Original Article

Radiological assessment of cervical lateral mass screw angulations in Asian patients

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Abstract

Background: Various lateral mass screw fixation methods have been described in the literature with various levels of safety in relation to the anterior neurovascular structures. This study was designed to radiologically determine the minimum lateral angulations of the screw to avoid penetration of the vertebral artery canalusing three of the most common techniques: Roy-Camille, An, and Magerl.

Materials and Methods: Sixty normal cervical CT scans were reviewed. A minimum lateral angulation of a 3.5 mm lateral mass screw which was required to avoid penetration of the vertebral artery canal at each level of vertebra were measured.

Results: The mean lateral angulations of the latera 10.4103/0019-5413.87118 confidence interval) to avoid vertebral artery canal penetration, in relation to the starting point at the n mm medial (An), and 2 mm medial (Magerl) to the midpoint of lateral mass were 6.8° (range, 6.3–7.4°), and 14.1° (range, 13.6–14.6°) at C3 vertebrae; 6.8° (range, 6.2–7.5°), 10.7° (range, 10.0–11.5°), and 14 C4 vertebrae; 6.6° (range, 6.0–7.2°), 10.1° (range, 9.3–10.8°), and 13.5° (range, 12.8–14.3°) at C5 vert –8.3°), 10.9° (range, 10.3–11.6°), and 14.3° (range, 13.7–15.0°) at C6 vertebrae. The recommended latera ille, Magerl, and An are 10°, 25°,and 30°, respectively. Statistically, there is a higher risk of vertebral forame amille technique at C3, C4 and C6 levels, $P < 0.05$.

Conclusions: Magerl and An techniques have a wi n should be practised with Roy-Camille's technique at C3, C4, and C6 levels to avoid vertebral vessels injury in Asian population.

Key words: Asians, cervical spine, lateral mass screw, angulation

Introduction

Posterior instrumentation using lateral mass screws had gained popularity compared to a sublaminar wiring technique especially in cases where laminectomy was indicated. Various authors have reported that posterior lateral-mass screw fixation provides equal or greater biomechanical stability than anterior plating or posterior wiring fixation.[1-4]

Various techniques of lateral screw placement have been described. The commonly used methods are the Roy-Camille, Louis, Anderson, An, and Magerl techniques.[5-9] Each has its unique entrance point for screw insertion and screw trajectory. Excluding the Roy-Camille and Louis techniques, the screw trajectories in the rest of the three techniques are directed superiorly and laterally.[10] The screw trajectory is of critical importance because nerve roots, vertebral arteries and facet joints are at risk of injury with errant positioning. A lot of effort has been made to determine the safety of lateral mass screw placement in cadaveric models.[10-13] However to our knowledge, there is no radiological evaluation of the lateral angulation required to avoid the neurovascular structures.

We embarked on this study to objectively measure the lateral angulation required to avoid penetration of the vertebral artery canal in three of the most commonly applied techniques, Roy-Camille, An, and Magerl [Figure 1], based on the cervical CT scan model.

Materials and Methods

Digitised computed tomography images of the cervical spine (using IMPAX software from AGFA HealthCare)

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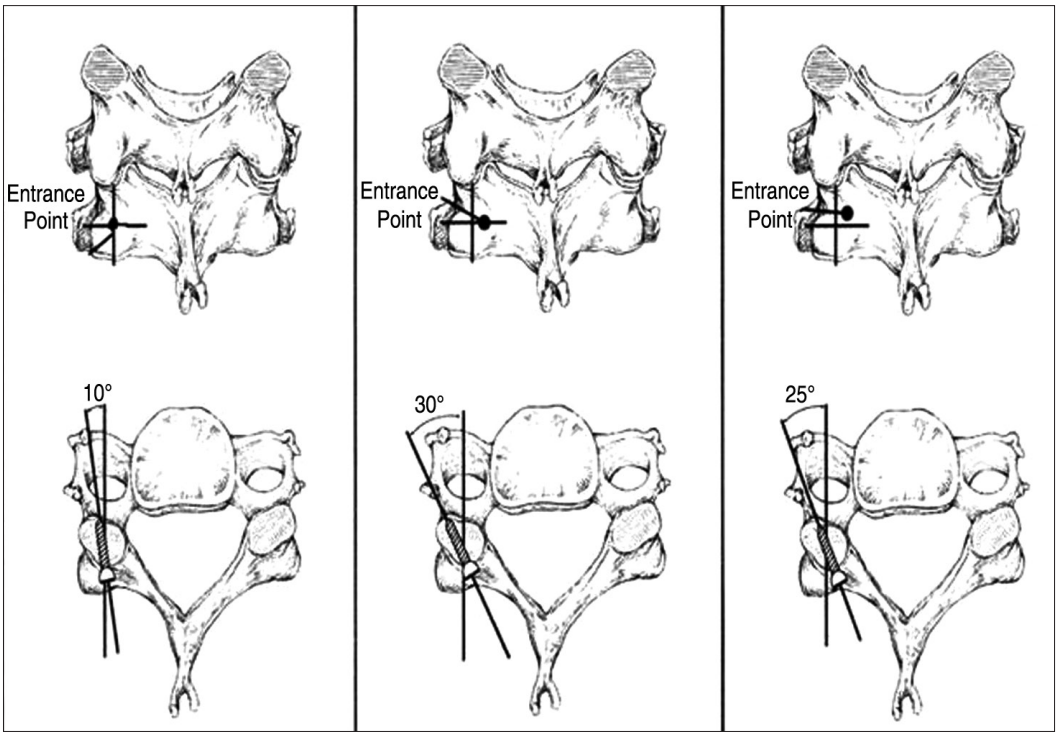

