A variety of surgical procedures have been developed for stabilization of the lower cervical spine (C3–C7). These include interspinous wiring,4,7,11,12,23,25 facet-to-facet wiring,20,23 sublaminar wiring,9,18 facet-to-spinous process wiring,5,6 use of Halifax clamps,15 placement of hook plates,16 and posterior cervical plating.2,8,10,22 Most wiring techniques can be accomplished only if some portions of the posterior bony elements are intact. This is often not the situation after cervical trauma, laminectomies, or tumor resection. One technique, articular pillar posterior plating, does not depend on the spinous processes or laminae.

Roy-Camille and coworkers21 first introduced the use of posterior plate and screw fixation into the articular pillars for cervical spine arthrodeses in the 1970s. They compared the results of wire fixation versus posterior cervical plates in a ligamentous injury model and demonstrated that flexion stiffness was increased by 33% with interspinous wire in contrast to 92% with cervical plate fixation.22 Cooper9 was a pioneer in the use of such a plating system on this side of the Atlantic and reported successful fusion in 19 of 20 patients. Others have also reported excellent outcomes with posterior plate–screw fixation.13,17,19

Posterior plate systems provide immediate stability for ligamentous injuries, facet joint disruptions, and certain vertebral body fractures. The use of this method of internal fixation of the cervical spine requires that the surgeon understand the anatomical relationships of key bony elements and other vital structures. This technique involves posterior screw placement into the articular pillars, commonly known as “the lateral cervical masses,” and carries the potential for injury to the vertebral arteries and cervical roots, which pass in proximity to them. The vertebral arteries and cervical roots run beneath the bone surface and cannot be seen. The surgeon must at all times be aware of the location of these structures to avoid injuring them. To better understand the anatomy of this region, we evaluated the articular pillars from C-3 to C-7. Important bony landmarks for the placement of articular pillar (lateral mass) screws were determined. From this study arose the concept of quadrant anatomy of the articular pillars of the cervical spine. This involves dividing the articular pillar into four quadrants: superolateral, inferolateral, superomedial, and inferomedial (Fig. 1). Using this quadrant concept facilitates the placement of the screws for posterior plate systems.

Materials and Methods

The anatomy of the articular pillars from C-3 to C-7 was studied in 10 cadaveric spines from humans aged 61 to 85 years. The bony landmarks were measured with calipers and rulers. The superior and inferior processes form the articular pillar, which bulges at the junction of the pedicle and lamina. When viewed posteriorly, the articular pillar appears as a square. The concept of quadrant anatomy begins with bony landmarks seen from

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Knowledge of the relevant anatomy is important when developing a strategy for introducing screws into the lateral masses to secure internal fixation devices. This paper defines key bony landmarks and their relationship to critical neurovascular structures and identifies a location for safe placement of cervical articular pillar (lateral mass) screws.

Measurements of anatomical landmarks in 10 spines from human cadavers aged 61 to 85 years were made by caliper and a metric ruler. Landmarks were the lateral facet line, rostrocaudal line, medial facet line, intrafacet line, and medial facet line–vertebral artery line. The average distances and ranges were recorded. Such great variance existed in measurements from spine to spine and within the same spine as to render averages clinically unreliable. Dissection revealed that division of the articular pillar into four quadrants leaves one, the superior lateral quadrant, under which there are no neurovascular structures; this may be considered the “safe quadrant” for placement of posterior screws and plates.

Key words • spinal stabilization • posterior cervical arthrodesis • lateral mass posterior plating • cervical spine • vertebral artery • anatomical study
behind, including: 1) the lateral facet line (LFL), a line from one facet joint to the next facet joint along the posterolateral border of the articular pillar; 2) the medial facet line (MFL), a line from one facet joint to the next facet joint at the junction of the lamina and the articular pillar; 3) the rostrocaudal line (RCL), a line on the posterior surface of the pillar in a rostrocaudal direction dividing the pillar into two vertical halves; and 4) the intrafacet line, a line extending mediolaterally through the center of the articular pillar perpendicular to the above lines. Thus, the articular pillar has been divided into quadrants: the superolateral, inferolateral, superomedial, and inferomedial (Fig. 1 upper). The medial facet line/vertebral artery line (MFL/VAL) extends from the midportion of the medial facet line to the vertebral artery (Fig. 1 lower).

Measurements of these lines were made bilaterally from C-2 to C-7. The articular pillars were then dissected with a high-speed surgical drill by removing in layers the dorsal bony elements overlying the neurovascular elements.

