DOI: 10.7860/IJARS/2020/43146:2533

Original Article

Anatomy Section

Posterior Screw Placement on Lateral Mass of Atlas: An Anatomical Perspective

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ABSTRACT

Introduction: Fusion of the occipitocervical or atlantoaxial vertebra is an accepted treatment option in upper cervical spine instability caused by cervical trauma or various other disorders. The C1-C2 fusion techniques have limitations which may be overcome by the lateral mass screws. Posterior screw placement in the atlas lateral mass avoids the loss of occipitocervical motion and enables posterior C1-C2 fusion in patients. This is followed in patients who are not suitable for transarticular screw fixation.

Aim: To define ideal entry point, exit point, trajectory and dimensions of the lateral mass screw during the posterior screw fixation of atlas vertebra, to avoid damage to vertebral artery and contents of vertebral canal.

Material and Methods: For this study 50 intact dried human atlas vertebrae from the Indian population were measured using a digital Vernier calliper that provides accurate resolution up to 0.01 mm and a goniometer. The measurements were entered in an excel sheet. Mean and standard deviation were calculated.

Results: In the present study, the ideal entry point for the lateral mass screw to prevent damage to 1st part of vertebral artery was found to be the midpoint of pedicle analog of atlas. The ideal exit point for the screw to avoid injury vertebral canal contents and 2nd part of vertebral artery was on the anterior surface of lateral mass at a distance of 16.3 mm (SD=1.8) from the anterior tubercle. The horizontal angulation of screw trajectory was found to be 4 degrees medial and vertical angulation 5.4 degrees superior. The distance between entry point and ideal exit point was taken as the optimum length of screw (17.3 mm). The optimum width of screw was calculated by adding the distance of lateral mass inferior to pedicle analog and the thickness of vertebral artery groove (7.2 mm).

Conclusion: The above findings and landmarks will be of great help to spine surgeons while performing posterior screw fixation of lateral mass of atlas vertebra.

Keywords: 1st cervical vertebra, Entry point, Exit point, Trajectory

INTRODUCTION

The first cervical vertebra (atlas) has a pair of lateral masses connected anteriorly by anterior arch and posteriorly by Posterior Arch (PA). Anterior arch has an anterior tubercle anteriorly. Posterior arch has a groove of vertebral artery (3rd part) on its superior aspect. Lateral mass consists of superior and inferior articular facets and foramen transversarium. Foramen transversarium transmits 2nd part of vertebral artery [1].

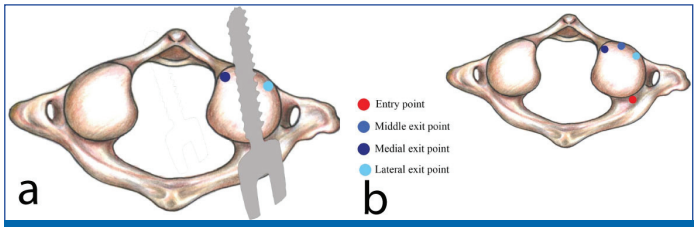
Fusion of the occipitocervical or atlantoaxial vertebra is an accepted treatment option in upper cervical spine instability caused by cervical trauma or various other disorders. The C1-C2 fusion techniques have limitations which may be overcome by the lateral mass screws [2]. Cervical instability can be caused by conditions like cervical trauma, degenerative conditions, inflammations and neoplasms. This may be treated to attain cervical stability and reduce neurological consequences [2]. Earlier treatment options were occipitocervical fusion or atlantoaxial fusion techniques. However, these techniques have the disadvantages of loss of occipitocervical motion, non-union and inability to perform the technique due to anatomical variations respectively. These limitations may be overcome by posterior screw fixation technique of C1 lateral mass [3]. The latter method which was clinically introduced by Goel and Laheri, was later popularised by Harms and Melcher [4]. In this method, the screw is introduced through pedicle and lateral mass of C1 vertebra. Although many studies have been conducted on the anatomy of atlas vertebra, adequate studies regarding the trajectory of lateral mass screw is lacking [4].

The purpose of this study was to evaluate meticulously the ideal key points for posterior C1 lateral mass screw fixation. Thereby, the entry point, the projection angles of the screw and optimum screw lengths are re-considered.

