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MR and Cryomicrotomy of C1 and C2 Roots

Peter S. P. Ho^{1,2}
 Shiwei Yu¹
 Lowell Sether³
 Marvin Wagner³
 Victor M. Haughton¹

Paramedian sagittal MR images and cryotome sections in four cadavers were correlated with eight clinical MR studies to analyze the appearance of the C1 and C2 nerve roots and adjacent tissue. The C2 nerve roots and anatomically related venous plexus were identified. The C1 root, although not visualized by MR, could be localized by its relation to the vertebral artery, C1 lateral mass, and posterior arch.

The anatomic relationship between the C3–C8 nerve roots and their foramina has been described [1]; however, C1 and C2, which lack neural foramina, have not been identified in previous MR studies. The purpose of this study is to examine the MR appearance of the C1 and C2 nerve roots.

Materials and Methods

Four male cadavers (ages 43, 61, 81, and 86) were used for the correlative MR anatomic study. MR images were obtained in paramedian sagittal plane with a GE 1.5-T Signa MR imager and a 5-in.-diameter butterfly surface coil,* which was placed against the cadaver's back. Technical factors for imaging included 800/20/2, 800/40/2, 2500/20/2, and 2500/80/2 (TR/TE/excitations); 256 × 256 matrix; 16- or 20-cm field of view, and 3-mm contiguous slices. The cadavers were frozen and the necks were removed by bandsaw and placed on the stage of an LKB 2250 heavy-duty sledge cryomicrotome for sectioning in the same plane in which images were obtained. The surface of the specimen was photographed after the removal of each 1-mm-thick slice of tissue. The cryotome techniques are described in detail elsewhere [1].

Eight clinical MR studies of the cervical spine before and after the injection of gadolinium DTPA (0.1 mmol/kg) were reviewed. Technical factors for these clinical images included 800/20/2; 256 × 128 or 256 × 256 matrix; 20-cm field of view, and 5-mm slice thickness at 6-mm intervals.

Results

The C1 and C2 nerve root sheaths, which are more posteriorly located than their counterparts at C3–C7, were identified on the cryotome sections approximately 2 cm from the midline (Fig. 1A). In this plane the posterior arch and lateral mass of C1 and the facet joints of C2 through C4 were conspicuous. The C2 nerve root penetrates the dura below the arch of C1, above the arch of C2, posterior to the body of C2, and anterior to the inferior oblique muscle (Fig. 1A). Its ganglion in the parasagittal anatomic section has an oval shape. The C2 ganglion was seen on MR images as a structure with an intermediate signal intensity (Figs. 1B and 1C). It enhanced (brighter signal) on T1-weighted MR images after an IV injection of gadolinium DTPA (Fig. 2). Surrounding the C2 roots and ganglion are the root sheath, a venous plexus, and a variable amount of fat. The root sheath and CSF near the ganglion were not distinguished. The veins had a variable appearance; in

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¹ Department of Radiology, The Medical College of Wisconsin, Froedtert Memorial Lutheran Hospital, 9200 W. Wisconsin Ave., Milwaukee, WI 53226. Address reprint requests to V. M. Haughton.

² Present address: Tri-Service General Hospital, 622 Ting-Chow Rd., Taipei, Taiwan.

³ Department of Anatomy, The Medical College of Wisconsin, Milwaukee, WI 53226.

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* Medical Advances, Inc., Wauwatosa, WI 53226.

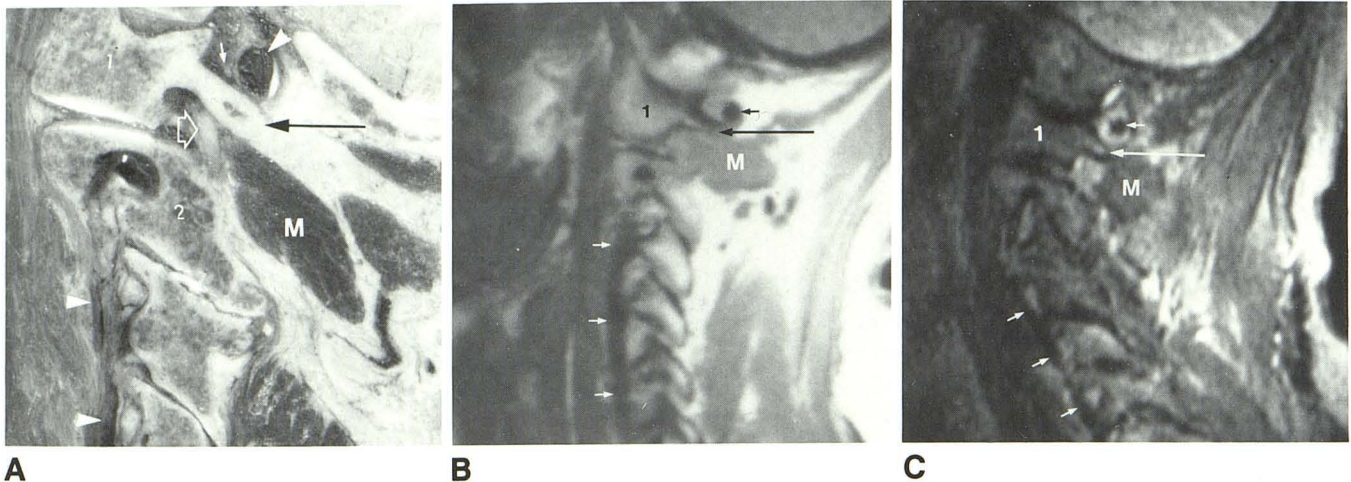


Fig. 1.—A–C, Paramedian sagittal anatomic (A) and MR (B and C) sections of cervical spine in a plane 2 cm from midline (A). Note lateral masses of C1 (1) and C2 (2), vertebral artery (arrowheads in A, short arrows in B and C), inferior oblique muscle (M), C2 root (open arrow), and C1 arch (long arrow). In A, the C1 root (short arrow) appears above the arch of C1. In B, bright signal adjacent to vertebral artery represents a venous plexus. (B, 800/20/2; C, 2500/80/2.)

