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C2 Lateral Mass Vertebrae Anthropometry for Evaluating C2 Straight Lateral Mass Screw Fixation

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Abstract

Background: The cervical vertebra is an important vertebra as there are blood vessels in its surroundings from the brain to the entire vertebrae. Cervical injury has the most fatal consequences when it occurs as high as C1-C2. If instability occurs in the C1-C2 vertebrae and atlantoaxial joints, the procedure of surgical techniques include cervical arthrodesis or spinal fusion. C2 straight lateral mass fixation is one technique that can be used for fixation in patients with spinal cord compression and anomalous vertebral artery by inserting shorter screws in the lateral mass of the C2 vertebrae from the posterior direction. There have been not many references similar to the present study of anatomy to discover the screw characteristics needed in this technique.

Aim: This study aimed to identify the length of the lateral mass in the C2 vertebra for the purposes of the C2 straight lateral mass screw fixation technique.

Method: This research was an observational descriptive study with cross sectional design that observed the results of cervical CT-Scan. Observation was made using the RadiAnt DICOM Viewer application and measurements were based on a sagittal cross section. The length was measured from the posterior parallel to the posterior longitudinal ligament (PLL). The initial mean was measured on the right and left side; afterwards, the final mean is the total mean of both sides.

Result: From 10 samples, there were mean long lateral masses of C2 vertebrae on the right side of 13.511 ± 1.081 millimeters, the left side of 13.444 ± 1.396 millimeters, and the final mean of 13.48 ± 1,216 millimeters. It was rounded to an average of 13.5 ± 1.2 millimeters.

Discussion: The line parallel to the posterior longitudinal ligament (PLL) is more posterior than the line parallel to the foramen transversum wall which causes the measured length to be shorter. This is useful for the C2 straight lateral mass screw technique as it avoids the possibility of lesions in the vertebral artery.

Conclusion: The average lateral mass length in the population of Surabaya is 13.5 ± 1.2 millimeters.

Keywords: *Lateral Mass Vertebrae C2, C2 Straight Lateral Mass Screw Fixation.*

Introduction

The cervical vertebrae consist of 7 bone spaces, namely C1-C7.[1] The cervical vertebra has a transverse foramen in each segment through which the vertebral artery passes.[2] The vertebral artery is tasked with vascularizing the brain; hence, cervical vertebrae injuries and failure to identify can cause serious complications.[3] The most fatal consequences can occur in the upper cervical area, both in the crania cervical junction and

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in the C1-C2 vertebrae.[4] This is because the anatomical structure of the C1 and C2 vertebrae is unique and has a close relationship with the vertebral arteries.[5] Cases of C1-C2 injuries that have dislocations should be surgically removed.[6] The principles of cervical vertebrae surgery are stabilization and prevention of nerve decompression, optimizing the results of actions, and avoiding complications that may occur if non-surgical measures are performed.[7]

Cervical arthrodesis is a surgical treatment that unites one vertebra with another vertebra.[8] This technique can be performed on any cervical vertebra in accordance with the location of the injury. Fusion of vertebrae as high as C1-C2 is used for fusion due to instability in the C1-C2 vertebrae and atlantoaxial joint.[9, 10]

Because of their unique and biomechanical properties, most cervical vertebrae stabilization studies have focused on modification of fixation in C2 vertebrae.[11] Trans-articular fixation resulted in limitations on flexion and extension movements.[12] Meanwhile, the C2 pedicle technique by Harm further reduces the risk of lesions in the vertebral artery compared to the Magerl technique; however, it is still not possible to be used in patients who have anomalies in the vertebral artery.[13] The C2 laminar screw technique is used to avoid lesions in the vertebral artery[14], but this technique is not recommended for patients who require laminectomy to decompress the spinal cord.[15]

To explore the contraindications to the C1-C2 technique, a study in Japan stated that there were 238 (24.4%) cases accompanied by the incidence of compression of the cervical spinal cord[16] and another study asserted that of 200 patients, there were 66 patients with High-Riding Vertebral Artery (HRVA) and 90 patients with narrow pedicles after being detected using thinly-sliced pedicular-oriented CT (TPCT).[17] The high number of these two numbers makes it possible for both conditions to occur in an individual; consequently, other techniques are needed for patients with the mentioned condition.

