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RESEARCH ARTICLE

COMPUTERISED TOMOGRAPHIC MORPHOMETRIC ANALYSIS OF ATLAS AND AXIS VERTEBRAE.

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Abstract

Aim: To study the variations in the morphological dimensions of atlas and axis vertebrae using computerised tomographic scan in Indian population , which can be extrapolated for effective future planning and meticulous surgical technique while operating in C1- C2 region for all kind of pathologies.

Materials And Methods: Fifty subjects from both sexes who took computed tomographic scan of brain or cervical spine in Coimbatore medical college for any indications without any abnormality of C1 and C2 are taken for morphological analysis. Study includes patients of adult age group of more than 20 years. Various dimensions of Atlas and Axis are measured and compared with previous studies .

Results: The mean value of the various dimensions of lateral mass of atlas is 15.6 mm (AP) and 12.7 mm(TR) and lateral mass of axis is 14.5 mm(AP) and 14.2 mm(TR) respectively , the average screwable thickness in the posterior aspect of C1 lateral mass is 5.4 mm on left and right side. The safe angle for trajectory of C1 lateral mass in sagittal plane is 13^0 and in axial plane is 11.9^0 .

Conclusion: Morphometric analysis of C1-C2 vertebra shows light on the ideal dimensions and screws to be used in our population. It also shows light on the safety angle and safety margin to avoid complications related to vertebral artery and spinal cord injury.

Introduction:-

Atlas and axis vertebrae are smaller in size but they serve anatomically and biomechanically important functions. They give maximum range of mobility without compromising stability. These two vertebrae can be affected by various diseases like congenital anomaly to trauma. Though traumatic C1C2 spine injury lead to death in certain cases,but in certain patients secondary cord injury can be prevented by proper surgical procedures and stabilisation. By analysing the computerised tomographic morphometric dimensions in our Indian population we can use optimum size screws and implants.

The commonly done CVJ surgeries are occipitocervical fusion , C1C2 lateral mass fixation, odontoid screw fixation. In all the above surgeries the purchasable dimension and the quality of the bone decide the better outcome.

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With modern era of thin slice CT, it is easy to measure these dimensions with CT scan. There are so many western studies done to analyse the morphometry of atlas and axis vertebrae,but our study is to analyse the morphometric dimensions of atlas and axis and their surgical implications.

CT brain with lower limit extending to C3 vertebra with multiplanar reconstruction images are used . The maximum dimension of C1 lateral mass, odontoid, body of C2, lateral mass of C2 are identified and recorded in detail. Surgery in these locations are highly complex, thus the dimensions of instrumentations and their point of entry, directions are important for surgical planning. As there is ethnical difference, we want to know the morphometric dimensions of atlas and axis in our Indian population.

Material AndMethods:-

50 subjects from both sexes who took CT scan of brain or cervical spine in Coimbatore medical college for any indication (following trauma, CVA, degenerative diseases) without any abnormalities of C1 and C2 are taken for morphological analysis.

Study includes the patients of adult age group more than 20 years.

In CV junction surgery, the thickest part of C1 and C2 lateral mass is used for lateral mass screw fixation. C2 body and odontoid is used for odontoid screw fixation in case of odontoid fracture . Thickest part of spine and lamina of C2 is used for translaminar screw. Trans articular screw is used in C1-C2 subluxation.

In this study we want to define the variations in the dimensions of screw purchasable bony parts of C1 and C2 in Indian population. Vertebral artery injury is the worst complication in CV junction surgery . The relation of vertebral artery in relation to screwable C2 lateral mass is identified and measured . Spinal canal dimension is larger when compared to cord diameter.

In this study, we measured the following dimensions: C2 body –AP and TR dimension, C2 lamina length and height , total length from C2 base towards tip of dens, C2 lateral mass AP and TR dimension, the length from C2 articular surface to superior margin of vertebral artery in parasagital plane to know about the safety of screw purchase . In C1 ,lateral mass AP ,TR dimensions noted . Spinal canal and spinal cord dimensions noted . In C1, screwable area in the posterior surface of C1 lateral mass below the lamina is measured. The diameter of transverse foramina is measured. Favourable C2 anatomy for segmental fixation is identified.

