HEAD AND NECK IMAGING

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Those of us who have been privileged to practice in the field of radiology during last 20 years marvel at the advances made in the cross-sectional techniques. The digital revolution has propelled our specialty into one of the most dynamic times for medicine, rivaling that of the introduction of antibiotics and the discovery of the X-ray. As we take account of the great strides made in the field of head and neck imaging over the last 20 years and humbly look into the future, we must acknowledge the pioneers who shed the first light on the various head and neck disease processes. Indeed, our head and neck imaging tools have only confirmed much of what these early clinical pioneers described many years before without the benefit of CT, MR imaging, sonography, single photon–emission CT (SPECT), or positron-emission tomography (PET). Ballantyne (1), a head and neck surgeon, and Lederman (2), a radiation oncologist, reported the various patterns of spread of head and neck malignancy, and teamed with Fletcher (3) to apply this anatomic knowledge with that of radiobiology to pioneer the multidisciplinary treatment of head and neck cancer. Renowned otologist Schuknecht (4) set the stage for the understanding of temporal bone polytomography and CT with his work on the anatomy and pathology of the temporal bone. These contributions have been truly monumental in scope and difficulty, and these investigators deserve much of the credit for laying the foundation for those who later correlated this information with imaging.

The modern era of head and neck imaging was brought to us by several pioneering radiologists. One of the most influential was Valvassori, whose annual course on the temporal bone evolved into the annual meeting of the American Society of Head and Neck Radiology. Hanafee, one of the founders of the American Society of Head and Neck Radiology, and Mancuso, his student and eventual partner, launched the field of head and neck radiology with their use of cross-sectional CT. Credit for those early years of head and neck development also goes to Potter and Johnson of New Orleans, cofounders of the ASHNR. Peter Som, Tom Bergeron, Barbara Carter, and Hugh Curtin were also instrumental in the development and progress of modern head and neck radiology. Many others have impacted the development of this field and go unmentioned here only for lack of space. We owe them all a debt for contributions to this specialty, which has developed into a mature discipline and truly a part of modern neuroradiology.

Many of the articles in head and neck imaging began appearing in the *AJNR* in the late 1980s and early 1990s after the journal became the official organ of the American Society of Head and Neck Radiology. Until then, our journal was largely devoted to imaging of the central nervous system. I have selected a few of the many interesting articles over the last 20 years to highlight the contribution of the *AJNR* to the field of head and neck imaging.

Cancer Staging

The great advance in cancer staging occurred with the introduction of cross-sectional imaging. After CT was introduced in the mid-1970s, it was not long before this technique was applied to the temporal bone and in staging of cancer of the head and neck. With the addition of MR scanning during the last 15 years, the treating physician was permitted a look at the third dimension of tumor growth—that which is deep to and beneath the mucosa, beyond the reach of palpation. This information was formerly only detected at surgery (remember the ‘‘peek and shriek’’?), from pathologic analysis or assumed by indirect signs of tumor fixation, or other signs or symptoms of nonresectability.

In the field of cancer staging, some of the early literature included a landmark article by Gatenby et al (5), who first demonstrated the utility of CT over clinical examination for the staging of head and neck cancers. In their study, 100 patients with tumors at the skull base or in the aerodigestive tract were staged both conventionally and with CT scanning. In 10 patients, CT revealed tumor that had not been apparent clinically, and in another 26 patients, CT showed the tumor to be more locally extensive than had been clinically evident. Thus, CT altered significantly the treatment planning in 36 of the 100 patients.

The introduction of MR contrast materials was not only a major advance for neuroradiology, but also for head and neck radiology. Zoarksi (6) published the multicenter trial of gadoteridol administration among patients with suspected head and neck pathology, showing the value of contrast-enhanced imaging of the head and neck. Sakai (7) evaluated the impact of gadolinium on MR imaging for the diagnosis and staging of laryngohypopharyngeal cancer. The use of contrast material in the diagnosis of head and neck cancer continued with the report of Escott (8), who compared the dynamic contrast-enhanced gradient-echo and spin-echo sequences in MR imaging of head and neck neoplasms. In 1998, Nemzek (9) demonstrated that the sensitivity of MR imaging for the detection of perineural spread was 95%; however, he noted that the entire extent of perineural tumor spread was often not visible with MR imaging. Tien and colleages (10) reported on the further improved sensitivity of contrast-enhanced MR scanning of the head and neck region with the introduction of fat-suppressed MR imaging.

The field of laryngeal imaging increased dramatically with the addition of high-resolution helical CT and MR scanning. In a landmark article, Schmalfuss (11) described the sclerosis of the arytenoid cartilage and its clinical significance in the setting of carcinoma of the larynx. This investigation showed that sclerosis can be seen in normal individuals and is not in itself a marker of metastatic carcinoma.

