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Original Article

Radiology Section

Fluoroscopic Detection of Ventral Wall Violation during C2 Intralaminar Screw Insertion: A Descriptive Study

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ABSTRACT

Introduction: The C2 (second cervical) laminar screws were considered for rigid fixation of the axis because the use of pars or pedicle screws posed a risk to the vertebral artery with C2. Though considered to be a relatively safe method, ventral spinal canal violations have been reported in laminar screws fixations. Fluoroscopy-based image guidance may increase the accuracy and safety of the technique.

Aim: To report the use of fluoroscopy technique in the detection of ventral wall violation during C2 intralaminar screw insertion.

Materials and Methods: This descriptive study reports seven dry axis vertebrae from the adult south Indian population for which fluoroscopic analysis was done from January 2013 to December 2013. True lateral views were taken before and after applying a vertical line of barium paint on the ventral surface of the lamina at two points: at the centre of the lamina and close to the facet joints at the face to-laminar junction.

Results: In the total seven dry axis vertebrae analysed, the mean ratio of the distance from the spinolaminar junction to the barium line (drawn on the ventral surface of the lamina just next to face to laminar junction) to the distance between the spinolaminar junction and uppermost part of inferior articular facet of C2 vertebrae was 0.465±0.0389 mm.

Conclusion: Even though considered a relatively safer technique, laminar cortical violations have been reported in C2 translaminar screw fixations. Fluoroscopy-based imaging guidance can improve the accuracy of C2 translaminar screw insertion, as this technology provides real-time imaging during the process of screw insertion and helps in accurate screw sizing.

Keywords: Anatomy, Computer-assisted, Isocentre C-arm, Navigation, Translaminar screw, Vertebra

INTRODUCTION

The C2 translaminar screw, brought into use by Wright in 2004, has gained popularity for these reasons: the large size of the C2 lamina, there is rigid fixation of the axis, and has low risk of injuring the vertebral artery [1,2]. This technique has now been compared with other available methods and biomechanical comparability has been established [3,4]. Although considered to be a relatively safer method, laminar violations have been reported in some cases [1,2]. Translaminar screws which may transgress the ventral cortical wall of the lamina can lead to debilitating complications. Also, in recent times, the reliability of intraoperative plain radiographs in detecting violations of C2 intralaminar screws has been called into question [5]. The advent of the fluoroscopy-based image-guidance technique has helped in safe and precise spinal instrumentation at all vertebral levels, including placement into C2 pars, C2 pedicle, the odontoid, and the C1-C2 transarticular junction [6-12]. In past published literature, one report on fluoroscopy-based image guidance usage for the placement of C2 laminar screws is available [13]. Hence, this descriptive study was done to report the use of fluoroscopy technique in the detection of ventral wall violation during C2 intralaminar screw insertion.

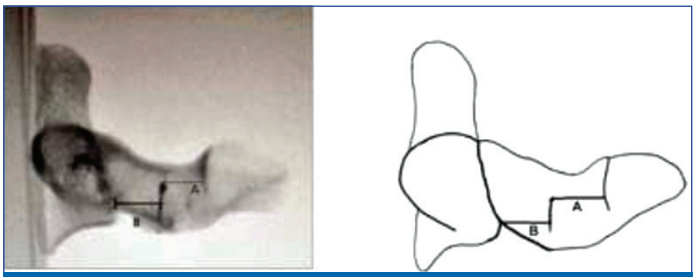
MATERIALS AND METHODS

This descriptive study was conducted at the Human Anatomy Department, St. Johns Medical College, Bangalore, Karnataka, India, from January 2013 to December 2013.

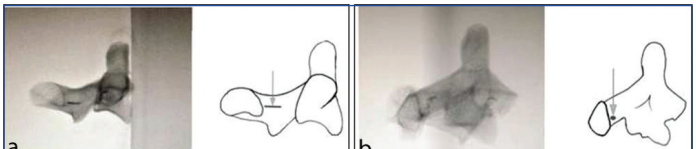
Inclusion criteria: A total of seven dry axis vertebrae from the adult south Indian population (anatomical specimen) were included in this study.

Exclusion criteria: Those specimens with deformities, defects or tumours were excluded from the study.

True lateral views were taken before and after applying a vertical line of barium paint on the ventral surface of lamina at two points: at the centre of the lamina and close to the facet joints at the face to-laminar junction using Philips brilliance machine. Distances from the highest point of the inferior articular facet (distance B) and the spinolaminar line (distance A) to the vertical barium line adjacent to the facet joint were measured [Table/Fig-1]. A ratio A/(A +B) was measured. A horizontal line of barium paint was marked on the ventral surface of the lamina. The fluoroscopic arm was tilted till this barium line was seen as a point (co-axial view) [Table/Fig-2].



[Table/Fig-1]: Lateral View with barium applied at the ventral surface at mid lamina and close to the facet joint.
A=spinolaminar line to the vertical barium line; B=from the highest point of the inferior articular facet to the vertical barium line



[Table/Fig-2]: A horizontal barium line is marked on the ventral surface of the lamina (a); The angle of tilt noted when the barium line was seen as Bull's eye, (b) the co-axial image of the lamina with all cortical margins of the lamina is also noted.