The available vertical dimensions of the posterior surface of C1 lateral mass below the lamina in vertical plane for screw entry point is identified. The safe angle of screw insertion in sagittal plane and the thickness of posterior arch near the vertebral artery groove documented. The safe angle of screw trajectory in sagittal plane and the safe angle of screw trajectory in axial plane are noted .

Results:-

The dimensions related to atlas vertebra are described below and also showed in Table-1 and Table- 2

The maximum AP dimension of C1 lateral mass on right side ranges from 11.6 mm to 18.5 mm and the mean is 15.64 mm. The maximum AP dimension of C1 lateral mass on left side ranges from 13.4 mm to 18.1 mm and the mean is 16.06 mm. The maximum transverse dimension of C1 lateral mass on right side ranges from 9.5 mm to 15.8 mm and the mean is 12.74 mm. The maximum transverse dimension of C1 lateral mass on left side ranges from 9.1 mm to 16.3 mm and the mean is 12.5 mm.

The average vertical dimension in the posterior surface of C1 lateral mass below posterior arch is 5.4 mm. The average height of posterior arch at the level of vertebral artery groove is 5.3 mm. The mean distance from midline to the vertebral artery groove is 14.75 mm and 14.04 mm on right and left side respectively.

The sagittal angle in the sagittal plane is measured at junction of anterior arch and the lateral mass. The measured mean sagittal angle is 13^0 on right and 10.86^0 on left side respectively. The safe cranial angle in axial plane were 11.9^0 and 12.9^0 on right and left side respectively.

Mean canal dimension at C1 AP is 18.95 mm transverse is 27.80 mm and cord dimension is AP 8.02 mm and transverse 10.41 mm. Mean canal dimension of C2 AP is 17.43 mm and transverse 24.14 mm and cord dimension AP is 8.15 mm and transverse is 11.05 mm.
The dimensions related to axis vertebra are described below and also showed in Table-2 and Table- 3

The mean length of C2 base to odontoid tip is 30.38 mm. The transverse dimension of odontoid process is 10.37 mm.

Average length of C2 lamina is 23.96 mm on right and 24.09mm on left side. Average width of C2 lamina is 5.28 mm on right side and 5.51 mm on left side. Average vertical height of C2 lamina is 6.58 mm on right side and 6.72 mm on left side.

The average safe sagittal angle of C2 lateral mass is 41.2^0 and 42.4^0 on right and left side respectively. The average safe cranial angle in axial plane is 27^0 and 28.93^0 on right and left side respectively.

The average distance between vertebral artery foramen from superior facet of C2 is 4.4 mm and 4.64 mm on right and left side respectively. The distance from medial margin of spinal canal to vertebral foramen is 4.49 mm and 4.21mm on right and left side.

Table 1:-Dimensions of Atlas vertebra

The parameters (mm)	Mean	Min	Max
ATLAS (C1)			
Lateral mass AP-right	15.6	11.6	18.5
Lateral mass AP-left	16	13.4	18.1
Lateral mass TR-right	12.7	9.5	15.8
Lateral mass TR-left	12.5	9.1	16.3
Transverse foramen-right	7	4.6	8
Transverse foramen-left	6.8	4.9	8.2
Lamina thickness-right	5.2	3.7	5.3
Lamina thickness-left	5.4	3.8	6.4
Lamina-length-right	24.7	20	27.1
Lamina-length-left	23.7	21.5	28.1
Lamina-height-right	4.2	3.1	6.6
Lamina-height-left	4.4	3.2	6.5
Distance between midline to vertebral artery grove-right	14.7	9.3	19.9
Distance between midline to vertebral artery grove-left	14	11	17.4
Spinal canal- AP	18.9	14	22.1
Spinal canal –TR	27.8	23.3	33.5
Spinal cord –AP	8	6.6	10.3
Spinal cord –TR	10.4	7.8	12
Lateral mass-Vertical height-medial-right	6.2	5.4	7.5
Lateral mass-Vertical height-medial-left	6.8	5.1	8.7
Lateral mass-Vertical height-lateral-right	16.4	13.9	21.2
Lateral mass-Vertical height-lateral –left	15.4	12.2	18.3
Lateral mass- posterior- screwable thickness -right	5.4	4.3	7
Lateral mass- posterior- screwable thickness -left	5.4	3.6	8.3