The staging of carcinoma of the head and neck is an important aspect of head and neck imaging. Using sonography, van den Breckel (12) established the size criteria of lymph nodes in the neck for metastasis has improved our knowledge and made the world aware that sonography is an important and developing tool for staging neck disease.

Advances in the use of metabolic imaging for staging head and neck cancer have appeared in the journal in recent years. Mukherji and colleagues discussed the role of FDG-SPECT and thallium-201 SPECT for imaging squamous carcinoma of the head and neck, the pretreatment predictive value of CT in determining local control of T2 glottic carcinomas treated with radiation therapy alone (14), and the use of proton MR spectroscopy for imaging squamous cell carcinoma of the upper aerodigestive tract (15). Fischbein and colleagues (16) described the clinical utility of positron-emission tomography for detecting residual and recurrent squamous cell carcinoma, a subject also discussed by Goodwin et al (17).

Temporal Bone and Hearing Loss

The use of high-resolution CT scanning revolutionized the field of otology, allowing the assessment of one of the smallest organs in the body. Neuroradiology has been at the center of this investigation for many years. Initial investigations by Valvassori using polytomography laid a foundation for further work once the CT revolution occurred. In 1982, the *AJNR* published an investigation by Turski et al (18) demonstrating the utility of reformatted images of the temporal bone, which set the groundwork for later work using helical CT scanning. Valavanis (19) reported on the utility of high-resolution CT for investigating paragangliomas of the temporal bone. Other technical studies improving the use of CT for imaging the temporal bone region conducted by Chakeres (20), Virapongse (21), and Lee (22) also appeared in the *AJNR*. Luker (23) wrote the first article regarding helical CT scanning of the temporal bone, which appeared in the *AJNR* in 1993 (23), emphasizing its use in unsedated pediatric patients. Swartz (24) demonstrated the retrocochlear auditory pathway, enlightening the *AJNR* audience to the intracranial pathways of hearing.

With the introduction of MR imaging in the early and mid-1980s, it wasn't long before MR imaging was applied to the skull base and evaluation of hearing loss. The first article in the *AJNR* describing the use of MR imaging for the evaluation of the skull base was by Daniels (25), who described the MR appearance of the jugular foramen. Although many articles followed, in the *AJNR*, Allen (26) first reported on the use of low-cost high-resolution fast spin-echo imaging for the detection of acoustic schwannoma. Dahlen (27) carried this work forward, describing the utility of overlapping thin-section fast spin-echo MR imaging for the evaluation of the large vestibular aqueduct syndrome. Weissman (28) reviewed the radiology of otalgia and demonstrated the evolving MR appearance of structures in the internal auditory canal after removal of acoustic neuroma. Curtin (29) also contributed an important investigation regarding the use of contrast enhancement versus high-resolution MR imaging for the detection of acoustic neuroma, a subject that is still controversial.

Enhancement of the facial nerve was first described by Daniels (30) and was further expanded by Tien in his landmark studies on the MR appearance of Bell's Palsy (10) and the appearance of herpes trigeminal neuritis on contrast-enhanced MR images (31).

MR imaging has also impacted the evaluation of vascular disorders of the head and neck. Dietz et al (32) described the MR imaging and MR angiography depictions of pulsatile tinnitus. Weissman (33) demonstrated that high signal from the otic labyrinth on unenhanced MR images may be seen among patients with acute labyrinthitis. This study complemented the work of Mark et al (34), which first correlated the segmental enhancement of the cochlea on contrast-enhanced MR images with the frequency of hearing loss.

Sinonasal Disease

CT and MR imaging also revolutionized the workup of sinonasal disease. With the advent of functional endoscopic sinus surgery in the early 1990s, coronal sinus CT screening became an important and frequently applied imaging technique prior to surgery. Babbel et al (35) clarified the role of CT for depicting the recurring patterns of inflammatory sinonasal disease. The use of MR imaging for detecting sinonasal disease and separating neoplasms from sinus obstruction became an important advantage of MR imaging. Som (36) described the characteristic marginal tumor cysts surrounding sinonasal esthesioneuroblastomas that had spread intracranially.

The Future of Head and Neck Imaging

Where does imaging of the head and neck go from here? It is hard to imagine further anatomic advances, although the continued improvement of dedicated head and neck surface coils, higher field strength, and more selective contrast agents may indeed assist us in the future to detect lesions at an earlier point in time. No doubt, the advances made in MR imaging and spectroscopy, PET, and SPECT will improve our ability to detect recurrent cancer earlier. The fusion of these different imaging technologies is a challenge that is being addressed by many manufacturers. Advanced 3D workstations and new imaging systems combining CT and PET or CT and SPECT are a reality today. It is not farfetched to imagine an MR scanner integrated with some metabolic imaging device such as PET or SPECT in which both high-resolution anatomic images as well as metabolic profiles of this anatomy are rendered.