Figure 1: Diagrammatic presentation entry point and lateral angulation of the common techniques in lateral mass screw insertion. Left, Roy-Camille technique. Middle, An technique. Right, Magerl technique

performed from 1st January 2007 to 31st December 2008 were utilised in the study. The CT images were screened through to exclude the following pathologies, i.e. fractures, dislocations, tumorous lesions, and infection. Similarly, images with oblique axial cuts were excluded from this study. Sixty normal cervical CT scans with symmetrically perpendicular axial cuts at each level between C3 and C6 were selected from our digital image database. All measurements were performed by a single assessor, and the mean of three measured values were taken to reduce interobserver variation.

The axial section through the base of inferior articular process was chosen [Figure 2a], and a vertical line (A–B) bisecting the body, spinal canal, and spinous process was drawn. The midpoint of lateral mass was determined; it corresponds to the midpoint between the medial edge of inferior articular process and the lateral edge of lateral mass. The perpendicular distance of this midpoint from the line A–B is documented as distance X. A second axial section through the mid-distance between inferior articular process of upper vertebrae and the measured vertebrae were selected [Figure 2b]. The axis line A-B is redrawn, and the X distance from line A-B is marked which represents the centre point of lateral mass (point M).

The entry points (point C) for the various techniques were measured based on this center point; (Roy-Camille technique) on the center point, (An technique) 1 mm medial, and (Magerl technique) 2 mm medial to the center point.

Screw projections were determined based on Figure 2b. A line parallel to the vertical axis (A–B) is drawn over the entry point (line C–D). The axis of screw will be represented by a straight line connecting the entry point of lateral mass and the point 1.75 mm (based on the 3.5 mm diameter screw is commonly used screw) lateral to the border of vertebral artery canal (line C–E). The angulation between the line C–D and the line C–E will be the minimum lateral angulation of the lateral mass screw. These measurements were repeated from C3 to C6 vertebra.

These data were analysed with SPSS (Version 16) to compute the demographic distribution and calculate the mean and 95% confidence interval of the minimum lateral angulations of lateral mass screws.

Results

Sixty normal cervical spine CT scans were analysed using IMPAX software. Forty-two males and 18 females were included in this study with the racial distribution of Malay (n=30), Indian (n=13), Chinese (n=12) and other race (n=5). The mean age was 36.0 years old (range18-68 years).

The mean minimum lateral angulation of the lateral mass screw (with 95% confidence interval) to avoid vertebral

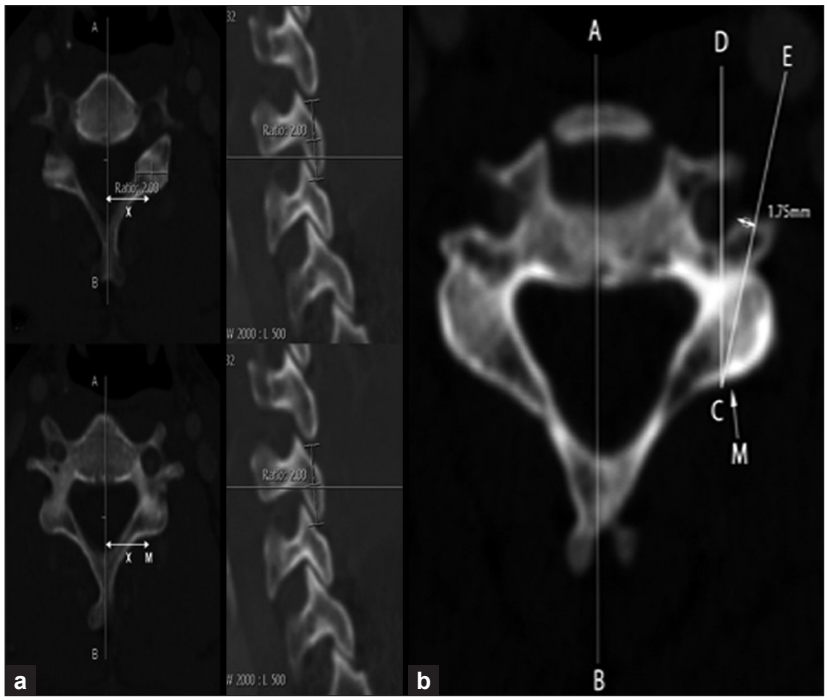

Figure 2: (a) Determination of the center point of lateral mass (M). (b) Center point of lateral mass (M), screw entry point (C), and lateral angulation of screw (C–D and C–E).