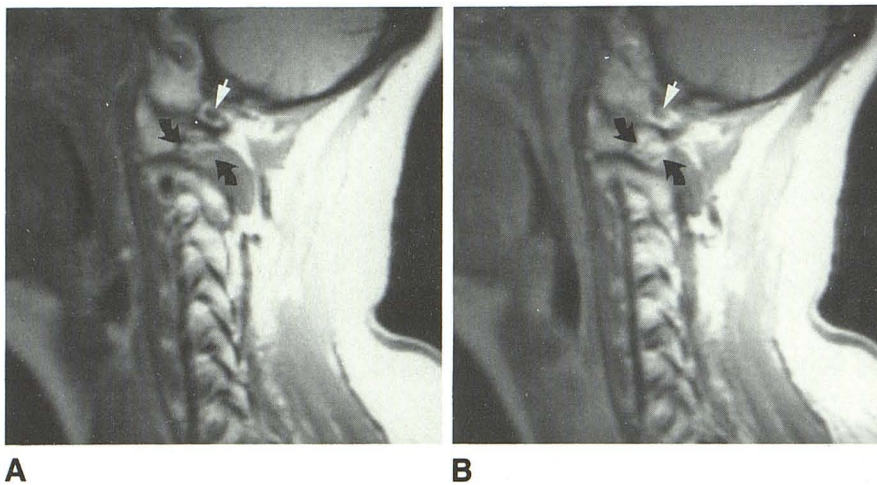


Fig. 2.—Short TR images before (A) and after (B) IV gadolinium DTPA. Note enhancement in venous plexus around vertebral artery (white arrow) and in C2 ganglion and venous plexus (black arrows) anterior to inferior oblique muscle.

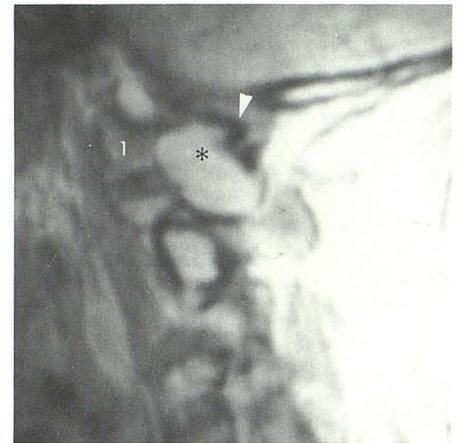


Fig. 3.—A neurofibroma (asterisk) obscuring the C2 root. Paramedian sagittal short TR image shows destruction of C1 posterior arch, erosion of posterior border of C1 lateral mass (1), and elevation of vertebral artery (arrowhead).

cadavers they had an intermediate signal intensity on T1- and T2-weighted images. In patients, the plexus, like the ganglion, enhanced on T1-weighted MR images after an IV injection of gadolinium (Fig. 2). The fat near the C2 root had a bright signal on T1-weighted images.

The C1 nerve and root sheath were identified in cryotome sections behind the C1 mass and above the C1 posterior arch and ventral to the vertebral artery. C1 was not identified in the correlative MR sections but could be localized by reference to the large, angular lateral mass and posterior arch of C1, which were recognized on the MR image by the negligible signal from their dense cortical margins and moderately bright signal from the marrow (Figs. 1B and 1C). The C1 nerve root lies between the vertebral artery and lateral mass of C1 and above the arch of C1. A plexus of veins around the vertebral

artery, barely conspicuous on the cryotome sections, appears as a halo of a bright signal on some T2-weighted spin-echo sequences. The inferior oblique muscle, the larger of the two muscles originating from the spinous process of C2 and inserting on the dorsal surface of the C1 transverse process, was a prominent structure on the parasagittal anatomic and MR images (Figs. 1 and 2). On T1- or T2-weighted MR images it had an intermediate homogeneous signal intensity.

Discussion

Previous investigators have described the MR appearance of the vertebral arteries, the muscles of the neck, and the lateral masses of C1 and C2 [1–5]. The MR appearances of

the C2 root, adjacent venous plexus, and inferior oblique muscle have not been emphasized. Displacement of these landmarks by a mass, and differentiation of these structures from tumor presumes that the normal appearance is familiar (Fig. 3). On paramedian sagittal MR images, for example, the inferior oblique muscle resembles a mass. The normal enhancement after gadolinium DTPA in the veins anterior to the muscle could suggest a disease process. Enhancement in the C2 ganglion is also a normal finding, not indicative of a mass or inflammatory process. Since the sagittal plane is used routinely for spine imaging, identification of abnormalities in this plane is important. Axial images can be used to confirm observations or questionable findings on the sagittal images.

The correlative study in cadavers can be applied to clinical studies despite the technical differences. To provide the greatest anatomic resolution possible, the MR techniques in cadavers included longer acquisitions and thinner slices than are used clinically. Furthermore, the contrast in cadavers, because of postmortem changes and lower temperatures, may differ from that in clinical images. Nonetheless, the cadaver and clinical images were comparable. Freezing

causes little distortion of anatomic relationships in the epidural space [6].

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