The integration of imaging technology into the therapeutic arena is also a reality today and will only improve with time. Neuronavigation using preoperative imaging has improved the surgeon's ability to find and resect smaller lesions in the brain. The same technology is applied to sinonasal and skull base surgery. Intraoperative imaging with MR imaging, CT, and sonography will increase. Through the use of image guidance systems, we will see further integration of imaging technology, not only in the operating room but also in the radiation therapy department. The fusion of CT and MR imaging and the integration of these into the treatment-planning environment will surely improve the precision of radiation therapy treatment, which is long overdue. We are now entering an era when these advanced technologies will be combined in a cohesive way to treat a patient. No longer will it be acceptable to have many different examinations performed on a patient without the integration of this information into a data set that is easily manipulated by the treating physician, the radiation oncologist, or the neuroradiologist.

The molecular biological profile of patients may be used in the future to stratify individuals into risk categories. Imaging may then be used in a screening mode for those at high risk of disease, provided that early detection is accompanied by treatment options.

These advances will certainly keep us in business over the next 5 to 10 years. After that, who knows? In the field of head and neck imaging, higher resolution imaging, metabolic information, and the leverage that faster and more powerful computing will bring certainly will make for a bright future for our field.

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References

1. Ballantyne A. **Routes of spread.**In: Fletcher GH, McComb WS, eds. *Radiation Therapy in the Management of Cancers of the Oral Cavity and Oral Pharynx.*Springfield: Charles C Thomas; 1962
2. Lederman M. ***Cancer of the Nasopharynx: Its Natural History and Treatment.***Springfield: Charles C. Thomas; 1961
3. Fletcher GH, McComb WS. ***Radiation Therapy in the Management of Cancers of the Oral Cavity and Oral Pharynx.***Springfield: Charles C. Thomas; 1962
4. Schuknecht HF. ***Pathology of the Ear.***Philadelphia: Lea and Febeger; 1993
5. Gatenby RA, Mulhern CB, Jr., Strawitz J, Moldofsky PJ. **Comparison of clinical and computed tomographic staging of head and neck tumors.** *AJNR American Journal of Neuroradiology* 1985;6:399–401
6. Zoarski GH, Lufkin RB, Bradley WG, Jr., et al.**Multicenter trial of gadoteridol, a nonionic gadolinium chelate, in patients with suspected head and neck pathology.** *AJNR. American Journal of Neuroradiology* 1993;14:955–961
7. Sakai F, Sone S, Kiyono K, et al.**MR evaluation of laryngohypopharyngeal cancer: value of gadopentetate dimeglumine enhancement.** *AJNR. American Journal of Neuroradiology* 1993;14:1059–1069
8. Escott EJ, Rao VM, Ko WD, Guitierrez JE. **Comparison of dynamic contrast-enhanced gradient-echo and spin-echo sequences in MR of head and neck neoplasms.** *AJNR. American Journal of Neuroradiology* 1997;18:1411–1419
9. Nemzek WR, Brodie HA, Chong BW, et al.**Imaging findings of the developing temporal bone in fetal specimens.** *AJNR. American Journal of Neuroradiology* 1996;17:1467–1477
10. Tien R, Dillon WP, Jackler RK. **Contrast-enhanced MR imaging of the facial nerve in 11 patients with Bell's palsy.** *AJNR. American Journal of Neuroradiology* 1990;11:735–741
11. Schmalfuss IM, Mancuso AA, Tart RP. **Arytenoid cartilage sclerosis: normal variations and clinical significance.** *AJNR. American Journal of Neuroradiology* 1998;19:719–722
12. van den Brekel MW, Castelijns JA, Snow GB. **The size of lymph nodes in the neck on sonograms as a radiologic criterion for metastasis: how reliable is it?** *AJNR. American Journal of Neuroradiology* 1998;19:695–700
13. Mukherji SK, Drane WE, Tart RP, Landau S, Mancuso AA. **Comparison of thallium-201 and F-18 FDG SPECT uptake in squamous cell carcinoma of the head and neck.** *AJNR. American Journal of Neuroradiology* 1994;15:1837–1842
14. Mukherji SK, Mancuso AA, Mendenhall W, Kotzur IM, Kubilis P. **Can pretreatment CT predict local control of T2 glottic carcinomas treated with radiation therapy alone?** *AJNR. American Journal of Neuroradiology* 1995;16:655–662
15. Mukherji SK, Schiro S, Castillo M, et al.**Proton MR spectroscopy of squamous cell carcinoma of the upper aerodigestive tract: in vitro characteristics.** *AJNR. American Journal of Neuroradiology* 1996;17:1485–1490
16. Fischbein NJ, OS AA, Caputo GR, et al.**Clinical utility of positron emission tomography with 18F-fluorodeoxyglucose in detecting residual/recurrent squamous cell carcinoma of the head and neck.** *AJNR. American Journal of Neuroradiology* 1998;19:1189–1196
17. Goodwin WJ. **PET and recurrent squamous cell carcinoma of the head and neck: a surgeon's view.** *AJNR. American Journal of Neuroradiology* 1998;19:–1197
18. Turski P, Norman D, DeGroot J, Capra R. **High-resolution CT of the petrous bone: direct vs. Reformatted images.** *AJNR. American Journal of Neuroradiology* 1982;3:391–394
19. Valavanis A, Schubiger O, Oguz M. **High-resolution CT investigation of nonchromaffin paragangliomas of the temporal bone.** *AJNR. American Journal of Neuroradiology* 1983;4:516–519
20. Chakeres DW. **Clinical significance of partial volume averaging of the temporal bone.** *AJNR. American Journal of Neuroradiology* 1984;5:297–302
21. Virapongse C, Sarwar M, Bhimani S, Sasaki C, Shapiro R. **Computed tomography of temporal bone pneumatization: 2. Petrosquamosal suture and septum.** *AJNR. American Journal of Neuroradiology* 1985;6:561–568
22. Lee BC, Black ML, Lamb RB, et al.**CT evaluation of the temporal bone ossicles by using oblique reformations: a technical note.** *AJNR. American Journal of Neuroradiology* 1989;10:431–433
23. Luker GD, Lee BC, Erickson KK. **Spiral CT of the temporal bone in unsedated pediatric patients.** *AJNR. American Journal of Neuroradiology* 1993;14:1145–1150
24. Swartz JD, Daniels DL, Harnsberger HR, Ulmer JL, Shaffer KA, Mark LP. **Hearing, II: the retrocochlear auditory pathway.** *AJNR. American Journal of Neuroradiology* 1996;17:1479–1481
25. Daniels DL, Schenck JF, Foster T, et al.**Magnetic resonance imaging of the jugular foramen.** *AJNR. American Journal of Neuroradiology* 1985;6:699–703
26. Allen RW, Harnsberger HR, Shelton C, et al.**Low-cost high-resolution fast spin-echo MR of acoustic schwannoma: an alter-**

