivo.studiedfound there areFlexion significantly increased the foraminal height (by 1.0 mm; 11%), foraminal width (by 1.0 mm; 16%), and foraminal area (by 12 mm2; 28%) ($P < 0.01$). Extension significantly decreased the foraminal height (by 0.9 mm; 10%), foraminal width (by 1.4 mm; 22%), and foraminal area (by 8.0 mm2; 17%) ($P < 0.01$). Segmental sagittal rotation significantly positively correlated with % change in foraminal height ($r = 0.434$, $P < 0.01$) and area ($r = 0.504$, $P < 0.01$).The present results are consistent with those of previous in vitro studies and may explain the clinical observation that cervical extension aggravates symptoms in patients with cervical radiculopathy and that flexion often relieves them. {Kitagawa et al,2004}.

Ahmed SH et al,2014. elucidate the correlation between the morphology and disorders of the cervical intervertebral foramina in normal and pathological conditions especially at the level of C3-C4 to C6-C7 on both sides and in both sexes.All measurements of the present study of the cervical disorders in females were found to be 6% less than in males in all age groups, which is statistically significant ($p < 0.01$) as compared with the control group (2%). The mean intervertebral foraminal areas in the control group of C5-C6 and C6-C7 are significantly greater than those of C3-C4 and C4-C5. The mean intervertebral foraminal area was greater in the lower cervical region than the upper in normal adult individuals. In pathological condition the affection of C3-C4 and C4-C5 intervertebral foramina was more due to narrower surface area. The pathology of cervical spine affecting the intervertebral foramina of female which complaint earlier than male due to narrower foramina.{Ahmed et al,2014}.

Ronald H et al,2001.evaluate the effects of implantation of a carbon fiber cage after anterior cervical discectomy (ACD) on the height of the foramen and the angulation between endplates of the disc space.the mean height of the foramina (± standard deviation) was 8.1 ± 1.5 mm (range 5.7–12 mm), and at 1 day postoperatively it was 9.7 ± 1.4 mm (range 7.5–12.8 mm). This difference reached statistical significance ($p < 0.0005$). The mean foraminal height after 1 year was 9.4 ± 1.4 mm (range 6.9–12.7 mm). In terms of the preoperative value, the 1-year measurement still reached statistical difference ($p < 0.005$) but not with the direct postoperative mean foraminal height. Preoperatively the mean value of the angle between the two adjacent endplates was 1.3 ± 2.4° (range 0–8°), and postoperatively it was 7.8 ± 2.9° (range 2–12°), which was statistically significant ($p < 0.0005$).The cervical carbon fiber cage effectively increased the height of the foramen even after 1 year, which contributed to decompression of the nerve root. The wedge shape of the device may contribute to restoration of lordosis.{Ronald et al,2001}.

Chapter three

Materials and methods

The methodology section of this thesis described the design of the study, the setting where it took place, the sampling design that was used, and the instruments that were involved in data collection, and also the procedures that were followed for data collection. The statistics that were used for data analysis and a description of the way in which data were analyzed are also discussed.

3.1 Materials

3.1.1 Study sample:

Total samples of 52 patients in the study, their ages were between (15-80) years old. Both genders were include 40were males and 12were females.

3.1.2 Area and duration of the study:

The study had been carried out during the period from March 2016 up to May2016 in Al-Ribat teaching Hospital ,Al-ZytounaHospital,Al-Amal National Hospital and Ebrahimmalik Hospital.

3.1.3 Machines used:

InAl-Ribat teaching Hospital CT scanner used neosoft 16 slices.

In Al-ZytounaHospital CT scanner used Toshiba 64 slices.

In Al-Amal National HospitalCT scanner usedToshiba 64 slices.

In EbrahimmalikHospitalCT scanner usedToshiba4 slices.

