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Original Research Article

Morphometry of C1 & C2 Lateral Mass-Relative to Lateral Mass Screw Placement

Archana. A[1], V.Sailaja[2], V.Deepika[3], Fahemeena Faiz[4]

[1]Assistant Professor Department of Anatomy Gandhi Medical College, Musheerabad, Hyderabad, Telangana

[2]Assistant Professor Department of Anatomy Gandhi Medical College, Musheerabad, Hyderabad, Telangana

[3]Assistant Professor Department of Anatomy Gandhi Medical College, Musheerabad, Hyderabad, Telangana

[4]Intern, Mediciti Institute of Medical Sciences, Ghanpur

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Corresponding author: Dr. Archana. A

Conflict of interest: Nil

Abstract

Introduction: The anatomy of the atlanto-axial region is complex and demands knowledge of its structure and morphometry. With the knowledge of morphometry of C1 and C2 vertebrae it is quite easy to carry out the process of placing lateral mass screws during cervical spine surgeries. Cervical spine surgery includes many common surgical procedures performed by spine surgeons. The pathologies treated include radiculopathy, myelopathy, instability caused by degeneration or trauma, infection and tumours. It is very important to have an understanding of surrounding anatomy at the C1 lateral mass screw site to avoid injury to the spinal cord, vertebral artery, C2 ganglion or nerve root, internal carotid artery or hypoglossal nerve. Cervical spine surgery performed for the correct indications yields good results.

Aims and Objectives:

- The main objective of our study is to provide data to spine surgeons in assessing the size of the screw having different morphological measurements known.
- Our study included the measurements such as antero-posterior diameter, transverse diameter, heights of lateral mass taken in both dried specimen and a CT scan as well. Having this data of variable morphological measurements surgeon can easily select the size of the screw to be placed by correlating the data of our study.
- Malpositioning of the screw can be rectified as the study provides the ideal entry and exit points of the screw.

Material and Methods:

Material:

1. 40 dried cadaveric specimens of cervical vertebrae (20C1+20C2).
2. 40 CT scans of same cervical vertebrae (20C1+20C2) are taken.
3. Total of 80 samples that is 40 cadaveric specimens and 40 CT scans were included.

Methodology:

1. Cadaveric specimens to be studied were collected from different Medical colleges in the city of Hyderabad.
2. The cadaveric specimens included were adult first (C1) and second (C2) cervical vertebrae of both the sexes.
3. CT scans of the collected vertebrae were taken from the department of Radiology, Mediciti institute of Medical Sciences.
4. The manual and the CT scan measurements were taken for each vertebra using vernier calliper and three dimentional (3D) imaging, computer aided navigation tools and special software respectively.

Observation and Results: 40 cervical vertebrae (20 C1 & 20 C2) i.e. total of 80 lateral masses of both C1 and C2 were studied , manual and CT scan measurements were noted and compared. The data was analysed by using medcalc statistical version 13.0 http://www.medcalc.org .Unpaired t-test was used to compare CT and manual measurements.

Among the CT and manual measurements of both C1 and C2 lateral mass there is significant difference between transverse diameter and height ($P<0.05$), which are important parameters for the surgeons in fixation of posterior arch screws. No significant differences were found between antero-posterior parameters and height between manual and CT measurements.

Conclusion: This study may be useful for surgeons and academicians in understanding the morphometry of C1 and C2 and to compare morphometric data with CT derived data to determine the accuracy in selecting the size of screw.

Keywords: Cervical Vertebra, Larteral Masses, Atlanto Axial Region, Screw Placement, Spinal Surgeries.

Introduction

The anatomy of the atlanto-axial region is complex and demands knowledge of its structure and morphometry. With the knowledge of morphometry of C1 and C2 vertebrae, it is quite easy to carry out the process of placing lateral mass screws. In 2001, Harms and Melcher first reported[1] the application of a rod-screw system(RSS) technique in posterior atlantoaxial fixation(AAF) and many other RSS techniques have since been developed[2].

