Vestibular schwannoma and the facial nerve

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Preservation of facial nerve function during excision of a moderate to large vestibular schwannoma was considered a significant surgical feat half a century ago. Today, loss of facial nerve function during such an operation is considered “a devastating complication” as stated by the authors of the very nice paper on this topic in the Journal of Neurosurgery describing the use of a sophisticated MR imaging technique to visualize the facial nerve.⁴ The Oregon group, which has had a significant interest in MR imaging techniques to visualize cranial nerves and neurovascular relationships, describe the use of what they call “high-density diffusion tensor imaging” (HD-DT imaging) to visualize the facial nerve and follow its course in the cerebellopontine angle (CPA) in 5 patients with large (> 2.5 cm) vestibular schwannomas. In all 5 patients, the authors were able to visualize the entire course of the facial nerve along the capsule of the tumor, and the predicted exact location of the nerve was confirmed in each case at surgery. In contrast, they could not visualize the nerve at all in 4 of these 5 patients using standard diffusion tensor (DT) imaging.

We believe that if this technique proves reliable in a larger number of patients, it will become an important preoperative surgical adjunct in patients with large vestibular schwannomas. Clearly, very experienced surgeons who have operated on hundreds of these tumors do not need this precaution since, aided by intraoperative stimulation, they have developed with experience, the ability to find, follow, and preserve the facial nerve even in cases of large tumors. However, most vestibular schwannomas are not treated by surgeons who perform this operation several times a week. For these surgeons, the ability to preoperatively predict with confidence the course of the facial nerve in the capsule of the tumor would be valuable. Any surgeon who has performed surgeries for vestibular schwannomas knows that the facial nerve could be located with accuracy and with the aid of intraoperative stimulation at the brainstem and in the meatus; however, it is frequently very difficult to know whether the nerve runs anteroinferiorly, anterosuperiorly, or straight anteriorly along the equator of the tumor. Even more concerning are the few rare cases in which the nerve runs along the posterior aspect of the capsule, although in these cases, early intraoperative stimulation is usually able to detect the course of the nerve.

Standard preoperative purely anatomical MR imaging techniques that are commonly used for visualization of cranial nerves include a high-resolution 3D T2-weighted sequence commonly known as MR cisternography (for example, CISS [constructive interference in the steady state] sequence and FIESTA [fast imaging employing steady state acquisition] in addition to the routine T2-weighted and T1-weighted images obtained before and after contrast administration. The newer heavily T2-weighted sequences such as CISS introduced by Casselman et al.¹ is a well-established and excellent method for imaging cranial nerves and neurovascular relationships. The further capability of obtaining multiplanar reformatted 3D images has enabled us to accurately delineate the facial nerve in relation to small vestibular schwannomas.

More recently, DT imaging–based fiber tracking has emerged as a novel MR imaging technique for demonstrating functional or structural changes in various cranial nerves.³ Several authors have studied the efficacy of standard DT imaging–based tractography in delineating the facial/vestibular complex in both healthy individuals and in patients with vestibular schwannomas with less reliable results. In a more recent study by Gerganov et al.⁵ results were much more encouraging in 20 (90.9%) of 22 patients with vestibular schwannomas in which they performed the standard DT imaging technique using a slightly greater slice thickness of 1.6 mm.

Compared with previous papers, the Oregon group used a higher resolution and HD-DT imaging with an increased number of diffusion sensing directions, a smaller voxel size, and thinner slices of 1.2 mm with no intersection gap. It is possible that the thinner slices resulted in less image distortion and signal loss that may have accounted for better visualization of the compressed or distorted facial nerves in this study compared with previous reports. With this refined technique, the authors were successful in reproducing a coherent tract that corresponded to the anatomical location and course of the facial nerve from the brainstem around the capsule of the tumor to the internal auditory canal in all 5 patients with large tumors.

One of the drawbacks of this HD-DT imaging study is the lack of quantification of the anisotropic changes between the affected and normal nerves. The results of this initial HD-DT imaging study are, however, promising, and the paper should not only lie as a foundation for further prospective studies in predicting microstructural changes in the facial nerve as a result of compression by tumor but also for demonstration of other cranial nerves.

In summary, we believe that this technique will prove
useful in surgical planning for large (> 2.5 cm) tumors in the CPA. Preoperative knowledge of the exact location of the facial nerve in relation to the tumor may change the choice of surgical approach for those surgeons who are just as comfortable with the retrosigmoid as with the translabyrinthine approach. Also, the sequential steps in terms of where to identify the nerve first and how to follow it may be influenced by this preoperative information. We believe that the application of this MR imaging technique for this purpose is an important contribution.

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Disclosure

The authors report no conflict of interest.

References


Response

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We thank Drs. Heros and Bhatia for their thoughtful and insightful discussion of our study. The use of preoperative modeling of intracranial pathology is becoming increasingly commonplace in the surgical arena. This is evident when applied to neuroimaging of cranial nerves involved in space-occupying lesions of the CPA. As recently published papers have capitalized on the advancements of diffusion tractography in modeling cranial nerves.3 Diffusion tensor imaging parameters have evolved over time, and at inception involved rather large voxel sizes (4 × 4 mm, with 4-mm slice thickness). These initial parameters were successful in identifying large bundles of white matter tracts as well as some cranial nerves but lacked the sensitivity to accurately and reliably identify small nerves or nerves associated with pathology (in this case, large tumors causing displacement).

We agree that smaller slice thickness and smaller voxel sizes are likely to result in less signal loss and image distortion, resulting in the more robust diffusion images necessary to localize the thinned fibers of the facial nerve in cases of large vestibular schwannomas. Diffusion tensor imaging parameters are on a continuum from those of low resolution, standard DT imaging, and 6 diffusion sensing directions to those of a high resolution and many diffusion sensing directions.

In the study referenced by Drs. Heros and Bhatia, Gerganov et al.1 used imaging parameters that are a clear advancement over the original standard DT imaging continuum. These used an unspecified voxel size with a slice thickness of 1.6 mm and 12 diffusion sensing directions. In our current paradigm, we used an increased number of directions (32), a voxel size of 0.78 × 0.78 mm, and a slice thickness of 1.2 mm. For comparison, we used standard DT imaging of 2 × 2-mm voxel size and 4-mm slice thickness with 6 directions. The large difference in the voxel sizes and slice thickness between our 2 paradigms likely accounts for the inability to reconstruct the same nerve bundle between the two (standard DT imaging vs HD-DT imaging). The work of Gerganov et al.1 lies somewhere between these methods.

Additionally, we obtained images only in patients with large vestibular schwannomas (> 2.5 cm) whom we believed would benefit most from preoperative imaging due to the significant amount of anatomical distortion and who posed a significant risk of facial nerve injury. Therefore, our patients were not consecutive but represent a select group of patients with vestibular schwannomas. The fact that we were unable to visualize the nerve in 4 of the 5 patients with vestibular schwannomas using our standard DT imaging methods highlights the importance of voxel size, slice thickness, and diffusion directions in increasing the sensitivity of preoperative reconstructions. This is also supported by the higher fractional anisotropy value that we were able to use (0.15) versus the fractional anisotropy value of 0.1 used in most other imaging studies of the facial nerve.3

The optimal parameters for visualization of the displaced facial nerve are unknown. It is apparent, however, that with smaller voxel size and slice thickness, and increased diffusion directions we were able to identify the facial nerve in our small patient cohort with large vestibular schwannomas. We agree that our method requires further evaluation in a larger series of patients with large vestibular schwannomas as well as modeling of unaffected cranial nerves.

References


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