MATERIALS AND METHODS

This was an observational study done on atlas vertebrae, available from the Department of Anatomy. Sample size was determined by population mean- absolute precision method, based on study done by Gebauer M et al., and was estimated to be 50 atlases [2]. The study was done in a seven months period, between April 2015 and October 2015.

Hundred lateral masses from 50 intact disarticulated C1 vertebrae were examined. The procedure was standardised by the neurosurgeon who marked three possible exit points for the screw (medial, lateral and middle) on each side of anterior arch of atlas [Table/Fig-1,2]. Entry point was taken as midpoint of pedicle analogue (junction between lateral mass and posterior arch) [Table/Fig-2a]. Multiple variables were measured to determine ideal entry and exit points and safe trajectories for placement of lateral mass screws.



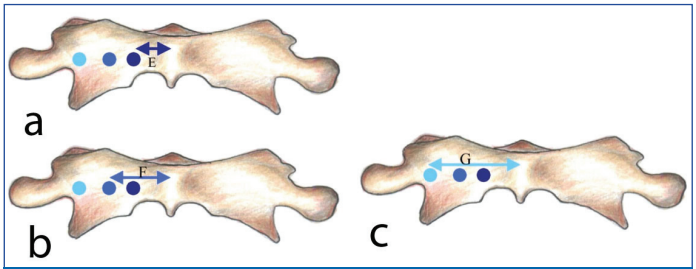
[Table/Fig-1]: a: Showing the inferior view of atlas with lateral mass screw inserted b: Inferior view of atlas showing the entry and exit points for lateral mass screw.

All variables, except the angulation of the screw, was measured by digital Vernier calliper that provides accurate resolution up to 0.01 mm. Angulation of screw was measured by a goniometer. The variables measured were:

E-Distance between anterior tubercle and medial exit point [Table/Fig-2a].

F-Distance between anterior tubercle and middle exit point [Table/Fig-2b].

G-Distance between anterior tubercle and lateral exit point [Table/Fig-2c].

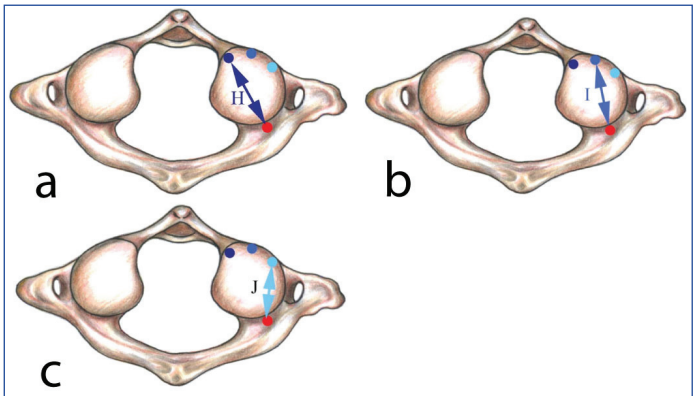


[Table/Fig-2]: a: Anterior view of Atlas showing 'E', distance between anterior tubercle and medial exit point; b: Anterior view of Atlas showing 'F', distance between anterior tubercle and ideal exit point; c: Anterior view of Atlas showing 'G' , distance between anterior tubercle and lateral exit point.

H-Distance between entry point and medial exit point [Table/Fig-3a].

I-Distance between entry point and middle exit point [Table/Fig-3b].

J-Distance between entry point and lateral exit point [Table/Fig-3c].



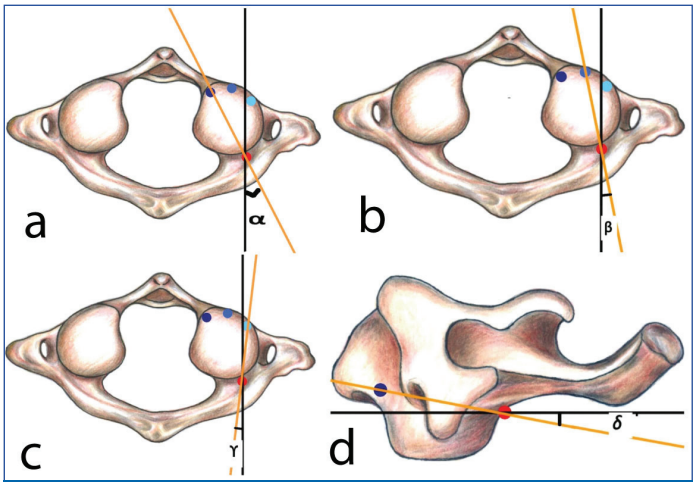
[Table/Fig-3]: a: Inferior view of Atlas showing 'H', distance between entry point and medial exit point; b: Inferior view of Atlas showing 'I'-Distance between entry point and ideal exit point; c: Inferior view of Atlas showing 'J'-Distance between entry point and lateral exit point.