Historical Review

In 1964 the first lateral mass screw fixation surgery on cervical spine was done by Roy-Camille in France. This was then followed by Louis in France and Magrel in Switzerland. Roy-Camille technique was introduced in USA to treat people suffering from fractures and dislocation of lower cervical spine. The complications such as nerve root injury by misplacement of screws, vertebral artery injury or obstruction due to laterally misplaced screws, injury to the spinal cord or dural sac by medially misplaced screws[3-7]. A recent meta-analysis shows that malposition rate of C1 lateral mass screws is 2.5%. Literature shows that vertebral artery injury is 1.09% in case of C2 posterior screw fixation. Cervical spine surgery includes many common surgical procedures performed by spine surgeons. The pathologies treated include radiculopathy, myelopathy, instability caused by degeneration or trauma, infection and tumours. Surgical strategies include decompression of neural elements and stabilization when necessary, either through an anterior, posterior or combined approach. The approach selection is based on location of the compressive element, type of fracture or ligament injury and the overall alignment. Surgeons need to be aware of possible complications with each step of the procedure and the methods to avoid or manage them(8). Cervical spine surgery performed for the correct indications yields good results. However, surgeons need to be mindful of the many possible pitfalls. Complications may occur starting from the anaesthetic procedure and patient positioning to dura exposure and instrumentation. In general, avoiding complications is best achieved with meticulous preoperative analysis of the pathology, good patient selection for a specific procedure and careful execution of the surgery. Cervical spine surgery is usually effective in treating most pathologies and only a reasonable complication rare exists[8]. Our study mainly focuses on calculating the size of screw which is to be inserted in the lateral masses of cervical vertebrae(C1 &C2) by taking anatomical and CT scan measurements into consideration to reduce the risk of complications. A number of recent studies have described the feasibility and safety of C1 lateral mass screw placement. It is very important to have an understanding of surrounding anatomy at the C1 lateral mass screw site to avoid injury to the spinal cord, vertebral artery, C2 ganglion or nerve root, internal carotid artery or hypoglossal nerve[9].

Aims and Objectives

- The main objective of our study is to provide data to spine surgeons in assessing the size of the screw having different morphological measurements known.
- Our study included the measurements such as antero-posterior diameter, transverse diameter, heights of lateral mass taken in both dried specimen and a CT scan as well. So a surgeon can easily get those measurements in CT scan as he operates in a live patient.
- Having this data of variable morphological measurements surgeon can easily select the size of the screw to be placed by correlating the data of our study.
- Here size of the screw not only indicates its length but its width as well as proper width of the screw is necessary to reduce complications.
- Study included the measurements of dried cadaveric cervical vertebrae and also CT scan measurements of same vertebrae to check percentage of error if any.
- Patients often undergo surgery for second or third time after screw placement surgery done because of default in positioning or improper size of screw, this study is helpful in reducing such complications.
- Malpositioning of the screw can be rectified as the study provides the ideal entry and exit points of the screw.

Material and Methods

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4. The manual and the CT scan measurements were taken for each vertebra using vernier calliper and three dimentional (3D) imaging, computer aided navigation tools and special software respectively.

Parameters Noted For C1 Lateral Mass

Superior View

1. Antero-posterior diameter.
2. Transverse diameter

Inferior View

1. Antero-posterior diameter.
2. Transverse diameter.

Posterior View: Height (H_p).

Lateral View

1. Height from superior surface to midpoint of transverse 47 process is taken as H_1.
2. Height from midpoint of transverse process to inferior surface is taken as H_2.
3. Total height is taken as H_t (H_1+H_2).

Parameters Noted for C2 Vertebrae

Superior Articular Facet

1. Antero-posterior diameter.
2. Transverse diameter.

Inferior Articular Facet

1. Antero-posterior diameter.
2. Transverse diameter.

Posterior View

Height of superior articular facet(H_S).

Lateral View

Height of inferior articular facet (H_i).

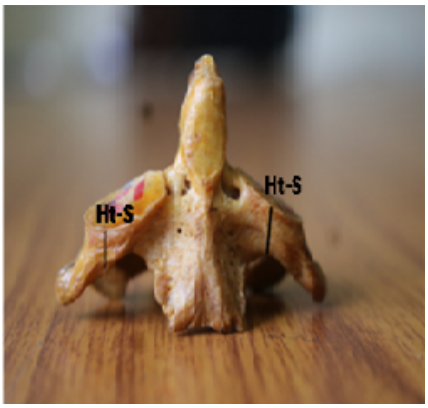

Figure 1: Height of superior articular facet of C2

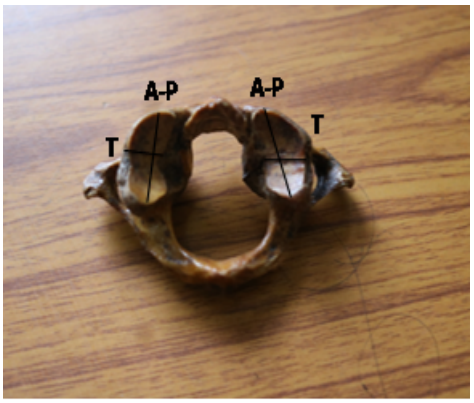

Figure 2: Superior view of C1

Figure 1 and 2: A-P=Antero-posterior diameter; T=Transverse diameter; Ht-S=Height of superior articular facet of C2