STATISTICAL ANALYSIS

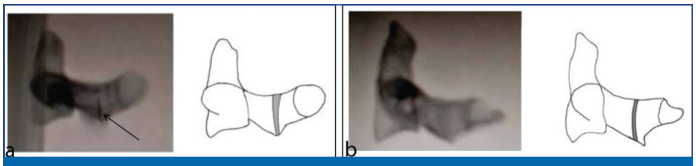
The statistical analysis was done using Microsoft (MS) Excel and the actual dimensions of the vertebrae has been tabulated.

RESULTS

The mean ratio of the distance from the spinolaminar junction to the barium line (drawn on the ventral surface of the lamina just next to the faucet laminar junction) to the distance between the spinolaminar junction and uppermost part of the inferior articular facet of C2 vertebrae was 0.465±0.0389 mm [Table/Fig-3]. Out of the 14 laminae studied, we were able to see a vertical faucet laminar line in 10 (71.48%) specimens. In 4 of 10 cases, the barium line corresponded to the face to-laminar line. In the remaining 6 of 10 cases, the face to-laminar line was just dorsal to the barium line. Vertical face to-laminar line corresponding to the barium line (A) and dorsal to the barium line (B) [Table/Fig-4].

No.	Right-A* (mm)	Right-B (mm)	Right A/ (A+B)	Left-A (mm)	Left-B (mm)	Left A/ (A+B)	Right angle (degree)	Left angle (degree)
1	0.93	1.17	0.44	1.02	1.11	0.47	41	47
2	1.08	0.87	0.55	1.02	0.9	0.53	42	37
3	1.2	1.45	0.45	1.23	1.45	0.46	45	29
4	1.32	1.54	0.46	1.36	1.39	0.49	43	38
5	0.92	1.36	0.41	1.11	1.39	0.44	53	36
6	1.11	1.2	0.47	1.02	1.29	0.44	47	40
7	1.23	1.2	0.50	1.21	1.14	0.51	44	37

[Table/Fig-3]: Fluoroscopic analysis of second cervical (C2) vertebrae.
*Distances from the highest point of the inferior articular facet (b) and the spinolaminar line (a) to the vertical barium line adjacent to the facet joint



[Table/Fig-4]: An example illustrating that the vertical face to-laminar line (shown by arrow) in images, corresponding to the barium line (a) and dorsal to the barium line (b).

DISCUSSION

This current study showed that placing C2 intralaminar screws under fluoroscopic guidance can detect ventral wall violation. This can be used intraoperatively to prevent the ventral wall violation that can occur during C2 intralaminar screw insertion. The technique, as defined by Wright NM and in other studies, is based completely on anatomical landmarks with or without the use of intraoperative fluoroscopy [1-4,14]. The dorsal laminar breach can be easily identifiable intraoperatively by visual inspection. But this is not possible for a ventral breach, which is important to confirm safe intralaminar screw placement. Hence, a fluoroscopy-guided approach can help in the detection intraoperatively. This usage has been demonstrated by this study in dry anatomical specimens. This procedure can be replicated intraoperatively by the surgeon.

Lehman RA et al., did a study to find the use of intraoperative plain radiographs in identifying violations of C2 intralaminar screws insertion in cadaveric models and showed that the overall accuracy rate was only 77.4% [5]. The authors also alerted that in cases of both C2 intralaminar screws were out, the accuracy was reduced to 63.9%. Thereby suggesting that in cases of bilateral screw perforations, plain radiographs cannot be relied on to detect the violation. Wang MY did a study on CT images of 59 intralaminar screws in 30 patients and established the partial dorsal laminar breach in 11 patients and violation of the spinal canal in one patient [15]. C2 translaminar screw placement has gained popularity as a new alternative for rigid fixation to the axis. Although, it is considered to be a relatively safe technique, laminar cortical violations have been reported and its safety profile has not been validated by long-term studies.

Based on the present study, the authors proposed that if the tip of the screw after placement is just dorsal to the 50% point between the spinolaminar line and superior most point of the inferior articular facet of the axis vertebra, one can safely rule out a ventral cortex violation. The need for a true lateral view cannot be over-emphasised in this regard. The vertical face-laminar line seen in some X-rays 10/14 (71.4%) is also a good indicator as it is seen just dorsal (6/10, 60%) or corresponds (4/10,40%) to the barium line just next to the facet joint. Alternatively, an oblique view of the axis vertebra can be taken as described in material and methods [Table/Fig-4] to have a coaxial image of the lamina. The screw can then be inserted safely within the cortical walls. However, this method can only be used with radiolucent operating table attachments. This is the first study using dry vertebrae and an objective method to effectively utilise fluoroscopy while inserting C2 translaminar screws. This can be adapted by spine surgeons on intraoperative usage.

Limitation(s)

Relatively small sample size and the procedure was done on the anatomical specimen.

CONCLUSION(S)

This study has shown that fluoroscopy-guided C2 translaminar screw fixation can improve the accuracy of fixation. This technique can provide real-time images intraoperatively and accurate placement can be achieved without ventral wall violation. Studies with large sample size and intraoperative fluoroscopic guided studies are recommended in the future following the sampling technique.

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