native to enhanced conventional spin-echo MR? *AJNR. American Journal of Neuroradiology* 1996;17:1205–1210
27. Dahlen RT, Harnsberger HR, Gray SD, et al.**Overlapping thin-section fast spin-echo MR of the large vestibular aqueduct syndrome.** *AJNR. American Journal of Neuroradiology* 1997;18:67–75
28. Weissman JL. **A pain in the ear: the radiology of otalgia.** *AJNR. American Journal of Neuroradiology* 1997;18:1641–1651
29. Curtin HD. **Rule out eighth nerve tumor: contrast-enhanced T1-weighted or high-resolution T2-weighted MR?** *AJNR. American Journal of Neuroradiology* 1997;18:1834–1838
30. Daniels DL, Czervionke LF, Pojunas KW, et al.**Facial nerve enhancement in MR imaging.** *AJNR. American Journal of Neuroradiology* 1987;8:605–607
31. Tien RD, Dillon WP. **Herpes trigeminal neuritis and rhombencephalitis on Gd-DTPA-enhanced MR imaging.** *AJNR. American Journal of Neuroradiology* 1990;11:413–414
32. Dietz RR, Davis WL, Harnsberger HR, Jacobs JM, Blatter DD. **MR imaging and MR angiography in the evaluation of pulsatile tinnitus.** *AJNR. American Journal of Neuroradiology* 1994;15:879–889
33. Weissman JL, Curtin HD, Hirsch BE, Hirsch WL, Jr. **High signal from the otic labyrinth on unenhanced magnetic resonance imaging.** *AJNR. American Journal of Neuroradiology* 1992;13:1183–1187
34. Mark AS, Fitzgerald D. **Segmental enhancement of the cochlea on contrast-enhanced MR: correlation with the frequency of hearing loss and possible sign of perilymphatic fistula and autoimmune labyrinthitis.** *AJNR. American Journal of Neuroradiology* 1993;14:991–996
35. Babbel RW, Harnsberger HR, Sonkens J, Hunt S. **Recurring patterns of inflammatory sinonasal disease demonstrated on screening sinus CT.** *AJNR. American Journal of Neuroradiology* 1992;13:903–912
36. Som PM, Lidov M, Brandwein M, Catalano P, Biller HF. **Sinonasal esthesioneuroblastoma with intracranial extension: marginal tumor cysts as a diagnostic MR finding.** *AJNR. American Journal of Neuroradiology* 1994;15:1259–1262