


Facial Nerve Venous Malformation: A Radiologic and Histopathologic Review of 11 Cases

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Objective: The purpose of this article was to provide a combined pathologic and radiologic review of previously pathologically diagnosed facial nerve “hemangiomas” to confirm that these lesions are most characteristic of venous malformations rather than neoplasms.

Study Design: Retrospective radiologic, clinical, and histopathologic review of all patients with a previously pathologically diagnosed facial nerve hemangioma of the temporal bone who underwent computed tomography or magnetic resonance imaging (MRI) were included. A consensus radiologic review for characteristic features and pathologic analysis was performed.

Materials and Methods: A panel of 4 neuroradiologists retrospectively analyzed CT and MRI exams for 11 facial nerve hemangiomas and provided a consensus agreement on the characteristic imaging features. Concurrently, two neuropathologists reevaluated archived tissue specimens from these lesions and applied additional immunohistochemical and histochemical stains including D240, CD31, smooth muscle actin (SMA), Verhoeff Van Gieson (VVG) and glucose transporter 1 (GLUT1).

Results: Lesions were composed of dilated vascular spaces with a simple, CD31-positive endothelial lining and a smooth muscle component. All lesions were negative for markers found in arterial and lymphatic malformations and infantile hemangiomas. They had characteristic radiologic features previously ascribed to facial nerve hemangiomas. Namely, these lesions are typically T1 isointense or hypointense and T2 hyperintense relative to cerebral cortex and heterogeneously enhance on MRI. Bony canal expansion and erosion, intralesional calcification, and intracranial extension are common.

Conclusions: On the basis of this radiologic and pathologic review, these lesions are best characterized as venous malformations.

Key Words: Facial nerve, geniculate hemangioma, temporal bone, venous malformation.

Level of Evidence: 4

INTRODUCTION

Facial nerve venous malformations (FNVMs) are rare, slow-growing, and benign vascular lesions of the petrous bone that arise from perineural capillary networks. They may involve any segment of the facial nerve, but the most common location is the geniculate ganglion (GG),^{1,2} followed by the internal auditory canal (IAC) and second genu of the intratemporal facial nerve.

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Conflict of interest: None.

Financial Disclosures: The authors have no relevant financial relationships to disclose.

IRB Information: Title, Hemangioma versus venous malformation of the facial nerve with pathologic correlation; Protocol number, PR15-004632-01; Principal Investigator, Christopher P. Wood, MD.

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DOI: 10.1002/liv.2.267

This distribution corresponds to the density of the respective capillary plexi at each location.³ FNVMs account for less than 1% of temporal bone lesions,⁴ and, thus, their pathogenesis is not well characterized. Lesion resection, often with sacrifice of the involved facial nerve segment, is usually necessary because of their infiltrative nature.⁵

Early studies describing the computed tomographic (CT) appearance of intratemporal FNVMs (previously described as hemangiomas) reported that the majority of these lesions have irregular, ill-defined margins with intralesional bone spicules characterized as a honeycomb pattern.⁶ A more recent review depicted these calcifications as “point”-like or “needle”-like.⁷ Expansion of the facial canal has also been described. On magnetic resonance imaging (MRI), FNVMs have been described as T1 isointense or hypointense, T2 hyperintense (sometimes heterogeneously) relative to cerebral cortex, and avidly enhancing.^{7–11} Foci of nonenhancement are often seen, likely corresponding to calcifications.

The pathologic diagnosis of hemangioma or benign vascular tumor was historically given for these lesions on the basis of hematoxylin-eosin stains showing dilated vascular spaces lined with endothelium. This original description preceded the regular use of immunohistochemical stains, which typically previously had not been used to arrive at this diagnosis. There has been an effort in recent years to better

categorize these lesions histopathologically as venous malformations by re-evaluating their pathologic characteristics. In a cohort analysis from 2010, Benoit et al¹² re-examined the pathologic specimens of seven patients previously identified as having facial nerve hemangioma to clarify whether these lesions were true vascular tumors. Histologically, they noted that the endothelial cells were mitotically quiescent with no internal elastic lamina, findings that are more typical for a vascular malformation. Prompted by previous studies reporting specificity of certain immunohistochemical markers for infantile hemangiomas and lymphatic malformations,^{13–15} Benoit et al¹² tested their own specimens for these markers. Podoplanin (D2-40), which is specific for lymphatic endothelial cells, and glucose transporter 1 (GLUT1) and Lewis Y antigen, which are found in infantile hemangioma endothelial cells, were all negative in 6 of the 7 specimens.