3.2 Methods:

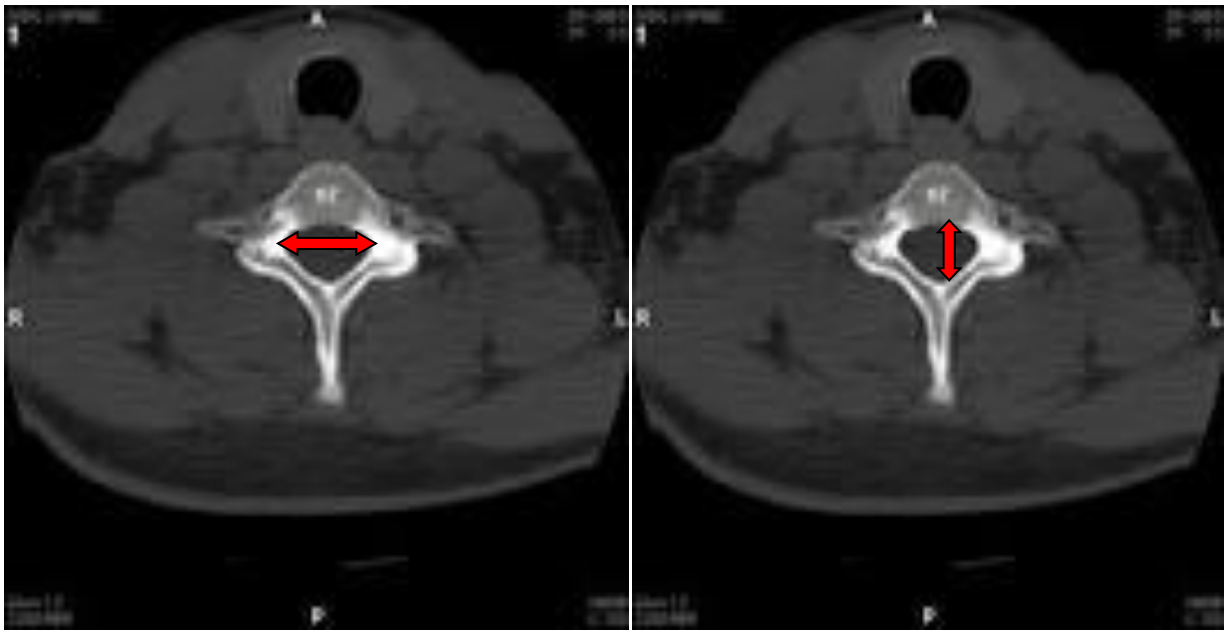
3.2.1 Methods of scanning:

CT scan was done started from base of skull to sternum notch . The technical exposures factors that were used in this study were 120 Kv, 200 mA, 1- 5 mm slice thickness with identical reconstruction index and a rotation time 1.5 sec.

3.2.2 Methods of measurements:

All the measurements done for cervical vertebral foramen diameters were obtained from C1up to C7 .

All images of study are measurement to transverse and antroposteiordiameters In axial CT cervical at levels C1,C2,C3,C4,C5,C6 and C7 the method show in figure (3.1)



(1)transversmeasurement (2) antroposteior measurement

Figure 3.1: Show method of transverse and antroposteior measurement.

Chapter Four

Results

Statistical Methods: the use of comparative analytical method using the SPSS statistical program based descriptive statistics and comparative and association hypothesis tests (0.05 sig. level), to demonstrate the differences in (length) and (width) of **(C1, C2, C3, C4, C5, C6 and C7)** among patients.

Note:

- C1: first Cervical, C2: second Cervical up to C7: seventh Cervical.
- L: Length.
- W: Width.

Thetest was usedfort-test and F test to study thehypothesiswhich statesthereare nosignificant differences in mean of (length and Wight).

Table (4.1):Participants distribution with Respect to Gender:

	Frequency	**Percent**
Male	40	76.9
Female	12	23.1
Total	**52**	**100.0**

Figure (4.1):Participants distribution with Respect to Gender:

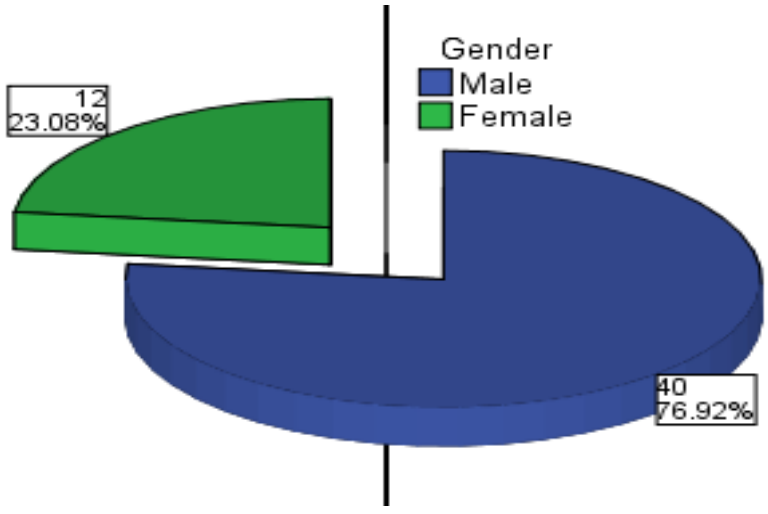


Table (1) and Figure (1) show the distribution of gender for sample units, that (76.9%) of them were male while (23.1%) were female.

Table (4.2):Participants distribution with Respect to Age:

	Frequency	Percent
15-25 Years	12	23.1
26-35 Years	15	28.8
36-45 Years	11	21.2
46-55 Years	5	9.6
56-65 Years	5	9.6
more than 65 Years	4	7.7
Total	**52**	**100.0**

Figure (4.2):Participantsdistribution with Respect to Age:

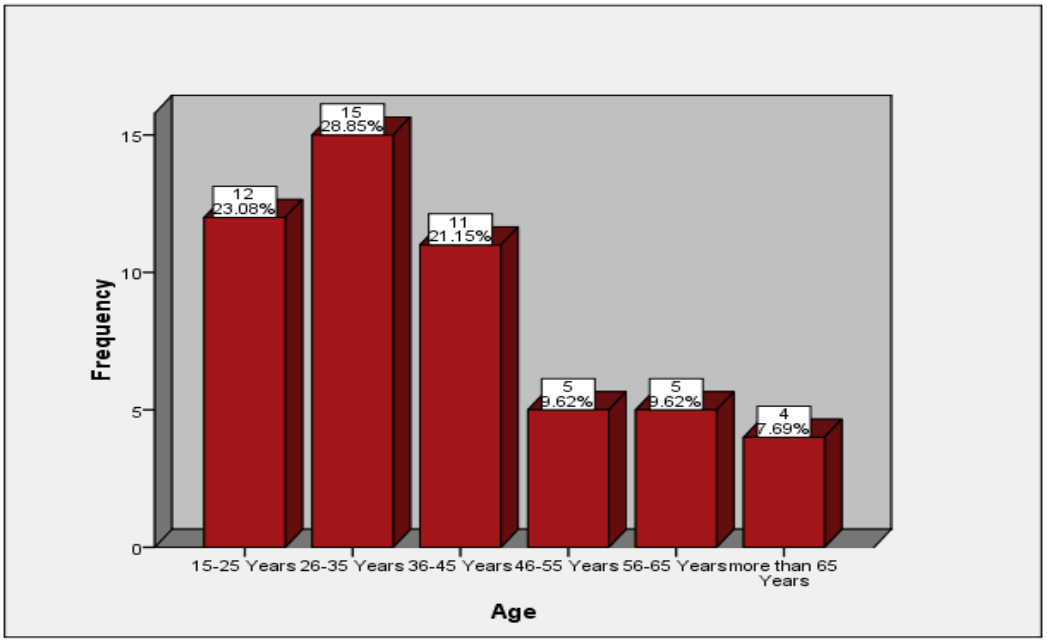


Table (2) and Figure (2) show that (23.1%) of sample units were (15-25 years old),(28.8%) of them (26-35 years), (21.2%) of them (36-45 years), (9.6%) of them (46-55 years), or (56-65 years) while (7.7%) were more than 65 years old. therefore most of the participants were (15-45 years old).

