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The comparison of the efficacy of 3D fast spoiled gradient echo sequence and steady state free precession sequence in imaging vascular compression in patients with trigeminal neuralgia

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ABSTRACT

Aims: Trigeminal neuralgia (TN) is a condition characterized by sudden and intense pain in the face, affecting the fifth cranial nerve. While it can occur for various reasons, vascular compression is a well-known cause. Additionally, conditions such as tumors, arachnoid cysts, idiopathic inflammation, damage, or demyelination can result in TN, extending to the distal branches of the trigeminal nerve from the pons. We aimed to investigate the diagnostic efectiveness of post-contrast three-dimensional fast spoiled gradient echo images (3D-FSPGR) in addition to steady-state free precession (SSFP) images in the imaging of TN.

Methods: A total of 33 patients with a preliminary diagnosis of TN between May 2022 and October 2023 were investigated and five individuals were excluded. Among the remaining 28 patients, vascular compression was observed in only 14 patients. Trigeminal nerve thickness on both side, the distance between trigeminal nerve and superior cerebellar artery on both side, presence of vascular compression, level of the compression, presence or absence of displacement and atrophy were reported for each sequences. The findings and results were compared using independent sample T-test and paired T-test.

Results: The mean age of the patient group was calculated to be 56.29±4.5, while for the control group, it was 52.07±3.09. Trigeminal nerve thickness wasn't different between patient with or without vascular compression (p=0.874 for right side on SSFP, p=0.804 for left side on SSFP, p=0.667 for right side on 3D-FSPGR and 0.769 for left side on 3D-FSPGR). In 10 patients, unilateral compression of the trigeminal nerve was observed, while in 4 patients, it was bilateral. In the right trigeminal nerve, vascular compression was observed in SSFP images in 5 cases in the transitional zone, 2 cases in the nerve root entry zone, and 1 case distally. In 3D-FSPGR images, it was interpreted as being in the transitional zone in 4 cases, in the NR entry zone in 3 cases, and distally in 1 case.

Conclusion: Both SSFP and 3D-FSPGR images can provide comparable information regarding the spatial relationship between the trigeminal nerve and vascular structures. Contrast enhanced imaging allows us diferentiate the tumoral and infammatory demyelinating processes from vascular compression, we recommended to continue with SSFP images in cases where contrast enhanced 3D FSGPR images are inconclusive.

Keywords: Trigeminal neuralgia, three dimensional images, vascular compression

INTRODUCTION

Trigeminal neuralgia (TN) is a condition characterized by sudden and intense pain in the face, affecting the fifth cranial nerve, known as the trigeminal nerve.[1] Episodes of abrupt pain, lasting from seconds to minutes, can be triggered by factors such as chewing, speaking, exposure to cold air, wind, or laughter.[1,2] TN is often observed unilaterally. While it can develop for various reasons, vascular compression is a well-known cause.[3] Additionally, conditions such as tumors, arachnoid cysts, idiopathic inflammation, cervical discopathy, damage, or demyelination can result in TN, extending to the distal branches of the trigeminal nerve from the pons.[1-4] Under the International Classification of

Headache Disorders (ICHD-3) diagnostic criteria, TN is divided into classical, secondary, and idiopathic TN.[5] New diagnostic criteria are developed based on several clinical pieces of research.[5-8] Classical TN, caused by neurovascular compression, is the most common form of TN.[6,9] Secondary TN, which accounts for approximately 15% of cases, results from an external cause, such as a tumor or multiple sclerosis.[5,6,10]

We aimed to investigate the diagnostic effectiveness of post-contrast three-dimensional fast spoiled gradient echo images (3D-FSPGR) in addition to the commonly used and evaluated as standard method, balanced steady-state free precession (SSFP) images in the imaging of TN.

METHODS

Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee approved the retrospective design of the study (Date: 07.11.2023, Decision No: 2023-379). And written informed consent was waived by them. A total of 33 patients referred to the radiology clinic for MRI with a preliminary diagnosis of TN between May 2022 and October 2023 were investigated and five individuals were excluded, with 4 patients lacking SSFP images and 1 patient with a mass causing TN. Among the remaining 28 patients, vascular compression was observed in only 14 patients. Trigeminal nerve thickness on both side, the distance between trigeminal nerve and superior cerebellar artery on both side, presence of vascular compression, level of the compression, presence or absence of displacement and atrophy were reported for each sequences. MR images were obtained with a 1.5 MRI system (GE Signa Explorer, USA). We obtained axial 3D FIESTA for SSFP and sagittal BRAVO for 3D-FSPGR. Paremeters for SSFP and 3D-FSPGR were, TR:7 ms, TE: 2.58 ms, matrix size: 300x288, NEX:4, slice thickness: 1 mm, spacing: 1 mm, FOV: 18x18 cm, bandwith 11kHz and TR:7 ms, TE: 3.03 ms, matrix size: 240x240, NEX:4, slice thickness: 1 mm, spacing: 1 mm, FOV: 25x25 cm, bandwith 11kHz, respectively. The findings and results of SSFP and 3D-FSPGR images of patients with and without vascular compression were compared using independent sample T-test and the measurements of the SSFP and 3D-FSPGR whole participants were compared using paired T-test.