Despite this recent awareness, these lesions are still widely referred to as hemangiomas or vascular tumors in the literature. In an effort to correlate the updated pathologic description of these lesions with previously described imaging characteristics, we conducted our own review of 11 patients with a previous pathologic diagnosis of facial nerve hemangioma. Histologic and immunohistochemical characteristics

were reviewed to confirm that our specimens should be designated as vascular malformations rather than vascular tumors. Imaging characteristics of these lesions were then reviewed to determine their consistency with the previously reported imaging term of *facial nerve hemangioma*. We present a combined pathologic and radiologic review of FNVMs.

MATERIALS AND METHODS

After institutional review board approval was obtained, the radiology database of a large tertiary academic health care system was queried from January 1, 1990, through December 31, 2014, to identify radiologic or pathologic reports containing the words *facial nerve hemangioma* relative to the GG or IAC. All patients with a previous pathologically diagnosed facial nerve hemangioma in the region of the GG or IAC who underwent CT or MRI were reviewed. A two-part analysis of these cases was performed to rereview both the imaging features and the histopathologic characteristics.

For the imaging evaluation, a panel of four neuroradiologists that included three staff neuroradiologists with a cumulative total of 64 years of experience and one neuroradiology fellow jointly reviewed CT and MRI results for all patients and provided a final consensus agreement on imaging features. Specifically, the panel evaluated available CTs for the presence or absence of stippled calcification, bony canal expansion (involving any part of the facial

