AJNR

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AJNR Am J Neuroradiol published online 22 November 2024
http://www.ajnr.org/content/early/2025/05/15/ajnr.A8592

Published May 15, 2025 as 10.3174/ajnr.A8592

ORIGINAL RESEARCH
HEAD AND NECK IMAGING

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ABSTRACT

BACKGROUND AND PURPOSE: Enhancement of the facial nerve can be seen on MRI due to its rich arteriovenous plexus. Classically, enhancement of the facial nerve beyond the geniculate ganglion has been described as a normal finding, while enhancement of the canalicular and labyrinthine segments is considered abnormal. We hypothesize facial nerve enhancement of the canalicular and labyrinthine segments is a normal finding on the postcontrast T1-weighted, fat-saturated volumetric interpolated breath-hold examination (VIBE) sequence on both 1.5T and 3T MRI scanners.

MATERIALS AND METHODS: Fifty patients without facial nerve symptoms undergoing MRI by using the internal auditory canal protocol were identified at our institution, 25 cases on a 1.5T scanner and 25 cases on a 3T scanner; a total of 100 facial nerves. Presence or absence of enhancement of the facial nerve segments on the postcontrast T1-weighted, fat-saturated VIBE sequence were independently analyzed by 2 neuroradiologists.

RESULTS: On 1.5T, of 50 facial nerves evaluated, percentage of nerves with enhancement at each segment was as follows: 80% canalicular, 92% labyrinthine, 100% tympanic, 100% mastoid, and 80% intraparotid. On 3T, of 50 facial nerves evaluated, percentage of nerves with enhancement at each segment was as follows: 60% canalicular, 84% labyrinthine, 98% tympanic, 100% mastoid, and 93% intraparotid.

CONCLUSIONS: Enhancement of the canalicular and labyrinthine segments of the facial nerve is a normal finding on the postcontrast, T1-weighted, fat-saturated VIBE sequence. Careful attention to clinical history and asymmetry should be considered before calling abnormality of the facial nerve.

ABBREVIATIONS: IAC = internal auditory canal; SPACE = Sampling Perfection with Application optimized Contrast by using different flip-angle Evolution; VIBE = volumetric interpolated breath-hold examination

The facial nerve, cranial nerve VII, is responsible for both motor and sensory innervation of the face, including facial expression, taste, parasympathetic, and somatosensory activity. This nerve can be divided into 3 broad segments; the intracranial segment originating in the brainstem, the intratemporal segment traversing the temporal bone, and the extracranial segment as the nerve exits the stylomastoid foramen and into the parotid gland.[1] The intratemporal segment can be further divided into 4 segments; canalicular segment within the internal auditory canal (IAC), labyrinthine segment from the IAC to the geniculate ganglion, tympanic segment from the geniculate ganglion to the pyramidal eminence, and the mastoid segment from the pyramidal eminence to the stylomastoid foramen.[2]

Received September 10, 2024; accepted after revision November 16.

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Indicates article with supplemental data.

http://dx.doi.org/10.3174/ajnr.A8592

The facial nerve is encased in a rich arteriovenous plexus, and as a result, venous pooling, or extravasation of intravenous contrast within this plexus results in apparent enhancement of the nerve on MRI. As such, nerve enhancement may be seen in normal or pathologic conditions. Classically, enhancement peripheral to the anterior geniculate ganglion is considered normal whereas enhancement proximal to the anterior geniculate ganglion is abnormal.[3] As technology and MRI sequences evolve, patterns of enhancement can change, and it is important to be familiar with these patterns so as not to mistake normal as pathology. Based on our anecdotal experience, we hypothesized facial nerve enhancement of the canalicular and labyrinthine segments is a normal finding on the T1-weighted postcontrast, fat-saturated volumetric interpolated breath-hold examination (VIBE; Siemens) sequence on both 1.5T and 3T MRI scanners.

MATERIALS AND METHODS

Patient Selection

Institutional review board approval was obtained, and methodology proposed on the Strengthening the Reporting of Observational

SUMMARY

PREVIOUS LITERATURE: Several studies have compared various segments of the facial nerve on different gradient and spin-echo postcontrast MRI sequences, such as 3D inversion recovery-prepared fast spoiled gradient-echo (IR-FSPGR), T1-VISTA, and MPRAGE, on both 1.5T and 3T MRI scanners and found enhancement of the tympanic, mastoid, and parotid segments of the facial nerve is a normal finding. However, there is lack of literature describing facial nerve enhancement on the T1-weighted, fat-saturated VIBE sequence.

KEY FINDINGS: Intratemporal segments of the normal facial nerve enhance on the T1 postcontrast, fat-saturated VIBE sequence. Enhancement patterns within an individual MRI examination were highly symmetric.