artery canal penetration, in relation to the starting point at the midpoint (Roy-Camille technique), 1 mm medial (An technique), and 2 mm medial (Magerl technique) to the midpoint of lateral mass for each level is shown in Table 1.

The amount of lateral angulation needed to avoid the vertebral vessels was the most at C6 vertebrae with a mean angulation of 7.6° (range, 6.9–8.3°), 10.9° (range, 10.3°–11.6°), 14.3° (range, 13.7°–15.0°) using Roy-Camille, An, and Magerl techniques, respectively. The C5 vertebral foramen is situated more medially in relation to lateral mass. As a result, the mean lateral angulation at the C5 vertebral level is the smallest angulation. At C4 and C3 vertebrae, the vertebral artery canal appears to shift more laterally compared to C5, and this had increased the mean lateral angulation angle.

Referring to published literatures, the recommended lateral angulation for Roy-Camille, An, and Magerl techniques is 10°, 30°, and 25°, respectively.[5,9,10] With reference to Table 1, these techniques are safe in our Asian population based on the analysis of the 60 cervical CT scans.

Discussion

To prevent injury to the vertebral artery during the posterior instrumentation procedure, anatomical knowledge of the location of the vertebral artery in relation to the lateral mass is critical. Ebraheim *et al.* reported the mean distance of transverse foramen from the lateral border of vertebral body to be approximately 2 mm; however, no measurement available for anatomical landmarks posteriorly.[14] We embarked on an effort to determine the minimum lateral angulation necessary to avoid the vertebral artery canal in relation to the starting point of the few common techniques of lateral mass screw insertion, the Roy-Camille, An and Magerl, by using CT scan.[6]

Table 1: The mean of minimum lateral angulation of the lateral mass screw to avoid penetration of the vertebral artery canal (with 95% confidence interval) at each level of the typical cervical vertebrae

Technique	Roy-Camille	An	Magerl
Starting point	Midpoint	1 mm medial	2 mm medial
Recommended angulations	10°	30°	25°
C3	6.8° (6.3–7.4°)	10.3° (9.8–10.8°)	14.1° (13.6–14.6°)
C4	6.8° (6.2–7.5°)	10.7° (10.0–11.5°)	14.1° (13.4–14.8°)
C5	6.6° (6.0–7.2°)	10.1° (9.3–10.8°)	13.5° (12.8–14.3°)
C6	7.6° (6.9–8.3°)	10.9° (10.3–11.6°)	14.3° (13.7–15.0°)

Merola *et al.* conducted an anatomical study on the safety of lateral mass screw placement on 10 fresh frozen cadaveric cervical spines.[15] He concluded that the Roy-Camille technique shows a higher preponderance to violate the vertebral vessel at C6 and C7 vertebrae while the Magerl and Anderson technique is relatively safe.

Our study result showed that all the three techniques of applying lateral mass screw are safe, the mean angulation to avoid vertebral artery in the Roy-Camille range from 6.6 to 7.6° for C3–C6 while the recommended angulation is 10°, similarly in the An and Magerl technique range 10.1°–10.9° and 13.5°–14.3° and the recommended angulations are 30° and 25°. The important differences between these techniques are the safety margin. In the Roy-Camille technique, the margin of safety (recommended angulation—upper 95% confidence limit) is very narrow (range 1.7°–2.8°). Meanwhile, the An and Magerl techniques have a wider range of the safety margin (range, 18.4°–19.3° and 10.0°–10.7°, respectively). Therefore, the Roy-Camille technique has a smaller margin of safety as compared to the An and Magerl technique in our Asian population.

In this study, the radiological outcomes confirm that the Roy-Camille, An and Magerl techniques are feasible and safe in our Asian population. However, the Roy-Camille technique has a smaller safety margin, in comparison with the other two techniques. Therefore, we would like to suggest advocating caution in utilising this technique in Asian population.[15]

Conclusion

Roy-Camille, An, and Magerl techniques of applying the lateral mass screws in Asian population is safe and feasible. Caution should be exercised with the Roy-Camille technique because of the smaller safety margin as compared to the An and Magerl technique.

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