Table-2:-Safe Angle Of Atlas And Axis Screw Entry

Parameters	Mean	Min	Max
ATLAS(C1)			
Sagital angle-right	13^0	10^0	16^0
Sagital angle-left	10.8^0	10^0	13^0
Axial angle-right	11.9^0	10^0	16^0
Axial angle-left	12.9^0	10^0	16^0

AXIS(C2)			
Sagital angle-right	41.2^0	25^0	56^0
Sagital angle-left	42.4^0	30^0	56^0
Axial angle-right	27^0	20^0	40^0
Axial angle-left	28.9^0	15^0	45^0

Table 3:-Dimensions of axis vertebra

The parameters (mm)	Mean	Min	Max
AXIS (C2)			
Lateral mass AP-right	14.5	11.6	17.3
Lateral mass AP-left	13.9	11.5	18.1
Lateral mass TR-right	14.2	11.6	17.6
Lateral mass TR-left	12.2	10.3	16
Transverse foramen-right	5.5	2.8	8.2
Transverse foramen-left	5.7	4.2	9.1
Lamina thickness-right	5.2	3.8	6.3
Lamina thickness-left	5.5	3.9	7
Lamina-length-right	23.9	17.8	28
Lamina-length-left	24	20	28.6
Lamina-height-right	6.5	4.2	15.2
Lamina-height-left	6.7	4.7	14
Spinal canal- AP	17.4	12.6	22
Spinal canal –TR	24.1	21.4	26.3
Spinal cord –AP	8.1	6.2	10.7
Spinal cord –TR	11	8.2	15.8
Body –AP	13.5	11.2	15.7
Body- TR	22.2	17.6	25.1
Base of dens-AP	9.7	7	12.6
Base of dens-TR	10.3	7.9	14.1
Dist. b/w superior joint line & superior margin FT-right	4.4	2.3	6.5
Dist. b/w superior joint line & superior margin FT-left	4.6	2.1	6.5
Height body+Odontoid process	30.3	27	35
Distance between FT and medial border -right	4.4	2.9	6.6
Distance between FT and medial border -left	4.2	2	5.5