Observations and Results

40 cervical vertebrae (20 C1 & 20 C2) i.e total of 80 lateral masses of both C1 and C2 were studied, manual and CT scan measurements were noted and compared. The data was analysed by using medcalc statistical version 13.0 http://www.medcalc.org. Unpaired t-test was used to compare CT and manual measurements. The mean and SE of each parameter were measured for right and left sides and listed separately in table 1 and 2.

Table 1: Comparison of CT and MANUAL measurements of first cervical vertebrae considering Mean – Standard error and p value

C1	Mean ±Se CT	Mean ±Se Manual	P Value
Rt AP S	22.20 ± 0.47	21.48 ± 0.47	0.29
Rt AP I	17.04 ± 0.56	16.92 ±0.43	0.86
Rt Tr S	13.07± 0.34	10.46±0.28	0.0001 *
Rt Tr I	13.45± 0.44	14.54 ± 0.29	0.05

Rt Ht A	22.68 ± 1.05	21.80 ± 0.56	0.46
Rt Ht P	17.47 ± 0.47	18.92 ± 0.48	0.03 *
Lt AP S	21.96 ± 0.46	21.53 ± 0.45	0.50
Lt AP I	18.29 ± 0.70	17.39 ± 0.39	0.29
Lt Tr S	13.86 ± 0.38	10.35 ± 0.35	0.0001 *
Lt Tr I	13.94 ± 0.42	14.85 ± 0.28	0.084
Lt Ht A	23.88 ± 0.51	21.84 ± 0.59	0.01 *
Lt Ht P	18.10 ± 0.48	18.34 ± 0.43	0.71

Rt AP S – Right side- antero posterior – Superior view, Rt AP I - Right side- antero posterior – inferior view, Rt Tr S - Right side- Transverse – Superior view, Rt Tr I - Right side- Transverse – inferior view, Rt Ht A- Right side- Height – Anterior view, Rt Ht P - Right side- Height –posterior view, Lt AP S – Left side - antero posterior- Superior view, Lt AP I- Left side - antero posterior- inferior view, Lt Tr S- Left side -Transverse – Superior view, Lt Tr I – Left side -Transverse– Superior view, Lt Ht A - Left side -Height– Anterior view, Lt Ht P-Left side -Height– Posterior view.

Among the CT and manual measurements of C1 lateral mass there is significant difference between transvers diameter and height (P<0.05), which are important parameters for the surgeons in fixation of posterior arch screws. So surgeons has to take care while taking transvers diameter and height (Rt Tr S, Lt T S, Rt H A, Lt H p)of the lateral mass into consideration while selecting the screw. No significant differences were found between Rt AP S, Rt AP I, Rt HT A, Lt AP S, LT AP I, LT TR I, LT Ht P in these measurements (p value > 0.05). S these parameters can be considered because there is no significant difference between manual and CT measurements C2.

Table 2: Comparison of CT and MANUAL measurements of second cervical vertebrae considering Mean – Standard error and p value

C2	Mean ±SE CT Measurements in mm	Mean±SE Manual Measurements in mm	P Value
Rt AP S	17.07±0.32	17.86±0.29	0.07
Rt AP I	10.62±0.28	10.75±0.43	0.79
RtTr S	14.05±0.29	15.42±0.21	0.0006 *
RT TR I	9.91±0.35	10.09±0.36	0.72
RT HT S	8.68±0.20	5.68±0.30	0.0001 *
RT HT I	12.89±0.34	13.43±0.71	0.49
LT AP S	17.29±0.43	17.90±0.25	0.23
LT AP I	10.91±0.22	11.42±0.35	0.22
LT TR S	14.24±0.28	15.05±0.25	0.03 *
LT TR I	11.04±0.16	10.32±0.30	0.04 *
LT HT S	8.73±0.17	5.70±0.26	0.0001 *
LT HT I	13.54±0.28	14.61±0.32	0.01 *

Rt AP S – Right antero posterior Superior, Rt AP I - Right antero posterior – inferior view, Rt Tr S - Right side Transvers Superior, Rt Tr I - Right side Transvers inferior, Rt Ht S- Right side – Height – Superior, Rt Ht I - Right side – Height - inferior, Lt AP S – Left side - antero posterior- Superior, Lt AP I- Left side - antero posterior- inferior, Lt Tr S- Left side – Transvers – Superior, Lt Tr I – Left side -Transvers –inferio view, Lt Ht S- Left height Superior, Lt Ht I-Left Height– inferior view.