RESULTS

The mean age of the patient group was calculated to be 56.29±4.5, while for the control group, it was 52.07±3.09. Of the patient group, 64.3 percent were female, while in the control group, 78.6 percent were female.

No statistically significant difference was found between the thickness of the right and left trigeminal nerves in both imaging sequences (p=0.286 and p=0.564, respectively). Additionally, the closest distance between the trigeminal nerve and vascular structure was similar in both sequences (p=0.375 and p=1) (**Table**). Also trigeminal nerve thickness wasn't different between patient with or without vascular compression (p=0.874 for right side on SSFP, p=0.804 for left side on SSFP, p=0.667 for right side on 3D-FSPGR and 0.769 for left side on 3D-FSPGR).

In 10 patients, unilateral compression of the trigeminal nerve was observed, while in 4 patients, it was bilateral. In the right trigeminal nerve, vascular compression was observed in SSFP images in 5 cases in the transitional zone, 2 cases in the nerve root entry zone, and 1 case distally (**Figure 1**). In 3D-FSPGR images, it was interpreted as being in the transitional zone in 4 cases, in the NR entry zone in 3 cases, and distally in 1 case. On the other hand, for the left trigeminal nerve, vascular compression was observed in both SSFP and 3D FSGPR images where the compression was observed in 5 cases in the nerve root entry zone, 3 cases in the distal zone, and 2 cases in the transitional zone (**Figure 2, 3, 4**).

Table. Trigeminal nerve thickness and the closest distance between nerve and superior cerebellar artery (SCA)

	SSFP images	3D-FSGPR images	p-value
All participants (n=28)			
Right trigeminal nerve thickness	2.92±0.6 mm	3.03±0.7 mm	p=0.286
Left trigeminal nerve thickness	2.94±0.7 mm	2.99±0.6 mm	p=0.564
The closest right trigeminal nerve and SCA distance	1.193±0.9 mm	1.136±0.9 mm	p=0.375
The closest left trigeminal nerve and SCA distance	1.05±0.9 mm	1.05±0.9 mm	p=1

SSFP: Steady-state free precession, 3D-FSGPR: Three-dimensional fast spoiled gradient echo images

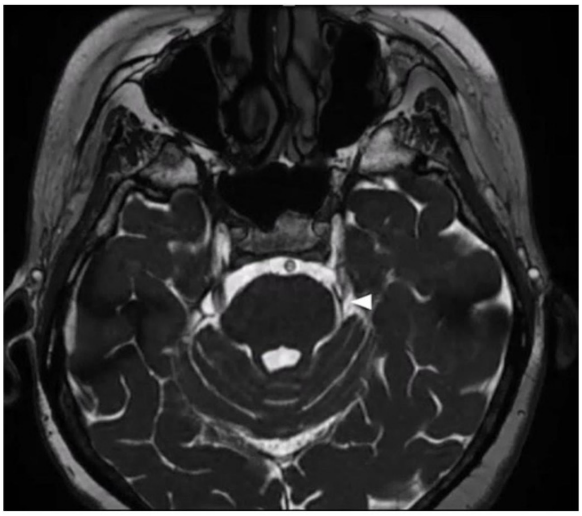

Figure 1. Axial SSFP image on the pons level. Vascular compression of left trigeminal nerve can be seen by left superior cerebellary artery (arrowhead)

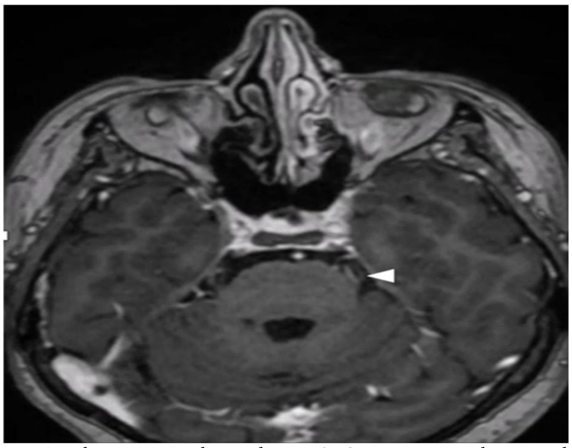

Figure 2. Axial contrast enhanced 3D-FSPGR image on the pons level. Vascular compression of left trigeminal nerve can be seen by left superior cerebellary artery (arrowhead)