*AP-Anteroposterior, TR-transverse, FT- foramen transversorium

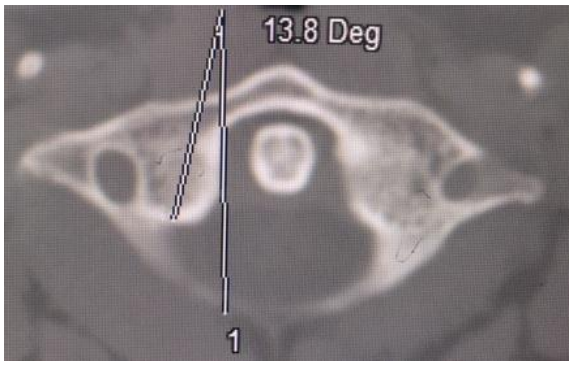

Fig-1:-Sagittal angle of C1

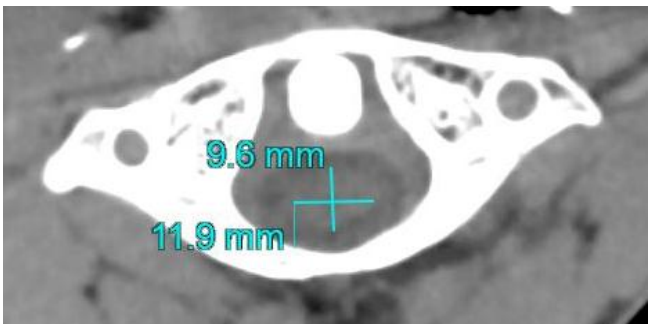

Fig-2:-Spinal cord dimension at C1

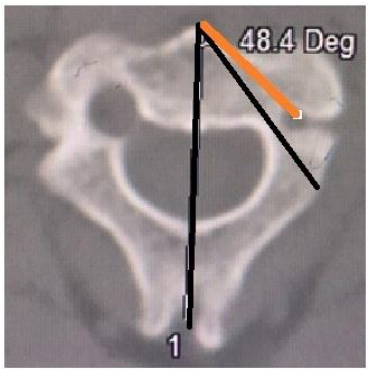

Fig-3:-Sagittal angle of C2

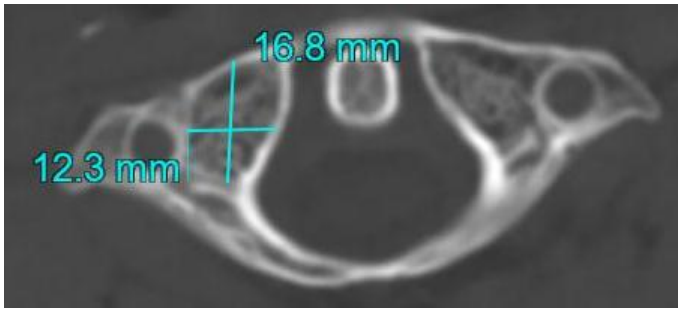

Fig-4:-Lateral mass of C1(AP'TR)

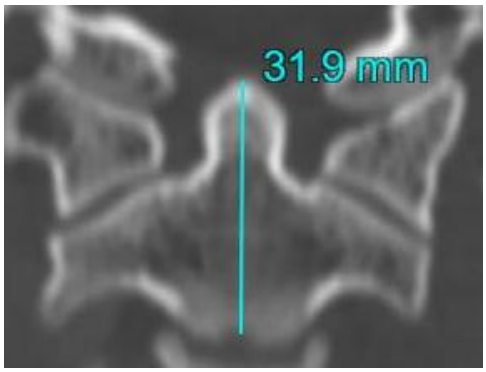

Fig-5:-Vertical height
C2 body + odontoid process

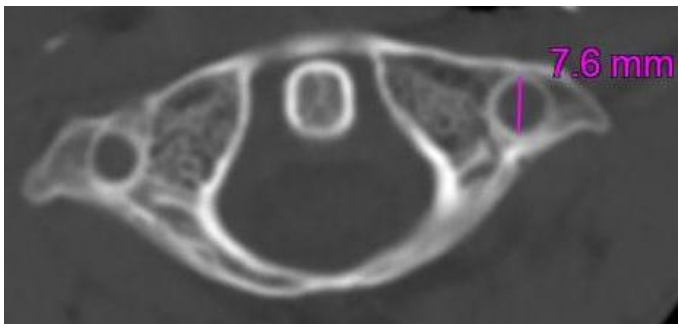

Fig-6:-Foramen transversorium of C1

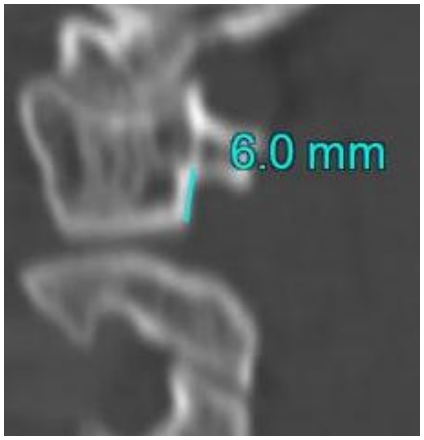

Fig-7:-Screwable thickness in the
Posterior aspect of C1 Lateral mass

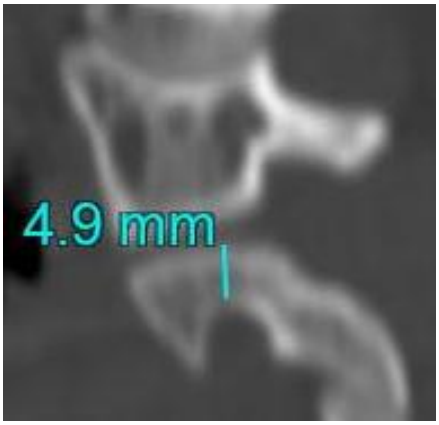

FIG-8:-Distance between superior joint
line and superior aspect of vertebral foramen

Discussion:-

The study which we performed is a random analysis of C1,C2 bone morphometry of 50 patients who have taken CT brain with bone cuts or CT-C spine for other reasons with normal bony anatomy of C1, C2. The parameters are measured are analysed which will be useful in planning for surgeries on C1 and C2.