Table (4.3): distribution of mm length and mm width of C1 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC1	40	32.310	3.1517
	WC1	40	26.607	4.0267
Female	LC1	12	31.442	2.4474
	WC1	12	27.258	3.3209

Table (4.4): distribution of mm length and mm width of C2 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC2	40	18.088	2.0500
	WC2	40	23.915	2.0754
Female	LC2	12	17.117	1.2805
	WC2	12	23.417	1.4497

Table (4.5): distribution of mm length and mm width of C3 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC3	40	14.345	1.6687
	WC3	40	23.290	2.0353
Female	LC3	12	14.592	1.5341
	WC3	12	23.400	1.9216

Table (4.6): distribution of mm length and mm width of C4 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC4	40	14.155	1.6469
	WC4	40	24.313	2.3810
Female	LC4	12	14.300	1.4930
	WC4	12	24.225	2.0596

Table (4.7): distribution of mm length and mm width of C5 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC5	40	14.553	1.4128
	WC5	40	25.645	2.0081
Female	LC5	12	14.258	1.5252
	WC5	12	24.383	2.2815

Table (4.8): distribution of mm length and mm width of C6 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC6	40	14.640	1.5340
	WC6	40	25.665	1.8547
Female	LC6	12	14.500	1.4985
	WC6	12	24.458	1.5877

Table (4.9): distribution of mm length and mm width of C7 with respect to gender:

Gender		N	Mean(mm)	Std. Deviation
Male	LC7	40	15.030	1.8614
	WC7	40	24.865	2.5112
Female	LC7	12	14.925	2.6755
	WC7	12	23.625	1.8748

Table (4.10): t-test for Equality of Means of (C1, C2, C3, C4, C5, C6 and C7) between males and females:

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
LC1	Equal variances assumed	.876	50	.385	.8683	.9910
	Equal variances not assumed	1.004	23.058	.326	.8683	.8646
WC1	Equal variances assumed	-.509	50	.613	-.6508	1.2779
	Equal variances not assumed	-.566	21.655	.578	-.6508	1.1508
LC2	Equal variances assumed	1.546	50	.128	.9708	.6279
	Equal variances not assumed	1.975	29.500	.058	.9708	.4916
WC2	Equal variances assumed	.774	50	.442	.4983	.6435
	Equal variances not assumed	.937	25.923	.357	.4983	.5318
LC3	Equal variances assumed	-.457	50	.650	-.2467	.5398
	Equal variances not assumed	-.478	19.502	.638	-.2467	.5155
WC3	Equal variances assumed	-.166	50	.869	-.1100	.6619
	Equal variances not assumed	-.172	19.041	.866	-.1100	.6413
LC4	Equal variances assumed	-.273	50	.786	-.1450	.5313
	Equal variances not assumed	-.288	19.754	.776	-.1450	.5036
WC4	Equal variances assumed	.115	50	.909	.0875	.7617
	Equal variances not assumed	.124	20.653	.902	.0875	.7037

LC5	Equal variances assumed	.621	50	.537	.2942	.4734
	Equal variances not assumed	.596	17.072	.559	.2942	.4937
WC5	Equal variances assumed	1.851	50	.070	1.2617	.6818
	Equal variances not assumed	1.726	16.456	.103	1.2617	.7311
LC6	Equal variances assumed	.279	50	.782	.1400	.5024
	Equal variances not assumed	.282	18.489	.781	.1400	.4959
WC6	Equal variances assumed	2.037	50	.047	1.2067	.5922
	Equal variances not assumed	2.218	20.863	.038	1.2067	.5441
LC7	Equal variances assumed	.154	50	.878	.1050	.6807
	Equal variances not assumed	.127	14.341	.901	.1050	.8265
WC7	Equal variances assumed	1.579	50	.121	1.2400	.7853
	Equal variances not assumed	1.847	24.062	.077	1.2400	.6712

Table (4.11): distribution of mm length and mm width of C1 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC1	12	32.617	3.1914
	WC1	12	26.542	3.7162
26-35 Years	LC1	15	31.433	2.7637
	WC1	15	26.373	3.9995
36-45 Years	LC1	11	31.582	2.4223
	WC1	11	27.009	5.4261
46-55 Years	LC1	5	32.060	5.7440
	WC1	5	26.020	3.8088
56-65 Years	LC1	5	33.760	1.8091
	WC1	5	28.200	1.6778
more than 65 Years	LC1	4	32.575	1.8283
	WC1	4	27.275	.3304