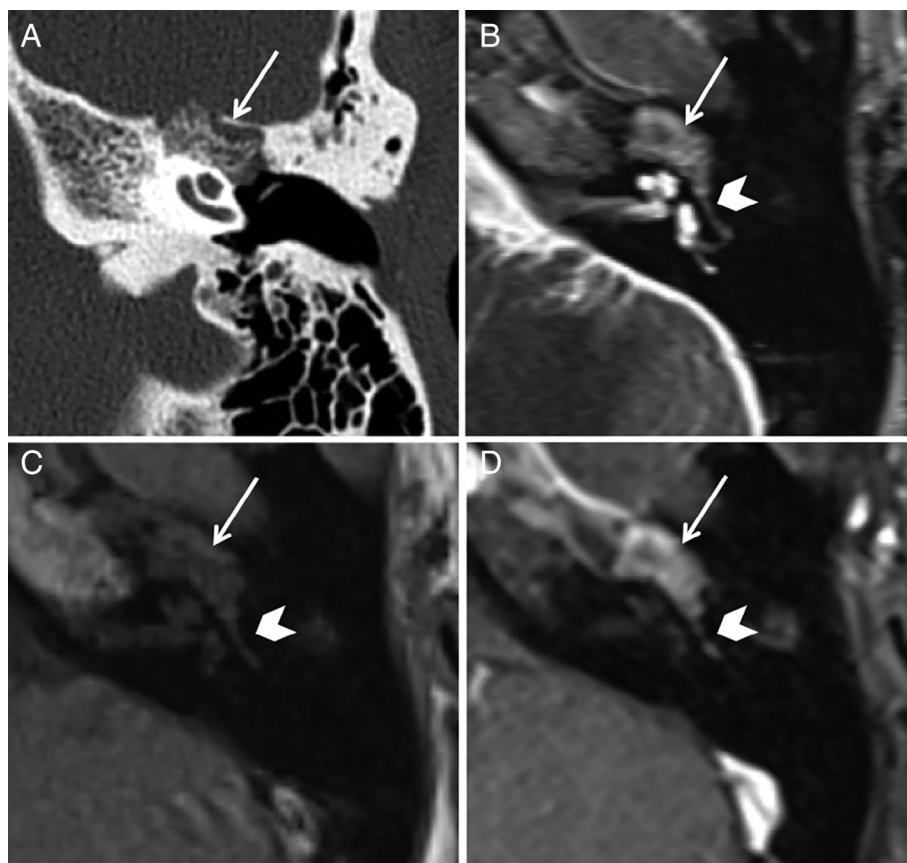


Fig. 1. Left facial nerve venous malformation. A 35-year-old woman presented in 2012 with decreased left facial function. (A) Axial high-resolution computed tomography shows a lesion centered at the left geniculate ganglion with irregular borders (arrow). Within the lesion, there are small spicules of calcification creating a “honeycomb” pattern; some of these have a pointed configuration. The facial canal is enlarged and there is bony erosion anteriorly where the lesion extends slightly beyond the temporal bone margin. The cochlea is intact. (B–D) Axial fast-spin echo T2-weighted (FSE-T2W), precontrast T1W, and postcontrast T1W images demonstrate the lesion is predominately T2 hyperintense, T1 isointense, and heterogeneously enhancing (arrows). Punctate foci of hypointense signal in all of these images correspond to intralesional calcifications. There is clear extension of the lesion along the tympanic segment of the facial canal (arrowheads).

canal), and bony erosion or thinning. MRIs were evaluated for the presence or absence of postgadolinium enhancement and T1 isointensity or hypointensity and T2 hyperintensity relative to cerebral cortex. The T2 signal on all examinations was determined from the T2 fast-spin echo sequences. Postcontrast enhancement on MRI was further characterized as being homogeneous or heterogeneous; if heterogeneous, it was graded as having less than 50% or 50% or more overall enhancement. Lesions centered at the GG were further characterized for any extension into the labyrinthine (fallopian) canal, tympanic canal, IAC, or middle ear cavity. Intracranial involvement was defined as extension of the lesion beyond the temporal bone margin, usually anteriorly or superiorly, and any growth along the greater superficial petrosal nerve was recorded. Lesions centered within the IAC were reviewed for canal expansion and extension into the porus acusticus.

A separate histopathologic analysis was performed by a neuropathologist and neuropathology fellow. In addition to reviewing initial diagnostic slides, additional immunohistochemical and histochemical evaluations were performed on archived tissue blocks to help differentiate the lesions as either hemangioma or venous or other benign vascular malformations. These included markers specific for lymphatic endothelium (D2-40), endothelial cells (CD31), vascular smooth muscle found in various vascular lesions, normal tunica media (smooth muscle actin), internal elastic lamina found in vascular lesions with an arterial component (Verhoeff-van Gieson), and GLUT1, a relatively sensitive but not specific marker of infantile (juvenile) hemangiomas.

RESULTS

On original histopathologic review, 11 patients (6 women; median age, 39 years; age range, 18–59 years) had an initial diagnosis of facial nerve hemangiomas. Seven lesions were centered on the GG, and four lesions were within the IAC. All but one patient (91%) had preoperative MRIs available, and these dated from November 8, 2005, through January 13, 2014. Of the seven patients with GG lesions, six (86%) had a preoperative CT, and one of the four patients with an IAC-centered lesion (25%) had an initial CT. One CT was obtained on January 26, 2000, and the remaining cases were from January 26, 2009, through April 25, 2014. The interval between the CT and MRI examinations ranged from the same day to more than 2 years.

Of the seven lesions centered on the GG, all extended into the labyrinthine canal. Additionally, one extended into the IAC fundus, three (43%) extended into the tympanic segment, and two (29%) extended into the middle ear cavity (one had subtle extension and one had a substantial component partially surrounding the ossicular chain). Five (71%) of the seven GG lesions had grown beyond the margins of the temporal bone intracranially, and one extended for some length along the greater superficial petrosal nerve. Of the four IAC lesions, three were confined to the IAC fundus and one extended through the porus acusticus.