In our study, we showed the various dimensions of C1 and C2. Our study showed the mean height of C2 30.3 mm which is almost similar to Sinan et al.[1] study which can be utilized for odontoid screw fixation.

Odontoid fractures which need fixation requires the knowledge regarding the diameter of odontoid process. The number of screws required for fixation varies with diameters of odontoid.

The current study show the Anteroposterior and transverse diameter of odontoid as 9.71 and 10.37 mm respectively,which are parallel to the results reported by Xu et al[2], Schaffer et al[3], Kandziora et al[4] and Naderi et al[5].

The Anteroposterior and transverse diameter of C2 body were found to be 13.5 and 21.2 mm respectively.This is similar to the results published by Lu et al[6] and Panjabi et al[7]. This parameter can be taken into consideration during the anterior plating of C2 body using screws and to detect screw length.

The minimum laminar width needed to allow safe placement of a 3.5 mm laminar screw varies in the literature. It ranges from 4 mm to 5.5 mm. Using the same criteria for analysis, Our study showed the average C2 lamina thickness to be 5.2 mm. This data is comparable to Ma et al[8] who evaluated C2 Anatomy relative to translaminar screw placement in Asian population.

The maximum mean Anteroposterior dimension of C2 lateral mass is 14.5 mm and 13 mm on right and left side respectively. Now considering the obliquity of trajectory and to extend the screw head beyond posterior arch additional 4 to 6 mm added to findout the screw length. The ideal length of screw used in Indian population varies between 20 to 24 mm. The mean transverse diameter of C1 lateral mass is 14.2 mm and 12.5 mm are right and left side respectively. So we can use screw with diameter 3.5 mm to 4.5 mm. Kauret al[9] also describes the Anteroposterior and transverse diameter in dry bones, which is slightly higher when compared to our values which are done on the CT scan.

The average height of C1 posterior arch at the level of vertebral artery groove is 4.2 mm. So the safety margin of drilling in the inferior aspect of lamina in our population is 4 mm. This finding is similar to the study done by Christensen et al[10] with atlas vertebras.

The average distance from midline to vertebral groove is 14.7 mm at right and 14 mm on left side which more or less similar to the mean inner distance of vertebral artery groove as enumerated by Lalitha B et al[11].

The safety margin of C1 screw observed in our population is 5.44 mm and 5.45 mm on Rt and Lt respectively, which is more when compared to study done by Serkan et al[12] where he analyzed ideal screw entry point and projection angle for posterior lateral mass fixation of Atlas in 40 dry human adult vertebra.

The range of safe sagital angle of C1 lateral mass screw is 10^0 to 16^0 and the range of safe cranial angle of C1 lateral mass screw at axial plane is 10^0 to 16^0 . The mean safe angle of trajectory of C1 lateral mass in our populations is 13^0 in sagital plane and 11^0 in axial plane. In a study by Roch et al[13] maximum angle of medialisation from midline was calculated as 16.7^0 . Hong et al[14] reported the screw angulations to be 14.7^0 relative to axial plane..

The percentage canal cord ratio is more at C1 C2 region which gives mobility of cord during extreme position. The canal cord ratio at C1 in anteroposterior dimension is 2.3 and in the transverse dimension is 2.6 and canal cord ratio at C2 in anteroposterior dimension is 2.1 and in transverse dimension is 2.1.

The average screwable dimension of C2 lamina is 23.9mm*5.2mm*6.8mm. So it can accommodate screw length of size 20 mm and diameter 3.5 mm. Our results pertaining to the C2 lamina are comparable to various study in the literature (Soyeon et al)[15].
Ideal screw trajectory in C2 lateral mass in Indian population is 41.2^0 in sagittal angle and 27^0 degree in cranial angle. Distance of vertebral artery to the superior articular surface is 4.4mm and to the medial margin of spinal canal is 4.3 mm . The diameter of screw that can be used varies from 2.3 and 6.5 mm.

Conclusion:-

Morphometric analysis of C1 C2 vertebra shows light on the ideal dimensions of screws to be used in our population. It also shows light on the safety angle and safety margin to avoid complications related to vertebral artery and spinal cord injury.

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