KNOWLEDGE ADVANCEMENT: This study provides insight into normal facial nerve enhancement patterns and helps avoid misdiagnosis of normal as pathology. It also prompts further considerations such as evaluation of enhancement in patients with known facial nerve abnormality, in addition to evaluation of enhancement patterns of other cranial nerves.

Studies in Epidemiology checklist was followed. Illuminate InSight (Version 5.0, Softek Illuminate) was used to identify patients who had undergone MRI of the IAC from January 2024 to April 2024. A radiology resident extracted 50 consecutive patients with MRI report of normal facial nerves; 25 patients scanned on a 1.5T MRI scanner and 25 patients scanned on a 3T MRI scanner, for a total of 100 facial nerves. Inclusion criteria were adult patients older than 18 years of age with no reported facial nerve symptoms, and therefore, presumed normal facial nerves. Exclusion criteria included patients with facial nerve symptoms such as weakness, numbness or tingling, reported Bell palsy, presence of a mass in or near the IAC, and prior surgery or radiation of the IAC or parotid space. Scanner type and patient information were de-identified before review of cases.

Scanning Protocol. The standard IAC protocol at our institution includes the following MRI parameters for T1-weighted postgadolinium, fat-saturated VIBE sequences: TR/TE: 8.53/3.67 ms; flip angle: 9°; FOV: 17 cm; base resolution: 256; slice thickness: 0.7 mm; voxel dimensions: $0.7 \times 0.7 \times 0.7$ mm^3; phase resolution: 100%; bandwidth: 180 Hz/Px; averages: 1; acceleration mode: none; fat-water contrast: fast fat saturation. These parameters are the same on both 1.5T and 3T scanners. The following parameters differed between 1.5T and 3T: phase oversampling: 50% at 1.5T/10% at 3T; slice oversampling: 45.5% at 1.5T and 33.3% at 3T; slice resolution: 84% at 1.5T/100% at 3T. Scan times were 6:14 min at 1.5T and 5:21 min at 3T.

Qualitative and Statistical Analysis. Two neuroradiologists with Certificate of Added Qualification in neuroradiology, 1 with subspecialty expertise in head and neck imaging, evaluated all cases independently and were blinded to MRI magnet strength and patient history. Binary values for presence or absence of enhancement (no enhancement = 1, enhancement = 2) were assigned to each facial nerve segment. Precontrast T1-weighted Sampling Perfection with Application optimized Contrast by using different flip-angle Evolution (SPACE; Siemens) sequence was available for comparison. The segments evaluated were: canalicular, labyrinthine, tympanic, mastoid, and intraparotid, on the T1-weighted postcontrast, fat-saturated VIBE sequence as shown in Fig 1. The data were sorted by corresponding MRI scanners and tallied by a radiology resident. Any discrepancies were resolved by group discussion, as if reading cases together without knowledge of scanner type or patient history. Percentages of nerves with enhancement were calculated on both 1.5T and 3T MRI scanners. Enhancement pattern symmetry or lack thereof was noted for each case. A chi-square test was performed comparing enhancement of each of the segments of the facial nerve, as well as overall enhancement between 1.5T and 3T scanners. Analysis was verified by an in-house statistician and by using R Statistical Software (Version 4.2.2; R Foundation for Statistical Computing). All statistical tests were 2-sided and P values less than .05 were considered statistically significant.

RESULTS

Patient age ranged from 24 to 102 years, with mean and median age 64 and 67, respectively. Of the total, 35 were women and 15 were men. On 1.5T MRI, of 50 facial nerves evaluated, the following had enhancement: 40 canalicular, 46 labyrinthine, 50 tympanic, 50 mastoid, and 40 intraparotid. On 3T, of 50 facial nerves evaluated, the following had enhancement: 30 canalicular, 42 labyrinthine, 49 tympanic, 50 mastoid, and 46 intraparotid. Enhancement was present in all segments of the facial nerve ranging from 60%–100%, summarized in Fig 2.

Among the 25 patients scanned on 1.5T, 23 patients showed left-right symmetry in facial nerve enhancement. Of 25 patients scanned on 3T, 21 patients had left-right symmetry in facial nerve enhancement.

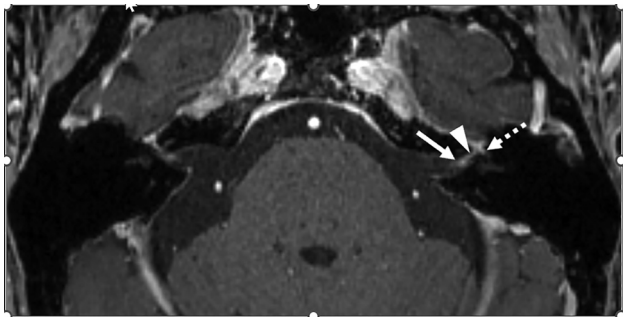

FIG 1. A 69-year-old man with vestibular symptoms and no facial nerve symptoms. Axial T1-weighted postcontrast, fat-saturated VIBE image demonstrates enhancement at the canalicular (*solid arrow*), labyrinthine (*arrowhead*), and tympanic (*dashed arrow*) segments of the facial nerve, bilaterally (annotated on the left).