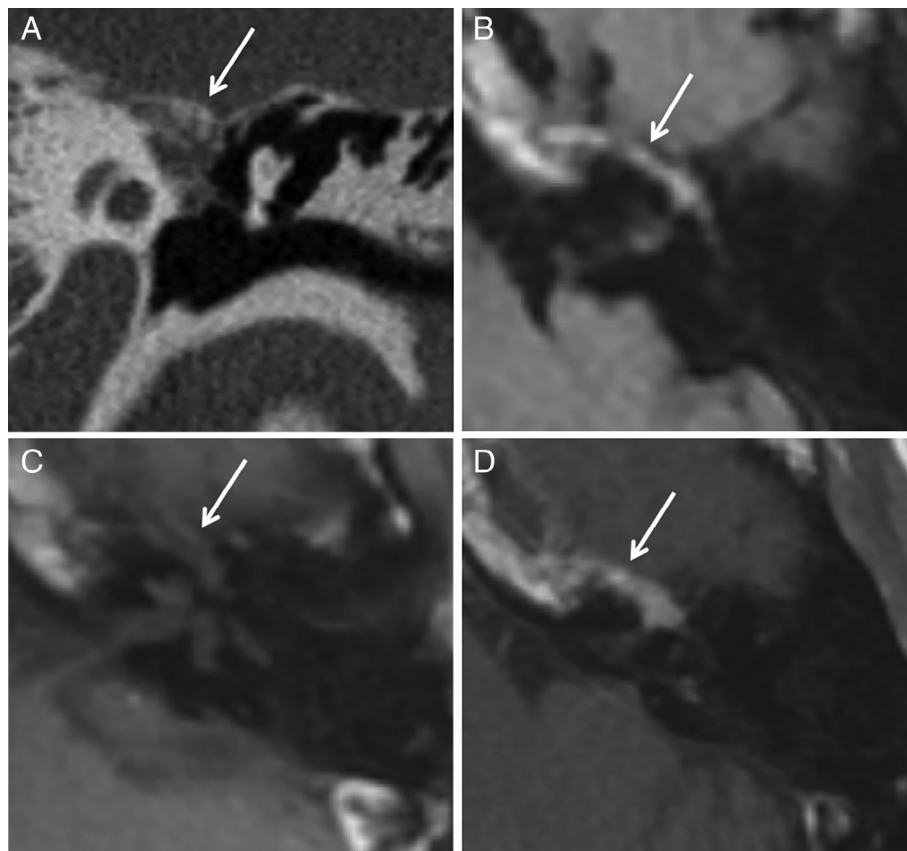


Fig. 2. Left facial nerve venous malformation. A 41-year-old man presented in 2011 with 1 year of left facial palsy and asymmetry. (A) Axial high-resolution computed tomography shows a lesion situated within an enlarged left geniculate ganglion with irregular borders and intralesional calcifications (arrow). This extends partly along the labyrinthine segment and anteriorly along the greater superficial petrosal nerve. The cochlea is intact. (B–D) Axial T2 FLAIR, precontrast T1W, and postcontrast T1W images demonstrate the lesion is predominately T2 hyperintense, T1 isointense, and homogeneously enhancing (arrows). The T2 FLAIR and postcontrast images (B, D) best demonstrate extensive involvement of the greater superficial petrosal nerve.

All patients in our series with lesions centered on the GG had progressive ipsilateral facial nerve paresis. Two of these patients reported intermittent hemifacial spasm, and two reported pulsatile tinnitus. A patient with a large component in the middle ear cavity experienced slowly progressive hearing loss. All four patients with lesions in the IAC had profound ipsilateral sensorineural hearing loss, reported in three as being rapidly progressive.

All six lesions centered on the GG for which CTs were available had bony canal widening and bony erosion or thinning. One small lesion at the GG lacked appreciable intralesional calcification; all of the five remaining cases had a characteristic honeycomb appearance on CT. The single IAC case that had preoperative CT imaging had intralesional calcification, bony canal widening, and bony erosion. Of the 10 lesions evaluated with MRI, all had avid postgadolinium enhancement; in nine of the cases, this was heterogeneous (seven with $\geq 50\%$ enhancement and two with $< 50\%$ enhancement). On MRI, lesions predominantly appeared T1 isointense relative to cerebral cortex, and one lesion at the GG was relatively T1 hypointense. Nine of the 10 lesions were T2 hyperintense and one lesion was T2 isointense relative to cerebral cortex. The median maximum tumor diameter was 8.7 mm (range: 3–12 mm). CT and MRI results for select cases are shown in Figures 1–3.

Rereview and additional immunohistochemical evaluation found similar findings in all 11 cases. Specimens from both the GG and the IAC were confirmed as benign vascular lesions composed of dilated vascular spaces with a simple, CD31-positive endothelial lining and a smooth muscle component of varying thickness. All lesions were negative for Verhoeff-van Gieson, D2-40, and GLUT1 (Figure 4). On the basis of this pathologic rereview, these lesions are best characterized as venous malformations.