Table (4.12): distribution of mm length and mm width of C2 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC2	12	18.517	2.0515
	WC2	12	23.883	1.6927
26-35 Years	LC2	15	17.327	1.6219
	WC2	15	23.687	2.3694
36-45 Years	LC2	11	17.645	1.5776
	WC2	11	23.409	.8227
46-55 Years	LC2	5	17.760	2.8641
	WC2	5	22.760	1.8823
56-65 Years	LC2	5	18.620	2.5411
	WC2	5	25.460	3.0956
more than 65 Years	LC2	4	17.700	1.9149
	WC2	4	24.275	.8098

Table (4.13): distribution of mm length and mm width of C3 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC3	12	14.783	1.4893
	WC3	12	23.250	1.2602
26-35 Years	LC3	15	13.827	1.6564
	WC3	15	22.920	2.5899
36-45 Years	LC3	11	14.555	1.4528
	WC3	11	23.818	1.5178
46-55 Years	LC3	5	14.260	1.7242
	WC3	5	22.340	2.3244
56-65 Years	LC3	5	15.200	1.5984
	WC3	5	24.840	2.2898
more than 65 Years	LC3	4	14.175	2.4878
	WC3	4	22.925	1.0210

Table (4.14): distribution of mm length and mm width of C4 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC4	12	14.383	1.2762
	WC4	12	23.725	3.1081
26-35 Years	LC4	15	13.507	1.4150
	WC4	15	24.007	2.0454
36-45 Years	LC4	11	14.709	2.0181
	WC4	11	25.382	.8316
46-55 Years	LC4	5	14.360	1.7009
	WC4	5	23.080	2.9778
56-65 Years	LC4	5	14.600	1.3910
	WC4	5	25.120	2.5430
more than 65 Years	LC4	4	14.000	2.0785
	WC4	4	24.550	1.3626

Table (4.15): distribution of mm length and mm width of C5 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC5	12	14.217	1.2320
	WC5	12	25.908	2.5343
26-35 Years	LC5	15	14.320	.8579
	WC5	15	24.940	1.5601
36-45 Years	LC5	11	14.836	1.9836
	WC5	11	25.564	1.4066
46-55 Years	LC5	5	14.360	1.4622
	WC5	5	23.920	3.8232
56-65 Years	LC5	5	15.020	1.2736
	WC5	5	26.000	2.2237
more than 65 Years	LC5	4	14.425	2.4958
	WC5	4	25.650	1.5264

Table (4.16): distribution of mm length and mm width of C6 with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC6	12	14.642	1.5986
	WC6	12	25.658	2.5543
26-35 Years	LC6	15	14.460	1.1382
	WC6	15	25.413	1.3071
36-45 Years	LC6	11	14.309	2.0656
	WC6	11	25.264	1.5895
46-55 Years	LC6	5	15.540	1.3631
	WC6	5	24.600	2.3537
56-65 Years	LC6	5	14.840	1.1567
	WC6	5	25.860	2.0900
more than 65 Years	LC6	4	14.425	1.7212
	WC6	4	25.200	1.7626

Table (4.17): distribution of mm length and mm width of C7with respect to Age:

Age		N	Mean(mm)	Std. Deviation
15-25 Years	LC7	12	14.792	1.4700
	WC7	12	24.767	3.1779
26-35 Years	LC7	15	14.633	1.7907
	WC7	15	24.127	2.4376
36-45 Years	LC7	11	15.009	2.5723
	WC7	11	24.727	2.3555
46-55 Years	LC7	5	16.380	3.3177
	WC7	5	23.980	2.1417
56-65 Years	LC7	5	15.300	1.6733
	WC7	5	24.760	1.9514
more than 65 Years	LC7	4	14.950	1.9485
	WC7	4	25.825	1.0874

Table (4.18): Analysis of Variance (ANOVA) table for Equality test of Means for (C1, C2, C3, C4, C5, C6 and C7) between age groups:

		Sum of Squares	df	Mean Square	F	Sig.
LC1	Between Groups	27.507	5	5.501	.585	.711
	Within Groups	432.738	46	9.407		
	Total	460.245	51			
WC1	Between Groups	17.664	5	3.533	.220	.952
	Within Groups	739.903	46	16.085		
	Total	757.567	51			
LC2	Between Groups	12.987	5	2.597	.673	.646
	Within Groups	177.653	46	3.862		
	Total	190.641	51			
WC2	Between Groups	22.045	5	4.409	1.184	.332
	Within Groups	171.355	46	3.725		
	Total	193.400	51			
LC3	Between Groups	10.457	5	2.091	.772	.575
	Within Groups	124.593	46	2.709		
	Total	135.050	51			
WC3	Between Groups	22.166	5	4.433	1.132	.357
	Within Groups	180.122	46	3.916		
	Total	202.288	51			
LC4	Between Groups	11.546	5	2.309	.893	.494
	Within Groups	118.947	46	2.586		
	Total	130.493	51			
WC4	Between Groups	29.183	5	5.837	1.125	.361
	Within Groups	238.654	46	5.188		
	Total	267.837	51			