C2 straight lateral mass fixation is one technique that can be used for fixation in patients with these two conditions. Fixation is performed by inserting shorter sized screws in the lateral mass of the C2 vertebrae from the posterior direction, as is the case in Korea which reduces the risk of bleeding in HRVA patients with C2 fixation by using shorter screws.[18] To date, there are not many references regarding this technique, therefore further studies on the anatomy of the C2 vertebrae are needed to support this fixation technique. Many modifications have been made to avoid complications. This is carried out by changing the entry point of the screw and the direction of screw installation.[19] These modifications can affect the required screw characteristics, such as length and diameter.

Method

This study aimed to measure anthropometric C2 lateral mass vertebrae from the lateral side for the C2 straight lateral mass screw fixation technique in order to determine the appropriate screw requirements and minimize complications that can occur. An observational analytic with cross-sectional approach was used.

Sample: The research samples were the results of the CT scan taken from the Mitra Keluarga Darmo Satelit Hospital, Surabaya in the period of August-November 2017. The sampling technique was conducted by using total sampling with the inclusion criteria of CT scan results as high as vertebrae C1-C7, while the exclusion criteria included CT Scan results with abnormalities of vertebral anatomy as high as C1-C7 and patients who are not domiciled in Surabaya.

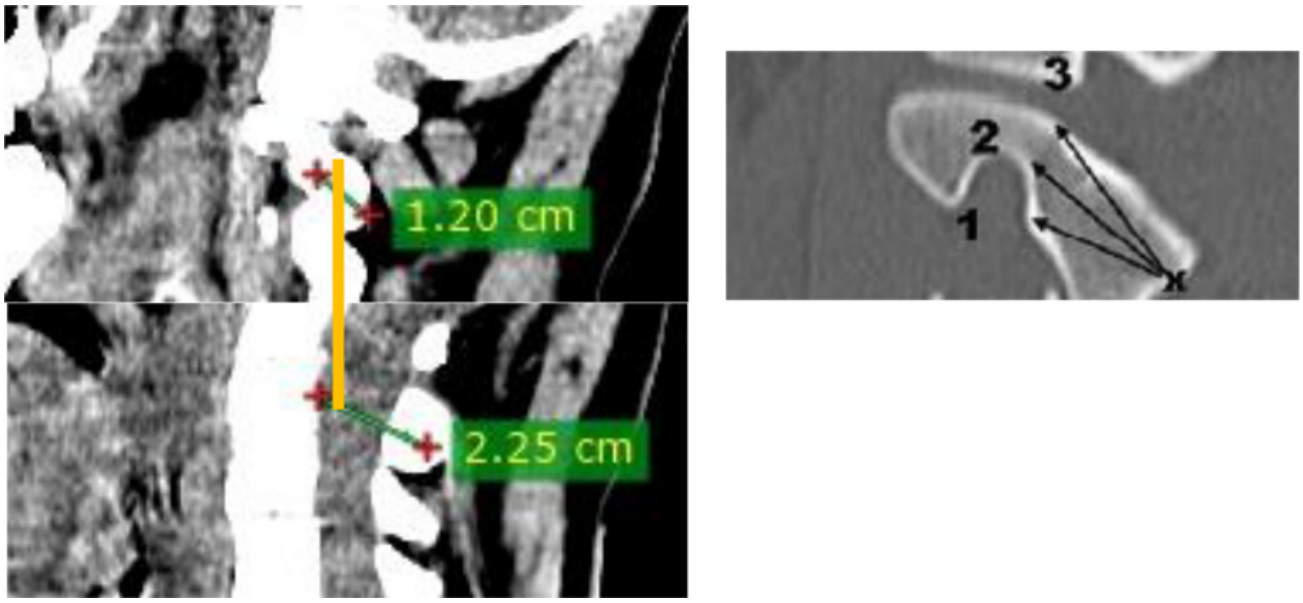
Research Instrument and Data Analysis: The instrument used to measure the CT scan result was RadiAnt DICOM Viewer Application version 4.1.6. The length of the lateral mass of the C2 vertebra was measured at the point of 3 millimeters superior to the facet line, median lateral mass, and anterior-superior direction parallel to the facet until the posterior longitudinal ligament (PLL). The PLL boundary point was initially marked. Afterwards, the length was measured on the slice showing the lateral mass picture from the posterior to the marked point. The initial mean was calculated on the right and left sides; then, the final mean was obtained from both sides. The measurement results were then processed using Microsoft Excel 2016.