DISCUSSION

The peak incidence of FNVMs has been reported to occur between 30 and 60 years of age, with a slight female predilection, as we found in our study population. The most common site in our series was the GG, and lesions were found in the IAC relatively less frequently. This finding is in keeping with that of previous studies and presumably is reflective of a greater density of capillary plexi in the GG. The size ranged from 3 to 12 mm (mean: 8.7 mm), also consistent with that reported in the literature.

Nearly all reported FNVMs centered on the GG present with progressive ipsilateral facial paralysis; sudden facial paralysis and spasm have also been reported.⁵ In a review of 17 patients with GG tumors by Lahlou et al,¹ severe facial palsy was present in 70% of those with FNVMs and in none

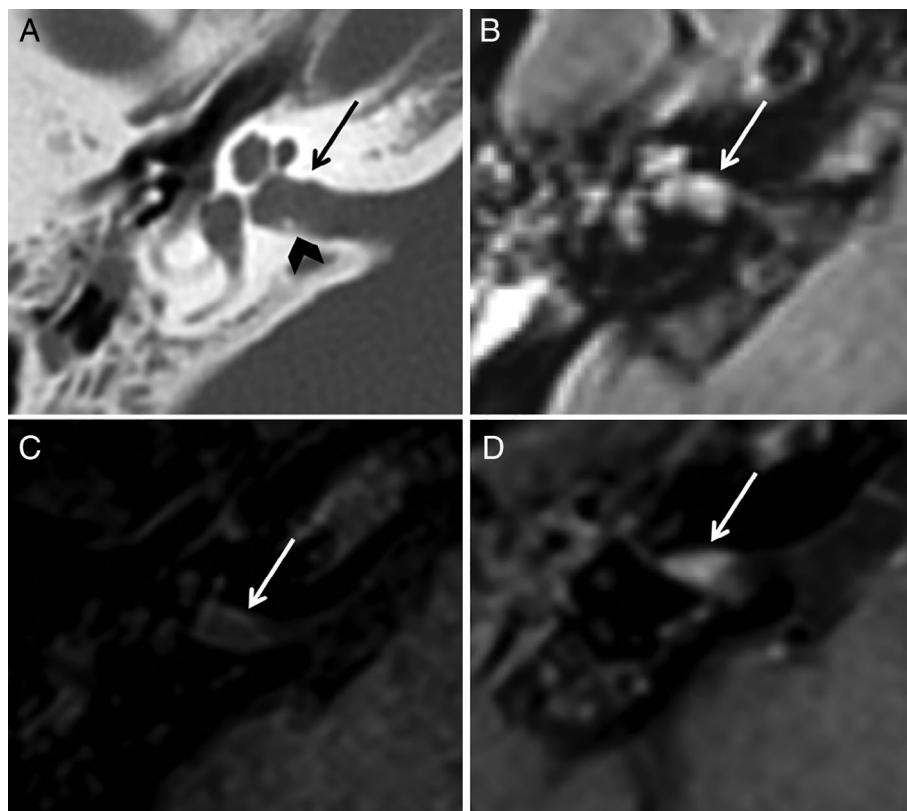


Fig. 3. Right facial nerve venous malformation. A 40-year-old woman presented in 2007 with sudden onset right-sided hearing loss. A magnetic resonance imaging showed an enhancing lesion in the right internal auditory canal (IAC) initially presumed to represent a vestibular schwannoma. (A) Axial high-resolution computed tomography shows expansion of the right IAC fundus (black arrow). The underlying lesion is not well seen on the bone kernel image but a spicule of calcification is noted along the posterior wall (arrowhead). (B–D) Axial T2 FLAIR, precontrast T1W, and postcontrast T1W images demonstrate the lesion is predominately T2 hyperintense, T1 isointense, and mildly heterogeneously enhancing (white arrows). The lesion does not extend to porus acusticus. This was ultimately resected and given a diagnosis of facial nerve hemangioma.