LC5	Between Groups	4.154	5	.831	.382	.859
	Within Groups	100.074	46	2.176		
	Total	104.228	51			
WC5	Between Groups	19.461	5	3.892	.854	.519
	Within Groups	209.749	46	4.560		
	Total	229.209	51			
LC6	Between Groups	6.071	5	1.214	.505	.771
	Within Groups	110.586	46	2.404		
	Total	116.657	51			
WC6	Between Groups	5.417	5	1.083	.293	.914
	Within Groups	169.904	46	3.694		
	Total	175.321	51			
LC7	Between Groups	12.519	5	2.504	.572	.721
	Within Groups	201.450	46	4.379		
	Total	213.968	51			
WC7	Between Groups	11.901	5	2.380	.382	.859
	Within Groups	286.885	46	6.237		
	Total	298.787	51			

Chapter five

(Discussion, conclusions and recommendation)

5.1Discussion:

This study attempting to establish the size (length and width) of (C1, C2, C3, C4, C5, C6 and C7) for patients and to study the variation according to age, gender.

The study was performed on a sample of size (52) patients aged (15-80) years old. The results showed as follow:

The study shows that, the mean length of C1was (0.87mm) longer in males than females, while it is (0.65mm) smaller in width. the mean length of C2 was (0.97mm) longer in males than females, and (0.5mm) larger in width. the mean length of C3 was (0.24mm) for males less than for females, and (0.11mm) smaller in width. the mean length of C4 was (0.14mm) for males less than for females, and (0.8mm) larger in width. the mean length of C5 was (0.24mm) longer for males than for females, and (1.27mm) larger in width. the mean length of C6 was (0.14mm) longer for males than for females, and (1.21mm) larger in width. the mean length of C7 was (0.10mm) longer for males than for females, and (1.24mm) larger in width.

The study shows that, (table 4.10), the means of (mm length and mm width) of (C1, C2, C3, C4, C5, C6 and C7) which were compared between males and female with corresponding significance values of t-tests (0.385, 0.613), (0.128, 0.442), (0.650, 0.869), (0.786, 0.909), (0.537, 0.070), (0.782, 0.047) and (0.878, 0.121), respectively for (C1, C2, C3, C4, C5, C6 and C7) (all of Sig. more than or equal to 0.05) which implies that, there were nostatistically significantdifferences between two groups (males and females).

These measurement compared to study done by ZHANG Ling 2012 found The mean sagittal diameter of cervical spinal canal at C 1 to C 7 ranges from 15.33 mm to 20.46 mm, the mean transverse diameter at the same levels ranges from 24.45 mm to 27.00 mm which was same to our study but difference at length of C1 by (12mm) this different may be due todifferent heightand methods of measurement. In anotherstudy done by Ahmed SH,2014 found The mean intervertebral foraminal areas in the control group of C5-C6 and C6-C7 are significantly greater than those of C3-C4 and C4-C5 which was different from our study (the mean of C3-C7 was same in our results).

The study shows that, (table 4.11), the mean size of C1for people who (15-25 years old) was (1.19mm length, 0.17mm width) larger than for (26-35 years) which was (0.15mm length, 0.47mm width) smaller than for (36-45 years) which itself was (0.48mm larger in length, 0.99mm larger in width) than for (46-55 years), while it was (1.14mm length, 1.66mm in width) smaller than for (56-65 years) but not for (more than 65 years).(table 4.12), the mean size of C2 for people who (15-25 years old) was (1.19mm length, 0.19mm width) larger than for (26-35 years) which was (0.08mm length smaller, 0.28mm width larger) than for (36-45 years) which itself was (0.11mm smaller in length, 0.65mm larger in width) than for (46-55 years), while it was (0.10mm length, 1.58mm in width) smaller than for (56-65 years) and (0.82mm larger length, 0.40mm smaller width) for (more than 65 years).(table 4.13), the mean size of C3 for people who (15-25 years old) was (0.95mm length, 0.33mm width) larger than for (26-35 years) which was (0.73mm length, 0.90mm width) smaller than for (36-45 years) which itself was (0.30mm length, 1.48mm width) larger than for (46-55 years), while it was (0.42mm length, 1.32mm in width) smaller than for (56-65 years) and (0.60mm length, 0.32mm width) larger than for (more than 65 years).(table 4.14), the mean size of C4 for people who (15-