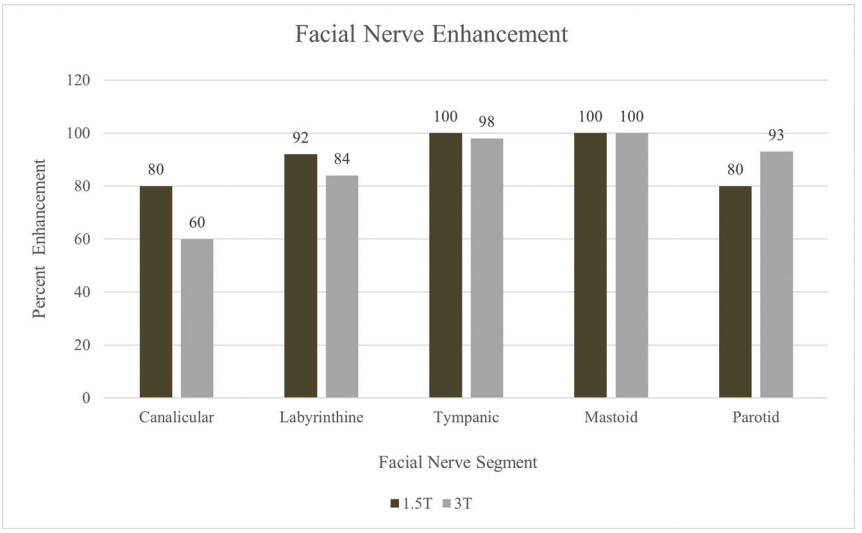

FIG 2. Percentage of nerves that enhanced at each segment on 1.5T versus 3T.

Table 1: Hypothesis test for association between enhancement/no enhancement and scanner 1.5T/3T

	1.5T (n = 50)	3T (n = 50)	Total (n = 100)	P Value
IAC				.029
Enhancement	40 (80.0%)	30 (60.0%)	70 (70.0%)	
No enhancement	10 (20.0%)	20 (40.0%)	30 (30.0%)	
Labyrinthine				.218
Enhancement	46 (92.0%)	42 (84.0%)	88 (88.0%)	
No enhancement	4 (8.0%)	8 (16.0%)	12 (12.0%)	
Tympanic				.315
Enhancement	50 (100.0%)	49 (98.0%)	99 (99.0%)	
No enhancement	0 (0.0%)	1 (2.0%)	1 (1.0%)	
Mastoid				N/A
Enhancement	50 (100.0%)	50 (100.0%)	100 (100.0%)	
No enhancement	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Parotid				.084
Enhancement	40 (80.0%)	46 (92.0%)	86 (86.0%)	
No enhancement	10 (20.0%)	4 (8.0%)	14 (14.0%)	

Note:—χ^2 test for categoric variables, P value $< .05$ indicates significant difference of enhancement between 1.5T versus 3T scanners based on each segment separately.
N/A = Not applicable.

Table 2: Hypothesis test for association between overall facial nerve enhancement and scanner 1.5T/3T

	1.5T (n = 226)	3T (n = 217)	P Value
Enhanced segment			.762
IAC	40 (17.7%)	30 (13.8%)	
Labyrinthine	46 (20.4%)	42 (19.4%)	
Tympanic	50 (22.1%)	49 (22.6%)	
Mastoid	50 (22.1%)	50 (23.0%)	
Parotid	40 (17.7%)	46 (21.2%)	

Note:—χ^2 test for combined categoric variables.

A χ^2 test was performed to evaluate if significant difference exists between enhancement on 1.5T and 3T scanners. IAC enhancement was significantly higher in the 1.5T group versus 3T group (80% versus 60%, $P = .029$). However, no significant difference in enhancement was observed in any of the other segments (Table 1). Similarly, there was no significant difference in overall enhancement of the facial nerve between the 2 different MRI scanners, 1.5T versus 3T (Table 2).