α-Angle between entry point and medial exit point [Table/Fig-4a].

β-Angle between entry point and middle exit point [Table/Fig-4b].

ϒ-Angle between entry point and lateral exit point [Table/Fig-4c].

δ-Angle between the horizontal drawn at entry point and the exit points [Table/Fig-4d].

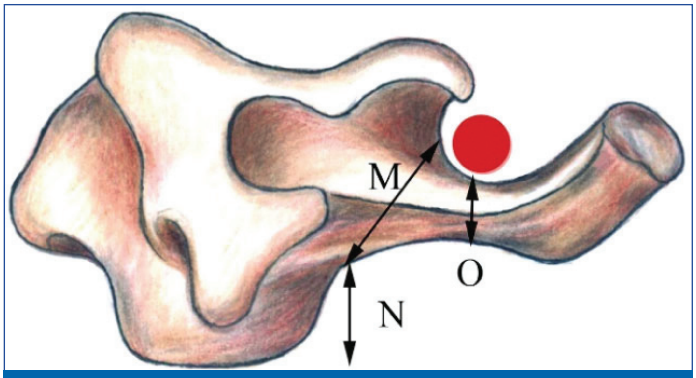


[Table/Fig-4]: a: Inferior view of Atlas showing 'α'- Angle between entry point and medial exit point b: Inferior view of Atlas showing 'β'- Angle between entry point and exit point c: Inferior view of atlas showing 'ϒ'- Angle between entry point and lateral exit point d: Lateral view of atlas showing 'δ'- Angle between the horizontal drawn at entry point and the exit points

M-Height of pedicle analog [Table/Fig-5].

N-Height of lateral mass inferior to pedicle analog [Table/Fig-5].

O-Height of posterior arch at the groove for vertebral artery [Table/Fig-5].



[Table/Fig-5]: Lateral view of atlas with vertebral artery in vertebral artery grove.

STATISTICAL ANALYSIS

The mean, range and standard deviation were calculated for all measurements for 50 vertebrae. Significant difference was calculated using the Z test and p≤0.05 in Microsoft excel sheet.

RESULTS

Thirteen parameters were studied for the 50 atlases. Measurement results were analysed and are shown in [Table/Fig-6-10].

	E (mm)			F (mm)			G (mm)		
	R	L	p-value	R	L	p-value	R	L	p-value
Mean	13	11.6	0.0001	16.3	15.4	0.009	19.8	18.5	0.0007
S.D.	1.8	1.6		1.8	1.5		1.9	1.7	

[Table/Fig-6]: Showing the distance of anterior tubercle of atlas from the medial (E), middle (F) and lateral (G) exit points. (R-right side, L-left side)

	H (mm)			I (mm)			J (mm)		
	R	L	p-value	R	L	p-value	R	L	p-value
Mean	18.9	19	0.68	17.3	17.2	0.57	16.1	15.9	0.68
S.D.	1.3	1.7		1.5	1.5		1.6	1.5	

[Table/Fig-7]: Showing the distance of entry point of screw to the medial (E), middle (F) and lateral (G) exit points. (R-right side, L-left side).

	α (degree)			β (degree)			ϒ (degree)		
	R	L	p	R	L	p	R	L	p-value
Mean (degree)	-11.3	-14.9	0.0001	-3.7	-4.8	0.08	5.8	3.8	0.0001

[Table/Fig-8]: Showing the angle between entry point and the medial (α), middle (β) and lateral (ϒ) exit points. (R-right side, L-left side).