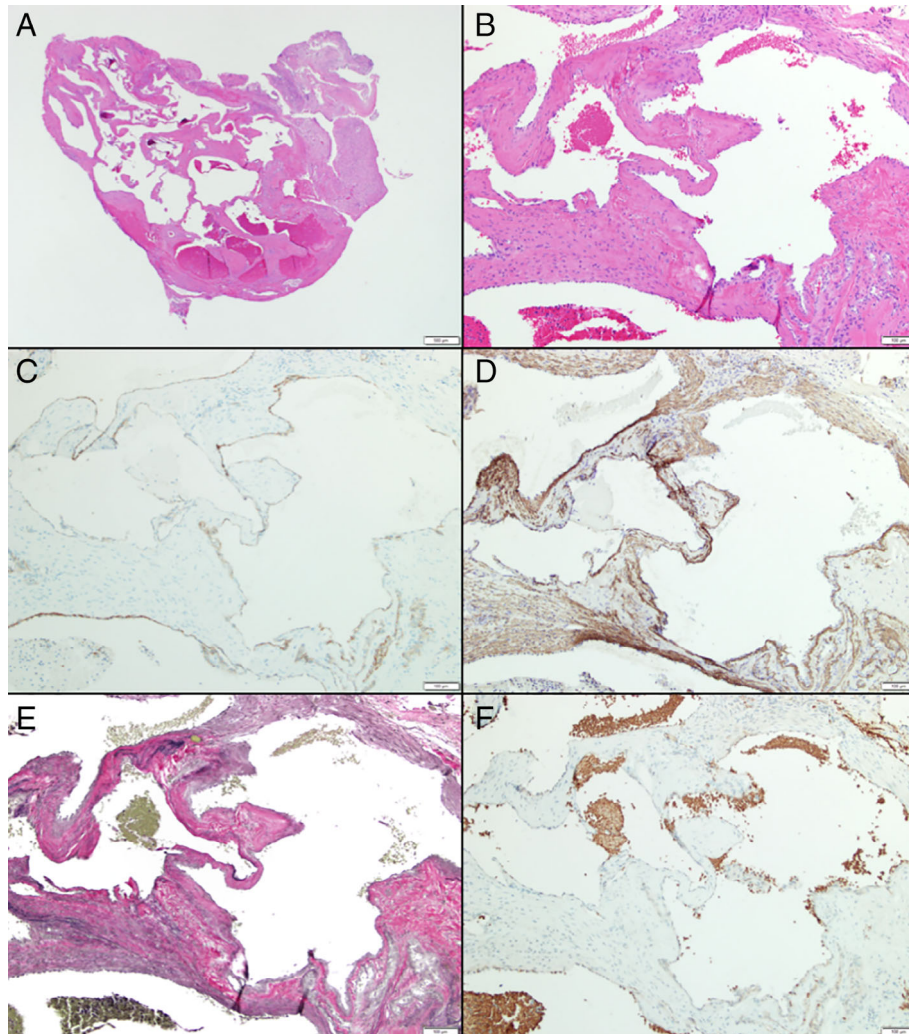


Fig. 4. A 52-year-old man presented with recurrent episodes of left facial weakness. He was found to have a lesion involving the left facial nerve canal geniculate ganglion and tympanic segment which was ultimately resected. (A, B) H&E sections of the lesion show dilated vascular spaces whose vascular walls vary in thickness. (C–F) CD31 (C), smooth muscle actin (SMA) (D), Verhoeff-van Gieson (VVG) (E), and glucose transporter 1 (GLUT1) (F) stains. These stains demonstrate an endothelium that is positive for CD31 overlying a smooth muscle layer of variable thickness highlighted by SMA and lacking an internal elastic lamina on the VVG stain. GLUT1 is negative within the endothelial cells; however, it highlights red blood cells and the D240 stain (not shown) is negative. Overall, the staining profile in conjunction with the morphology is more compatible with a venous malformation rather than an arterial or lymphatic lesion.

of those with schwannomas. Postulated explanations for associated symptoms have included neural compression, invasion, or vascular steal causing ischemia.¹ Patients with lesions causing associated cochlear or ossicular chain erosion may also present with hearing loss.^{2,16} When these lesions occur in the IAC, the predominant symptom is unilateral sensorineural hearing loss, similar to the symptoms in vestibular schwannomas. When they occur at the GG or IAC, FNVMs are typically smaller but more symptomatic^{1,2,17} than schwannomas or meningiomas.