DISCUSSION

As new MRI sequences are developed, one must adapt to normal patterns of enhancement. Several studies have described normal patterns of facial nerve enhancement on conventional T1-weighted MRI sequences.[4-6] A study by Hong et al,[4] in 2010 studied 40 normal facial nerves, comparing the unenhanced and contrast-enhanced signal intensity on IR-FSPGR at 3T, and showed enhancement in all segments of the facial nerve to a variable extent. Similarly, Dehkharghani et al[5] analyzed 23 patients with normal facial nerves on both unenhanced and contrast-enhanced spin- and gradient-echo images. They concluded that several segments including cisternal, canalicular, labyrinthine, and geniculate segments, enhanced on gradient-echo images whereas mainly the labyrinthine segment enhanced significantly on the spin-echo images.[5] In 2021, Warne et al[6] performed a retrospective analysis of 3D T1-weighted fast spin-echo sequence of 64 patients without suspected facial nerve pathology and found significant enhancement of the canalicular, tympanic, and mastoid segments.

Some studies have compared enhancement patterns on various magnet strengths or different sequences.[7,8] For instance, in 2009, Burmeister et al[7] studied T1- and T2-weighted postcontrast images of 20 patients on both 1.5T and 3T magnets and found that images obtained on 3T had higher precision in identifying smaller branches of the facial nerve. Haneda et al[8] conducted a prospective study in 2019 to compare nonenhanced T1-weighted images of the facial nerve segments on 3T in spin-echo (T1-VISTA; Phillips Healthcare) with that in gradient-echo (T1-FFE) T1-sequences. The spin-echo sequences showed increased detection of continuity of the facial nerve throughout all segments in comparison with the gradient-echo sequences.[8]

VIBE is a specialized imaging technique that utilizes an interpolated T1-weighted spoiled gradient recalled-echo sequence. This method employs asymmetric sampling of the central portion of the selection-select axis of k-space (kz), while the remaining datapoints in kz are zero-filled. This approach enables rapid acquisition of isotropic or near isotropic 3D images with high contrast and high spatial resolution.[9] Compared with other 3D T1-weighted sequences, such as MPRAGE (Siemens) and SPACE (Siemens), VIBE outperforms MPRAGE in the detection of contrast-enhancing lesions and offers comparable performance with SPACE. These capabilities make VIBE particularly useful in clinical settings where quick and precise imaging is essential.[10]

Our data support the hypothesis that enhancement of the canalicular and labyrinthine segments of the facial nerve is a normal finding on the T1-weighted, postcontrast, fat-saturated VIBE sequence. This remains consistent with our knowledge of facial nerve anatomy, and enhancement resulting from contrast traversing the vascular bundle surrounding the entire facial nerve. We observed a higher number of patients with enhancement of the canalicular segment on a 1.5T MRI scanner compared with a 3T MRI scanner, which was statistically significant. This difference may have been attributed to reduced slice resolution and increased scan time at 1.5T resulting in mild partial volume averaging and blurring of the nerve with the closely adjacent dura within the IAC, thus being interpreted as facial nerve enhancement on the 1.5T scanner. The increased contrast-to-noise ratio, slightly higher resolution, and shorter acquisition time at 3T likely result in sharper contrast enhancement and reduced blurring, thus allowing for more accurate identification of the facial nerve, and ultimately accurate assessment of enhancement.[11] However, it is also possible that the observed statistical significance is due to the smaller sample size; a larger cohort with additional interpreters of various backgrounds may yield no statistically significant difference. In comparison, the labyrinthine segment is clearly identified due to its known location without adjacent dura; no statistically significant difference in enhancement was seen between 1.5T and 3T scanners of this segment.

Concordant with existing data, enhancement of tympanic and mastoid segments was 100% on 1.5T and nearly 100% on 3T with no significant difference between the 2 magnet strengths. The patterns of enhancement within all segments were nearly symmetric on both scanners, thus highlighting symmetry may be used as an internal control when evaluating patients with facial nerve symptoms. Careful attention to laterality of complaint should be taken into consideration before calling findings abnormal.

A limitation of this study is lack of direct comparison with a precontrast T1-weighted VIBE sequence. Opportunities for future research include evaluation for enhancement of other nerves, both within and outside the IAC, on the VIBE sequence and other sequences. MRI examinations in patients with facial nerve pathology could also be reviewed to evaluate enhancement characteristics.

CONCLUSIONS

It is important to be familiar with normal patterns of facial nerve enhancement on various MRI sequences to avoid misdiagnosis as pathology. Enhancement of all intratemporal segments of the facial nerve is a normal finding on the postcontrast, fat-saturated 3D T1-weighted VIBE sequence on both 1.5T and 3T MRI scanners. Laterality of facial nerve complaint and asymmetry of enhancement should be considered before calling facial nerve abnormality on this sequence and perhaps consideration for additional evaluation by using 2D T1-weighted and other 3D T1-weighted sequences.

ACKNOWLEDGMENTS

The authors would like to thank Yaohua Ma for review of our statistical approach and results.

Disclosure forms provided by the authors are available with the full text and PDF of this article at www.ajnr.org.

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