	δ (degree)	
	R	L
Mean	5.4	5.4
S.D.	3.6	3.6

[Table/Fig-9]: Showing the vertical angulation (δ) between entry point and exit points.

Variables	Mean±SD (mm)
Height of pedicle analog (M)	5.4±0.8
Height of lateral mass inferior to pedicle analogue (N)	3.7±0.8
Height of PA+Height of lateral mass inferior to PA (M+N)	9.1±1.3
Width of PA	9.4±1.6
Shortest distance between foramen transversarium and vertebral canal	10.3±1.6
Height of posterior arch at the vertebral artery groove (O)	3.5±0.9

[Table/Fig-10]: Showing the other variables measured.
PA- Posterior arch

The vertical angulation between entry and exit points was same degree on both sides.

The height of pedicle analog was 5.4±0.8 mm while the height of lateral mass inferior to pedicle analog was 3.7±0.8 mm. The width of pedicle analogue was 9.4±1.6 mm.

DISCUSSION

In the present study, it was found that for posterior screw fixation of atlas, the ideal entry point is the midpoint of pedicle analog of atlas. The ideal exit point for the screw is on the anterior surface of lateral mass at a distance of 16.3 mm (SD= 1.8) from the anterior tubercle. The horizontal angulation of screw trajectory was found to be 4 degrees medial and vertical angulation 5.4 degrees superior. The distance between entry point and ideal exit point was taken as the optimum length of screw (17.3 mm). The optimum width of screw was calculated by adding the distance of lateral mass inferior to pedicle analog (3.7±0.8mm) and the thickness of vertebral artery groove (3.5±0.9 mm). The optimal width of screw estimated by a radiological study by Lin JM et al., estimated the width of screw to be 12.6±1.7 mm according to the later study, this is the screw width which could be accommodated by most posterior arches at vertebral artery groove [4]. This difference from present study may be because the study done by Lin JM et al., was radiological. Present study has the scope of extending to a radiological study for comparison. The study done by Yeom JS et.al., estimated the average height of posterior arch to be less than 4 mm [5], which is correlating with present study.

The study done by Gebauer M et al., in 41 adult human atlases in the German population describes the optimal screw insertion point as a point 21.6 mm in female and 23.6mm in male lateral from the posterior tubercle [2]. The same study describes the preferable screw direction with a medial inclination of 7.9 in female and 7.3 in male. It also describes a rostral inclination of 2.4 in females and 3.1 in males.

The study done by Hong X et al., on 30 dry adult atlases in Chinese population describes the ideal entry point for the posterior screw fixation of the C1 lateral mass, as the point of intersection of the inferior border of the posterior arch and the midpoint of the lateral mass. The study also describes the ideal exit point to be on the anterior surface of lateral mass, 3-4 mm inferior to the superior articular surface of C1, with a screw convergence of 15 degree and a cranial inclination of 20 degree. The length of the screw determined by the distance between entry and exit points was found to be 20-23 mm. The distance between the entry point and the inferior surface of the lateral mass was approximately 4.1 mm, giving enough space for 3.5 mm diameter screw [6].

A study done by Seal C et al., on 15 cadaveric atlases of Caucasian race described entry point of the lateral mass screw, below the posterior arch, midway between medial and lateral pillars. According to this study, the screw is to follow a trajectory of 10 degrees medial and 22 degrees cephalad [7]. In a study done by Ma XY et al., in Chinese population, the ideal entry point was described as a point below the C1 pedicle analog between the medial and lateral pillars, and 22.15 mm lateral to posterior tubercle. The ideal length of screw according to the above study was 28.55 mm [8]. The differences in values may be because of racial differences.

Limitation(s)

The study invloved limited sample size. Indian studies on similar topic is less. So, comparison of data couldn't be done. A radiological comparison of the data should be done as an extension of this study.

CONCLUSION(S)

While doing posterior screw fixation of lateral mass of atlas vertebra, surgeon should be cautious about nearby vital structures like vertebral artery and contents of vertebral canal. Any injury to vital structures can be avoided if the above described entry and exit points with suitable angulation is followed.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Oct 31, 2019**
Date of Peer Review: **Nov 21, 2019**
Date of Acceptance: **Jan 04, 2020**
Date of Publishing: **Apr 01, 2020**