There is a significant difference between transvers diameter (Rt Tr S, Lt Tr S, Lt T I) and height (Rt Ht S, Lt Ht I) (P<0.05) of second cervical vertebra (C2) measured by CT and manual methods. These parameters are useful for surgeons in atlanto axial arthrodesis. So surgeons has to take care while taking transvers diameter and height (Rt Tr S, Lt T S, Rt H A, Lt H p) of the C2 vertebra into consideration while selecting the screw. No significant differences were found between Rt AP S, Rt AP I, Rt HT A, Lt AP S, LT AP I, LT TR I, LT Ht P in these measurements (p value > 0.05). S these parameters can be considered because there is no significant difference between manual and CT measurements

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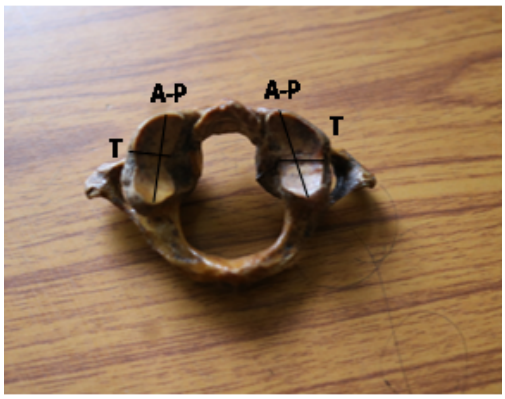