Results

The mean lengths of the bony landmarks are given in Table 1. A paired t-test was applied to these results and the lateral facet line on the left side was found to be significantly less than that on the right side (p = 0.001). There was also a significant difference between the MFL/VAL on the left and the right, with the left line greater than the right (p = 0.032). In spite of the variability of the measurements, the bony landmarks remained consistent. A grid consisting of four quadrants (superomedial, superolateral, inferomedial, and inferolateral) can be superimposed on the articular pillar using the above lines (Fig. 1). The MFL, which forms the medial border of the two median quadrants, demarcates the course of the underlying vertebral artery. This relationship has been noted previously.17

When the inferior articular process was removed, the cartilaginous endplate of the superior articular facet was exposed (Fig. 2 left). As the articular pillar was drilled away, the soft tissue covering the articular pillar and the pedicle began to appear. Another bony structure was now immediately evident: the lateral process of the foramen transversarium (Fig. 2 left). More soft tissue was removed to expose the vertebral artery, which coursed medial to the lateral process, and the pedicle was encountered medially (Fig. 2 right). The cervical nerve root was easily identified and passed dorsally to the vertebral artery at the medial aspect of the facet joint, coursing obliquely and downward. The obliquity and length of the roots successively increased caudally. The nerve root was located inferior to both the lateral process and the pedicle (Fig. 2 right). The MFL and the articulation of the superior and inferior articular processes served as important bony landmarks for the origin of the spinal nerve root. From its origin in the neural foramina, it had a lateral, oblique, forward, and downward orientation and, when projected onto the grid of the quadrant, coursed from the superolateral to the inferolateral quadrant (Fig. 3). These two quadrants of the articular mass defined the path of the nerve. The vertebral artery coursed under the superomedial and inferomedial quadrants, along the MFL. The superolateral quadrant, under which there is no artery or root, is a "safe quadrant" for screw placement (Fig. 3).

Discussion

The measurements of the bony landmarks in our investigation are consistent with the results of other studies, which demonstrated great variation of intrafacet distances.1 The variation in measurements may be attributed to normal anatomical variation and osteophytic changes. Variation in measurements of the MFL, LFL, and RCL occurred in each cadaver from level to level and from each side of the same level. Lengths also varied at the same level among different specimens. These measurements were of no clinical value. On the other hand, the MFL/VAL is of clinical value because it is the distance from the dorsal surface of the bony housing of the articular pillar to the underlying vertebral artery. No measure-

### Table 1

<table>
<thead>
<tr>
<th>Bony Landmark</th>
<th>Mean Left (mm)</th>
<th>Mean Right (mm)</th>
<th>SD</th>
<th>Range (mm)</th>
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<tbody>
<tr>
<td>medial facet line</td>
<td>15.34</td>
<td>15.10</td>
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<td>14.58</td>
<td>2.83</td>
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<td>intrafacet line</td>
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<td>1.99</td>
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<td>medial facet/vertebral artery line</td>
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<td>14.54</td>
<td>1.98</td>
<td>12-22</td>
</tr>
</tbody>
</table>

SD = standard deviation of the mean.
The articular pillars of the cervical spine

Fig. 2. Left: The inferior articular process has been removed, exposing the cartilaginous endplate of the superior articular facet and the lateral process of the foramen transversarium. Right: The vertebral artery is seen medial to the lateral process and lateral to the pedicle.

Sauter, et al. (unpublished data) noted that when the Magerl method of fixation was used (2 to 3 mm medial to the midpoint of the articular pillar, 25˚ lateral and parallel to the superior articular process), 17% of the screws penetrated the vertebral artery and encroached on the nerve root. With the Haid method (with a starting point of 1 mm medial to the lines bisecting the articular pillar, 30˚ lateral and 10˚ to 20˚ rostral), the distance between the screw and the vertebral artery averaged 7 mm, and the distance from the nerve root averaged 5 mm (unpublished data). The Haid method of articular plate fixation directed the screw into the “safe quadrant,” avoiding unwanted neurovascular injury.

Conclusions

It is evident from this work that the safest trajectory for screw fixation from C-3 to C-7 is into the superolateral “safe quadrant.” Understanding the concept of quadrant anatomy will lead to a safer, easier, and quicker method for placement of posterior articular pillar screws and plates.

Acknowledgments

We express our gratitude to Drs. Richard Wiggins and Rumy Hilloowala, Department of Anatomy, West Virginia University, for their assistance in procuring the anatomy specimens. We are indebted to Ms. Pavlina Vagoun for her artwork and express our appreciation to Ms. Linda Fletcher (Morgantown, West Virginia) and Ms. Tina Cohns (Little Rock, Arkansas) for their help in the preparation of this manuscript.

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Manuscript received July 5, 1994.
Accepted in final form September 29, 1994.
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**TABLE 1**

*Measurements of bony landmarks of the articular pillars*

<table>
<thead>
<tr>
<th>Bony Landmarks</th>
<th>Mean Length (mm)</th>
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<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>SD*</td>
<td>Range (mm)</td>
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</tr>
<tr>
<td>medial facet line</td>
<td>15.34</td>
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* SD = standard deviation of the means.