The previously established characteristic CT features of facial “hemangioma” of intralesional calcifications, canal expansion, and bony erosion or thinning were present in 6 of the 7 cases for which CT results were available. The single exception was 1 small (4 mm) lesion, which did not have convincing evidence of calcification. Notably, this apparently non-calcified lesion was evaluated in 2000 with an early CT platform, which may not have been as sensitive as the latest-

generation CT scanners. The six examinations that showed visible calcification were performed from 2009 through 2014. Intralesional calcification, or the honeycomb appearance, has been reported in only 50% of FNVMs¹⁸; however, this estimated percentage is from early CT literature predating the latest-generation CT scanners. We found intralesional calcification in 86% of FNVMs, similar to the 82.3% recently reported by Yue et al.⁷ Because calcification can be subtle, this increased detection may be related to improved resolution of newer-generation CT scanners.

The honeycomb pattern may be a result of residual bone trabeculae after invasion by vascular tissue or reactive bone formation between the vascular channels; this pattern has led to the term *ossifying hemangioma*.^{4,6,17,19} When identified, the osseous spicules can be helpful for differentiating from schwannoma, which typically has smooth, scalloped margins and no intralesional calcification. In fact, the presence of calcifications effectively excludes schwannoma

as a possibility. Facial canal expansion is relatively less specific for FNVM because other lesions such as schwannomas can produce this same feature.

On MRI, 9 of 10 FNVMs were T1 hypointense or isointense relative to cerebral cortex. Nine of the 10 lesions were T2 hyperintense, and one lesion in the IAC was relatively T2 isointense. T2 hyperintensity in larger FNVMs may be a differentiating factor from schwannomas, which tend to be relatively more T2 hypointense; however, given the small average size, this may not be a reliable distinguishing feature. On T1-weighted sequences after intravenous administration of gadolinium, all lesions showed avid enhancement, and 9 of the 10 were heterogeneously enhancing. Yue et al⁷ also reported a high incidence of heterogeneous enhancement (76%). The locations and growth patterns of FNVMs in this series are also consistent with those of prior reports of facial nerve "hemangioma."¹²

The recent 2018 classification of vascular anomalies by the International Society for the Study of Vascular Anomalies describes several types of simple venous malformations, although approximately 94% are the common variety, which tend to be isolated and sporadic.^{20,21} Whether venous malformations are unifocal or multifocal, sporadic or familial, they are distinguished by enlarged venous channels with a single flattened layer of endothelial cells surrounded by sparse smooth muscle cells.²² The pathologic specimens in this study were similar to those initially described by Mulliken and Glowacki²³ as characteristic of venous malformations and previously described by Benoit et al,¹² namely, lesions with flattened endothelial cells with no appreciable mitotic figures and absent internal elastic lamina. We additionally noted a smooth muscle component in all 11 lesions; however, the smooth muscle components could not be compared with the specimens in the study by Benoit et al¹² because the two studies did not use the same markers. Additionally, pathologic confirmation is challenging because these lesions and associated specimens are small, often with extensive cautery artifact in the specimen, a feature rendering further challenge to pathologic assessment. Furthermore, differentiating venous malformation from a vascular neoplasm requires specialized expertise, particularly for intracranial locations, in which vascular lesions have been reported to have a different GLUT1-staining profile.²⁴ Despite this, these lesions would best fit into the category of venous malformation on the basis of previous histologic descriptions and the current classification of the International Society for the Study of Vascular Anomalies.^{12,24,25}

The review has several limitations. Because of the rarity of these lesions, this study presents a small number of cases. CT and MRI findings were analyzed by group consensus rather than by blinded individual reviewers. This strategy may lend itself to group bias and does not allow for measurement of interobserver agreement. Because the Lewis Y antigen was not available for use in our pathologic analysis, direct comparison with the study by Benoit et al¹² was not possible. However, both GLUT1 and Lewis Y antigen are placenta-associated vascular antigens that are negative in vascular malformations and positive in hemangiomas.¹³ We considered the use of GLUT1 in conjunction with the additional supportive pathologic markers to be adequate for diagnosis.

This review confirms the GG as the most common location for this lesion, followed by the IAC. Bony canal expansion and erosion, intralesional calcification, and intracranial extension are common. These lesions are typically T1 isointense or hypointense and T2 hyperintense relative to cerebral cortex and heterogeneously enhance on MRI. On the basis of histologic and immunohistochemical findings, these lesions are favored to be a venous malformation rather than a vascular neoplasm, in support of the proposed reclassification of this entity by Benoit et al.¹² Correlating clinical, radiologic, and histopathologic findings is thus important for reaching the most appropriate diagnosis of this rare lesion.

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