Neurosurgical Forum

LETTERS TO THE EDITOR

Optimal entry point for C-1 lateral mass screw placement

TO THE EDITOR: In a recently published cadaver study regarding the optimal entry point for C-1 lateral mass screw placement, Moisi et al.¹ compared the traditional lateral mass entry point used in the Goel/Harms technique to a proposed alternative entry point in the posterior arch of the C-1 (i.e., the posterior arch lateral mass [PALM]), concluding that the latter technique is not only safe but also results in fewer medial penetrations of the spinal canal compared to the accepted Goel/Harms technique (Moisi M, Fisahn C, Tkachenko L, et al: Posterior arch C-1 screw technique: a cadaveric comparison study. *J Neurosurg Spine* 26:679–683, June 2017). Recognizing the proximity of the vertebral artery (VA) in the sulcus arteriosus to their proposed entry point, they advocate careful dissection and upward mobilization of the VA away from the sulcus arteriosus, and protection of the VA with a Penfield 4 dissector as drilling and screw placement are conducted. The authors do not provide any data about the thickness of the C-1 posterior arch or the frequency of penetration of the sulcus arteriosus in their study.

Intrigued by this study but concerned about the thin and tapering anatomy of the C-1 posterior arch as an entry point, we retrospectively reviewed the anatomy of the C-1 posterior arch and VA on 30 consecutive cervical CT angiograms recently performed at our institution. Of the 60 sides that were reviewed, 3 showed nonopacification of the VA. In all cases the thickness of the C-1 posterior arch in the sagittal plane bisecting the C-1 lateral mass was measured in 2 locations: at the posterior surface of the C-1 posterior arch and at the level of the sulcus arteriosus (Fig. 1). In the 57 cases that showed opacification of the VA, the distance between that artery and the superior margin of C-1 was noted.

The mean thickness of the C-1 posterior arch at its posterior surface was 6.9 ± 2.3 mm, and at the sulcus arteriosus it was 3.9 ± 1.2 mm (mean $\pm$ SD). Assuming a standard screw diameter of 3.5 mm (the authors did not mention screw size) and a margin of error of 1 mm for safe screw placement, we found that only 13 cases (21.7%) had a posterior arch thickness greater than 4.5 mm at the level of the sulcus arteriosus. With the PALM technique, there is

a 78% risk that a 3.5-mm-diameter screw would perforate the sulcus arteriosus. Furthermore, we found that in all but 4 cases the VA was in direct contact with the bone at the sulcus arteriosus, substantially increasing the risk of injury to the vessel.

With regard to the authors' directive to mobilize the VA out of the sulcus arteriosus during drilling and screw

FIG. 1. Sagittal CT angiographic images acquired through the mid-sagittal plane of the C-1 lateral mass in 6 representative patients. The thickness of the C-1 posterior arch is noted across its thicker posterior margin and thinner interior region below the sulcus arteriosus harboring the VA (black arrows). In panels A and B, the thickness of the C-1 posterior arch is adequate for screw placement, but there is limited opportunity for visualization and mobilization of the VA due to posterior bone thickness (arrowhead, A) and a tight atlantooccipital interval. In panels C–F, the bone thickness below the VA is inadequate for safe placement of a 3.5-mm-diameter screw through the C-1 posterior arch. Obstacles to visualization and mobilization of the VA include a bony outgrowth known as the ponticulus posticus (arrowhead, D); an extensive venous plexus around the VA (white arrow, E); and near-complete bony encasement of the VA in a foramen arteriosus (arrowhead, F). Figure is available in color online only.

insertion, it must be stated that the difficulty of such a maneuver is far greater during surgery than in cadaver dissection. First, bleeding from the robust venous plexus surrounding the VA (Fig. 1E, white arrow) would make visualization and mobilization of the vessel difficult and would increase the risk of VA injury in surgery as compared to a cadaver study. Second, the thickness of the posterior surface of the C-1 arch would make visualization of the VA challenging in some cases (Fig. 1A, arrowhead) and impossible in the presence of ponticulus posticus (Fig. 1D, arrowhead) or foramen arteriosus (Fig. 1F). Third, whereas the atlantooccipital interval is opened with head flexion during surgery, it is narrowed when the head returns to the neutral or extended position. In many cases, the VA travels in a very narrow space between the occiput and the C-1 posterior arch (Fig. 1A and B). In such cases, even if the VA is successfully mobilized during screw placement and then allowed to rest against a screw that has breached the sulcus arteriosus, one is left with the risk of position-dependent occlusion and subsequent thrombosis of the VA.

In our practice, we use a diamond burr to drill the inferior margin of the C-1 posterior arch, leaving a shell of cortical bone against the VA at the sulcus arteriosus. This permits screw entry at the junction of the C-1 lateral mass and posterior arch while reducing the potential for impingement of the C-2 nerve root. If surgeons elect to use the PALM technique, we recommend a preoperative CT angiogram and careful measurement of the thickness of the C-1 posterior arch and its relationship to the VA. Based on the above-mentioned observations, we expect that only a small minority of cases will be found suitable for the PALM technique.

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References

1. Moisi M, Fisahn C, Tkachenko L, Jeyamohan S, Reintjes S, Grunert P, et al: Posterior arch C-1 screw technique: a cadaveric comparison study. *J Neurosurg Spine* 26:679–683, 2017

Disclosures

The author reports no conflict of interest.

Response

We thank Dr. Pakzaban for his letter. He brings up a key point of the VA and the relationship to the C-1 screw and the C-1 bony anatomy when using a PALM technique as described.

As mentioned in our article, the anatomical circumstances of the posterior C-1 lateral mass can make safe screw placement challenging, and different methods of fixation have been developed. There is not one way that is safest amongst all the others. The informed surgeon should examine the preoperative imaging and determine which method will be safest for each patient.

We are in agreement with Dr. Pakzaban that the cadaver is not representative of an in vivo situation. However, despite the difficult anatomy, including the venous plexus encircling the VA and the proximity of the VA to the pathway, the screw can be navigated with a good understanding of the anatomy and careful dissection. It is possible to isolate the VA without excessive blood loss and without injury to the vessel. We do not think that the venous plexus around the VA should deter the surgeon. The C-2 nerve root also has a robust venous plexus that can be carefully dissected without excessive blood loss. Once the VA is isolated, it is safe to place the screw with the PALM technique. Nevertheless, if the VA cannot be isolated or the blood loss is excessive, the surgeon must be prepared to place the C-1 screw with a different technique.

The C-1 vertebra does indeed have anomalous anatomy, but with a good understanding of the bony anatomy as demonstrated on preoperative radiology studies, and with careful isolation of the VA, the PALM technique can be safely implemented for placement of C-1 lateral mass screws.

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