25 years old) was (0.87mm larger length, 0.29mm smaller width) than for (26-35 years) which was (1.20mm length, 1.37mm width) smaller than for (36-45 years) which itself was (0.35mm length, 2.30mm width) larger than for (46-55 years), while it was (0.22mm length, 1.40mm in width) smaller than for (56-65 years) and (0.38mm larger length, 0.83mm smaller width) than for (more than 65 years). (table 4.15), the mean size of C5 for people who (15-25 years old) was (0.10mm larger length, 0.97mm smaller width) than for (26-35 years) which was (0.52mm length, 0.62mm width) smaller than for (36-45 years) which itself was (0.48mm length, 1.64mm width) larger than for (46-55 years), while it was (0.80mm length, 0.09mm in width) smaller than for (56-65 years) and (0.21mm length, 0.26mm width) smaller than for (more than 65 years). (table 4.16), the mean size of C6 for people who (15-25 years old) was (0.18mm length, 0.25mm width) larger than for (26-35 years) which was (0.15mm length, 0.15mm width) larger than for (36-45 years) which itself was (0.1.23mm smaller length, 0.66mm larger width) than for (46-55 years), while it was (0.20mm length, 0.20mm in width) smaller than for (56-65 years) and (0.21mm smaller length, 0.46mm larger width) than for (more than 65 years). (table 4.17), the mean size of C7 for people who (15-25 years old) was (0.16mm length, 0.64mm width) larger than for (26-35 years) which was (0.38mm length, 0.60mm width) smaller than for (36-45 years) which itself was (0.1.37mm smaller length, 0.75mm larger width) than for (46-55 years), while it was (0.51mm smaller length, 0.01mm larger width) than for (56-65 years) and (0.16mm length, 1.06mm width) smaller than for (more than 65 years).

The study shows that, (table 4.18), the means of (mm length and mm width) of (C1, C2, C3, C4, C5, C6 and C7) which compared between different age groups (15-25), (26-35), (36-45), (46-55), (56-65) and (more than 65 years) with corresponding significance values of F-tests (0.711, 0.952), (0.64, 0.332), (0.575, 0.357), (0.494, 0.361), (0.859, 0.519), (0.771, 0.914) and (0.721, 0.859),

respectively for (C1, C2, C3, C4, C5, C6 and C7) (all of Sig. more than 0.05) which implies that, there were nostatisticallysignificants differences between age groups (in all Cs Size).

5.2 Conclusion:

The study concludesthe normalnormalcervical vertebral foramen diameter in Sudanese patient by CT was found that C1 is greater in size than other Cervicals.

There wereno statistically significant differences between two groups (males and females) in all Cervicals.

There were no statistically significant differences between age groups (in all Cervicals Size).

5.3 Recommendation:

The researcher recommended that:

Further study in evaluation of normal cervical vertebral foramen diameter with larger sample of Sudanese population for more accurate results is needed.

any doubt about any abnormal cases should be avoided although they were diagnosed as normal in order to avoid the limitations of this study.

use additional imaging method to confirm the results.

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Data collecting sheet (questionnaire)

- NO ☐
- **Patient data:**
  - Patient name ……
  - Age ☐ - Sex ☐
- **antroposterior measurment (length):**
  - C1 ☐ - C2 ☐
  - C3 ☐ - C4 ☐
  - C5 ☐ - C6 ☐
  - C7 ☐
- **transvers measurement (width):**
  - C1 ☐ - C2 ☐
  - C3 ☐ - C4 ☐
  - C5 ☐ - C6 ☐
  - C7 ☐