Result

The total CT scan results sampled in this study were 10. Observation of radiology results was carried out for 1 week to determine the mean lateral mass in each sample. Lateral mass is the mass located in both right and left lateral of C2 vertebrae. The length of the C2 vertebrae lateral mass was measured from the sagittal cross section at the point of 3 millimeters superior to the facet line,

median lateral mass, anterior-superior direction parallel to the facet to the PLL limit.

Referring to the observation results, it was obtained the mean lateral mass of C2 vertebrae from 10 samples of 13.511 ± 1.081 millimeters with a minimum value of 12.006 millimeters and a maximum value of 15.496 millimeters. Whereas, the mean lateral mass of the C2 vertebrae from 10 samples was 13.466 ± 1.396 millimeters with a minimum value of 11.343 millimeters and a maximum value of 15.630 millimeters (Table 1). The mean left and right lateral mass of the C2 vertebrae obtained a mean total of 13.448 ± 1.216 millimeters with a minimum value of 11.334 millimeters in both sides and a maximum value of 15.630 millimeters in both sides (Table 2).



Picture 1: (a) Measurement of lateral mass from posterior as high as PLL, (b) The marker points parallel to PLL, (c) The measurement limit based on a research in Los Angeles (Hoh, et al., 2010)

Table 1: The Length of C2 Vertebrae Lateral Mass

No	The Length of Right Lateral Mass (mm)	The Length of Left Lateral Mass (mm)
1	12.443	11.343
2	14.618	15.213
3	14.412	13.765
4	12.982	13.863
5	13.601	13.755
6	13.303	14.205
7	12.006	12.005
8	12.631	12.130
9	15.496	15.630
10	13.624	12.754
Mean	13.511	13.466
Min	12.006	11.343
Max	15.496	15.630
SD	1.081	1.396

Table 2 The Mean of C2 Vertebrae Lateral Mass Length

Mean	Length (mm)
Right	13.511
Left	13.466
Total mean	13.488
Min	11.343
Max	15.630
SD	1.216

Discussion

C1-C2 Trans-articular Screw Fixation is the technique that produces the most rigid outcome.[12] The entry point of this technique is at 2-3 millimeters superior-lateral from the facet to the axial isthmus in medial;[12] then, it is forwarded to the C1 lateral mass. C1-C2 joints are very functional in rotational movements

and with a little flexion-extension. Hence, the fixation in this area will cause limitations on flexion-extension movements, lateral swelling, and rotational movements. The screw mounting direction of this technique reduces freedom of movement in all directions so as to achieve a state of high stability. This technique can also prevent slippage between segments.[20] This technique is also an indication for C1-C2 instability due to rheumatoid arthritis, odontoid process fracture, os odontoideum, C1-C2 arthrosis.[12] This technique is contraindicated for the condition of vertebral artery anomalies in segments as high as C1-C2, axial isthmus that is too small, deformities in segments as high as C1-C2, prominent kyphosis in the cervical-thoracic junction, and destruction of the atlas bone lateral mass.