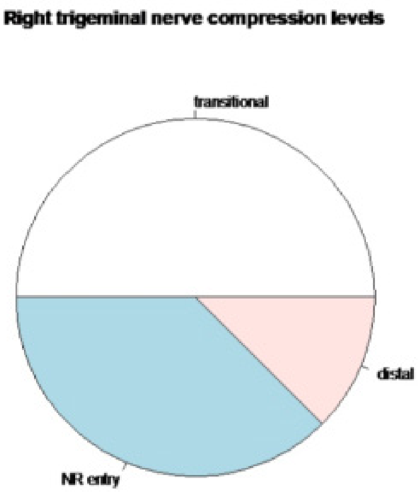

Figure 3. Pie chart of right trigeminal nerve compression levels

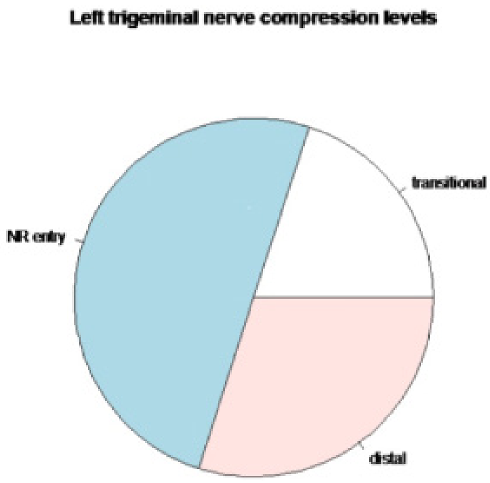

Figure 4. Pie chart of left trigeminal nerve compression levels

Displacement was present in the trigeminal nerve of only three patients, with two on the right side and one on the left for both imaging sequences. In SSFP sequence, atrophy was detected in six patients, with three on the right and three on the left. In 3D FSGPR images, atrophy was observed in five patients, with three on the right and two on the left.

DISCUSSION

In this study, we aimed to compare the efficacy of the 3D fast spoiled gradient echo (FSPGR) sequence and the SSFP sequence in visualizing vascular compression in patients with TN. TN is a neuropathic condition characterized by severe facial pain, often resulting from vascular compression of the trigeminal nerve. Precise imaging of neurovascular conflicts is crucial for both diagnostic and therapeutic purposes, especially when surgical intervention, such as microvascular decompression, is considered.

Both 3D-FSPGR and SSFP sequences provide valuable diagnostic information in detecting neurovascular compression; however, the SSFP sequence demonstrated superior clarity in identifying the compression site, especially in regions adjacent to the brainstem. This finding aligns with previous studies that emphasize the higher signal-to-noise ratio and contrast provided by SSFP sequences in neurovascular imaging.[11] SSFP is known for its ability to offer bright blood contrast, making it particularly useful in vascular imaging, which is consistent with our observations of its efficacy in depicting small vessels near the trigeminal nerve.

Conversely, the FSPGR sequence, while valuable for anatomical imaging, showed limitations in detecting smaller vessels, possibly due to its lower contrast resolution. These results are consistent with prior research indicating that FSPGR sequences, though widely used for anatomical imaging of the brain and nerves, may fall short in vascular detail when compared to SSFP. However, it is noteworthy that FSPGR sequences may still be preferable in patients where rapid acquisition time is necessary, or when motion artifacts are a concern.

The clinical implications of our findings are significant. The ability of the SSFP sequence to more clearly delineate vascular compression may lead to more accurate diagnoses and better surgical planning for patients with TN. As other studies have shown, accurate imaging is critical for determining the appropriate therapeutic approach, whether it be pharmacological treatment, percutaneous procedures, or microvascular decompression surgery.[12] The improved visualization of vascular compression provided by SSFP can potentially reduce the risk of misdiagnosis or unnecessary interventions.

However, our study does have limitations. The sample size was relatively small, and further studies with larger patient cohorts are necessary to validate our findings. Additionally, the imaging sequences were compared in a single institution using specific MRI machines and parameters, which may limit the generalization of the results to other settings or imaging systems. Future research could explore the application of these sequences across different institutions and with varying scanner configurations.

In conclusion, while both the 3D-FSPGR and SSFP sequences are useful in visualizing vascular compression in TN, SSFP demonstrates a higher diagnostic performance. Incorporating SSFP into routine imaging protocols for evaluating the relation between trigeminal nerve and vascular structure may enhance the accuracy of diagnosing neurovascular compression, thereby improving patient outcomes.

Since our results are similar in many measurements for both sequences, we suggest that either imaging sequence could be chosen without compromising the accuracy of trigeminal nerve thickness assessment. Additionally, the examination of the closest distance between the trigeminal nerve and superior cerebellar artery (SCA) in both imaging sequences showed no significant difference. This consistency supports the notion that both SSFP and 3D-FSPGR images can provide comparable information regarding the spatial relationship between the trigeminal nerve and vascular structures.

CONCLUSION

Our study highlights the reliability and consistency of both SSFP and 3D-FSPGR imaging sequences in assessing trigeminal nerve characteristics and vascular compression. Contrast enhanced imaging allows us differentiate the tumoral and inflammatory demyelinating procceses from vascular compression. Since the results are similar, we recommended to continue with SSFP images in cases where contrast enhanced 3D-FSGPR images are inconclusive.

ETHICAL DECLARATIONS

Ethics Committee Approval

Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee approved the retrospective design of the study (Date: 07.11.2023, Decision No: 2023-379).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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