Figure 3: Superior View of C1

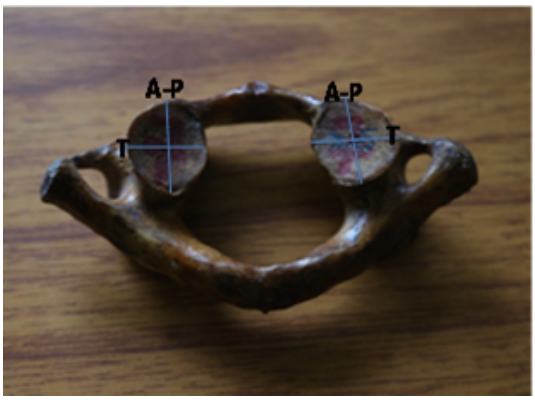

Figure 4: Inferior View of C1

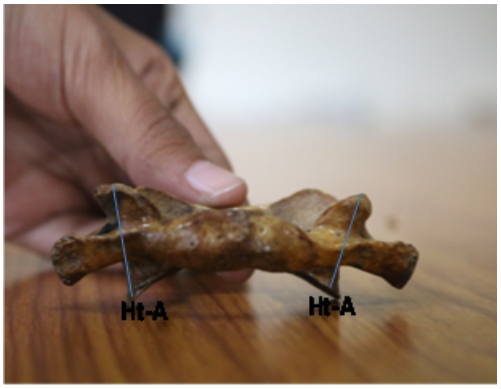

Figure 5: Anterior View of C1

Figure 6: Posterior View of C1

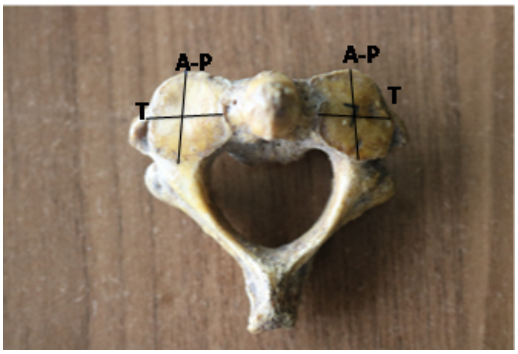

Figure 7: Superior View Showing Superior Facet of C2

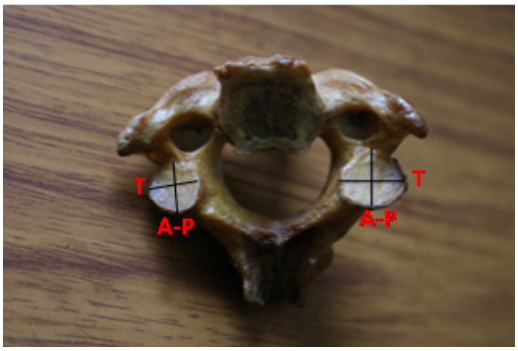

Figure 8: Inferior View Showing Inferior Facet of C2

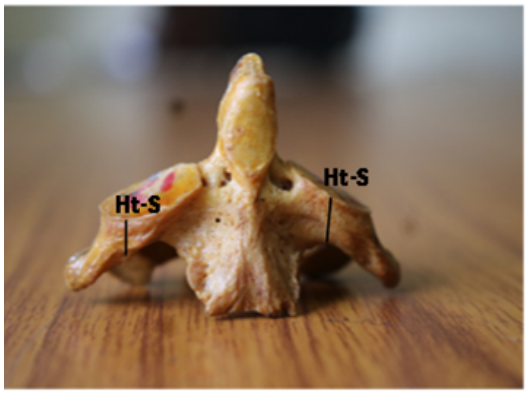

Figure 9: Height of Superior Articular Facet of C2

Figure 10: Height of Inferior Articular Facet of C2

Figure 11: CT Image- Anterior View of C1

Figure 12: CT Image- Anterior View of C1

Discussion

In the study of Serkan Simsek et al 52% of specimens, the length (the height of the entry zone) of the inferior articular process was less than 3.5 mm, which makes it difficult to accommodate 3.5 mm screws in present study height of inferior articular process of C1 in all the samples is more than 3.5 mm both in manual and CT scan measurements. which makes it easy to accommodate screw, this difference might be because of racial factors.

Wang and Samudarala[19] found that 41% of their specimens had a height less than 3.5 mm, and 65% had an entry height of less than 4 mm which is not similar to present study.

In the studies conducted by Hong X, Dong Y[17] and Hong JT the [18] height of the entry zone was bigger than 3.5 mm in all of the specimens which are in accordance with present study . In the study of David M Christensen et all(15) the minimum lateral mass dimensions found were 13.15mm antero-posterior, 4.22mm medio-lateral, and 4.73mm cephalocaudal. In the present study the minimum lateral mass dimensions found are 18.5mm antero-posterior, 9mm transverse or mediolateral, 12mm cephalocaudal which are more than above study.

The longest trajectory distance of the screw path w as found 30 mm by Tan, Mingsheng MD et al[20] whereas present study shows 25 mm in manual method and 26.5 cm by CT scan.

Conclusion

This study may be useful for surgeons and academicians in understanding the morphometry of C1 and C2 and to compare morphometric data with CT derived data to determine the accuracy in selecting the size of screw.

Summary

The complex structure of atlanto axial region demands the technical expertise for instrumentation and knowledge on its morphometry. The main objective of the study is to compare manual and CT scan parameters and to determine the difference. A total of 80 lateral masses of C1 and C2 (20 each) vertebrae were studied by using CT scan and manual methods. The Parameters studied were compared and data was analysed statistically by using unpaired t-test. Mean, Standard error of each parameter were calculated .The parameters measured by CT and manual methods were compared.

Among the measurements of C1 lateral mass there is significant difference between transvers diameter and height ($P<0.05$), which are important parameters for the surgeons in fixation of posterior arch screws. So surgeons has to take care while taking these measurements (Rt Tr S, Lt T S, Rt H A, Lt H p) of the lateral mass into consideration. No significant differences were found between Rt AP S, Rt AP I, Rt HT A, Lt AP S, LT AP I, LT TR I, LT Ht P in these measurements (p value > 0.05). these parameters can be considered because there is no significant difference between manual and CT measurements.

There is a difference between transvers diameter (Rt Tr S, Lt Tr S, Lt T I) and height (Rt Ht S, Lt Ht I) ($P<0.05$) of axis vertebrae measured by CT and manual methods. This knowledge may be useful for surgeons in atlanto axial arthrodesis. Extra care may be given while taking transverse diameter and height (Rt Tr S, Lt T S, Rt H A, Lt H p) of the C2 vertebra into consideration while selecting the screw. No differences were found between Rt AP S, Rt AP I, Rt HT A, Lt AP S, LT AP I, LT TR I, LT Ht P in these measurements (p value > 0.05), These parameters can be considered while using preoperative CT scan by surgeons.

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