C2 Pedicle Screw Fixation connects the vertebral body with the posterior component of the atlas bone. The screw is mounted obliquely from the pediculus to the vertebral body.[15] The advantage of this technique is that it can protect joints between C1-C2. In addition, it is possible to remove the screw after stability returns to restore movement to C1-C2. Compared with the trans-articular technique, this technique further reduces the risk of injury to the vertebral arteries.[13] The technique is indicated for C1-C2 instability caused by trauma, tumors, and inflammation, for non-fusion odontoid process fractures, unstable Jefferson fractures, and repair in failed odontoid screw fixation.[13] Contraindications are if there are anatomic variations in the vertebral artery.[13]

The entry point of the screw in the C2 Laminar Screw Fixation technique is between the spinous and lamina process, and is directed across the direction of the lamina on the contralateral side.[21] This technique is intended for 20% of patients who have anatomic anomalies that are contraindicated in trans-articular screw or pedicular screw techniques, because there is a risk of vertebral artery injury.[22] If there is a condition that requires decompression of the spinal cord, laminectomy of the axis bone is needed and this technique cannot be performed.[15]

C2 Pars Screw Fixation has the same entry point and direction as the trans-articular technique. The difference with the trans-articular technique is the depth of screw fixation that does not go through the atlas bone.[15]

Based on the results of the study, there have been no similar results from other references to the present study. However, a study with a similar concept was conducted in Los Angeles regarding the lateral mass of the C2 vertebra that used the same entry point and direction as this study and produced an average of 17.0 millimeters on both sides.[23] A case study conducted in Egypt on the evaluation of the efficacy and safety of C2 pars/pedicle screws also has a different number from this study, which used a screw with a size of 16 millimeters for the C2 vertebrae.[24]

The difference in results among studies can be caused by several factors. A factor that may be influential is the anterior border of the measurement. Measurements performed in research in Los Angeles was started from the posterior to the point before the transverse foramen wall,[23] which is different from this study which has a limit to the point parallel to the PLL.

Observation results show that the line parallel to the PLL is more posterior than the line parallel to the transverse foramen wall. This causes the length measured in this study is shorter. This is useful for the C2 straight lateral mass screw technique because it avoids the possibility of lesions in the vertebral artery (Picture 1).

Another factor that might influence differences in results is morphological variation in each different population. A previous study conducted in India has shown that the average antero-posterior length of the right and left C2 vertebrae superior facets were 16.61 ± 1.33 millimeters and 16.70 ± 1.49 millimeters respectively.[5] This result is different from a similar study conducted in Turkey with an average of 17.5 ± 14 on the right side and 17.5 ± 1.5 on the left side.[25] Specific references regarding differences in the lateral mass length of the C2 vertebrae were not found. However, the differences in the results of the two studies above may allow for differences in the lateral mass.

Limitation: There are several limitations in this study. A factor from the author that might be influential is the lack of accuracy in the measurement process. The small number of samples is also a disadvantage in this study. Retrieval of data in only one hospital is presumed to be insufficient to describe the lateral mass length of the entire population in Surabaya.

Conclusion

The mean of C2 vertebrae lateral mass length is 13.5 ± 1.2 millimeters.

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Ethical Clearance: This study received a certificate of ethical clearance from ethical commission of Faculty of Medicine, Universitas Airlangga Indonesia.

References

1. Panchbhavi VK. Neck Anatomy 2015 [cited 2017 13 November]. Available from: https://reference.medscape.com/article/1968303-overview#showall.
2. Windsor RE. Cervical Spine Anatomy 2017 [cited 2017 13 November]. Available from: https://emedicine.medscape.com/article/1948797-overview#showall.
3. Hertner GL. Cervical Spine Acute Bony Injuries in Sports Medicine 2017 [cited 2017 13 November]. Available from: https://emedicine.medscape.com/article/94234-overview#showall.
4. Davenport M. Cervical Spine Fracture Evaluation 2017 [cited 2017 13 November]. Available from: https://emedicine.medscape.com/article/824380-overview#showall.
5. Singla M, Goel P, Ansari MS, Ravi KS, Khare S. Morphometric Analysis of Axis and Its Clinical Significance -An Anatomical Study of Indian Human Axis Vertebrae. Journal of clinical and diagnostic research : JCDR 2015;95:AC04-9.
6. Marcon RM, Cristante AF, Teixeira WJ, Narasaki DK, Oliveira RP, de Barros Filho TE. Fractures of the cervical spine. Clinics 2013;6811:1455-61.
7. Alves PL, Martins DE, Ueta RH, Del Curto D, Wajchenberg M, Puertas EB. Options for surgical treatment of cervical fractures in patients with spondylotic spine: a case series and review of the literature. Journal of medical case reports 2015;9:234.
8. Peng B, DePalma MJ. Cervical disc degeneration and neck pain. Journal of pain research 2018;11:2853-7.
9. Bourdillon P, Perrin G, Lucas F, Debarge R, Barrey C. C1-C2 stabilization by Harms arthrodesis: indications, technique, complications and outcomes in a prospective 26-case series. Orthopaedics & traumatology, surgery & research : OTSR 2014;1002:221-7.
10. De Iure F, Donthineni R, Boriani S. Outcomes of C1 and C2 posterior screw fixation for upper cervical spine fusion. Eur Spine J 2009;18 Suppl 1Suppl 1:2-6.
11. Ghostine SS, Kaloostian PE, Ordookhanian C, Kaloostian S, Zarrini P, Kim T, et al. Improving C1-C2 Complex Fusion Rates: An Alternate Approach. Cureus 2017;911:e1887.
12. Winking M. Posterior Transarticular C1/C2 Screw Technique. In: Vieweg UV, Grochulla F, editors. Manual of Spine Surgery. Berlin: Springer; 2012. p. 187-94.
13. Schultz C. C1-C2 (Harms) Technique. In: Vieweg U, Grochulla F, editors. Manual of Spine Surgery. Berlin: Springer; 2012. p. 195-8.
14. Ma W, Feng L, Xu R, Liu X, Lee AH, Sun S, et al. Clinical application of C2 laminar screw technique. Eur Spine J 2010;198:1312-7.
15. Joaquim AF, Riew KD. Axis Screw Fixation – A Step-by-Step Review of the Surgical Techniques. Arq Bras Neurocir 2017;36:101-7.
16. Nagata K, Yoshimura N, Muraki S, Hashizume H, Ishimoto Y, Yamada H, et al. Prevalence of cervical cord compression and its association with physical performance in a population-based cohort in Japan: the Wakayama Spine Study. Spine 2012;3722:1892-8.
17. Wajanavisit W, Lertudomphonwanit T, Fuangfa P, Chanplakorn P, Kraiwattanapong C, Jaovisidha S. Prevalence of High-Riding Vertebral Artery and Morphometry of C2 Pedicles Using a Novel Computed Tomography Reconstruction Technique. Asian spine journal 2016;106:1141-8.
18. Park YS, Kang DH, Park KB, Hwang SH. Posterior atlantoaxial screw-rod fixation in a case of aberrant vertebral artery course combined with bilateral high-riding vertebral artery. Journal of Korean Neurosurgical Society 2010;484:367-70.
19. Mohamed E, Ihab Z, Moaz A, Ayman N, Haitham AE. Lateral mass fixation in subaxial cervical spine: anatomic review. Global spine journal 2012;21:39-46.
20. Turel M, Kerolus M, Traynelis V. Machined cervical interfacet allograft spacers for the management of atlantoaxial instability. Journal of Craniovertebral Junction and Spine 2017;84:332-7.
21. Finn MA, Schmidt MH. Occipital Cervical Stabilization with Rod-Screw Systems. In: Vieweg

U, Grochulla F, editors. Manual of Spine Surgery. Berlin: Springer; 2012. p. 181-5.

22. Siemionow K, Janusz P, Mardjetko S. The Four Fixation Points of the Axis: Technique and Case Report. International journal of spine surgery 2018;125:611-6.
23. Daniel JH, Charles YL, Michael YW. A radiographic computed tomography–based study to determine the ideal entry point, trajectory, and length for safe fixation using C-2 pars interarticularis screws. Journal of Neurosurgery: Spine SPI 2010;126:602-12.
24. Eshra MA. C2 pars/pedicle screws in management of craniocervical and upper cervical instability. Asian spine journal 2014;82:156-60.
25. Sengul G, Kadioglu HS. Morphometric Anatomy of the Atlas and Axis Vertebrae. Turkish Neurosurgery 2006;162:69-76.