Three Dimensional Constructive Interference in Steady State Magnetic Resonance Imaging Sequence: A Novel Modality in Imaging of Cranial Nerves

Ranjan Shetty, Gururaj Sharma, Harshali Shetty

Department of Radiodiagnosis, AJ Institute of Medical Sciences and Research Centre, Mangalore, India
Corresponding Author: Ranjan Shetty

Abstract: *Three dimensional (3D) Constructive Interference in Steady State [CISS] is a member of fast Gradient Echo Sequence. It is mainly used in the assessment of cranial nerves but is also used in the imaging of abdomen and the breast. This sequence provides excellent contrast between Cerebrospinal fluif (CSF) and other structures. It helps in detecting subtle CSF intensity lesions that may be missed on routine spin-echo sequences*
Keywords: *3D CISS; Cranial Nerve; MRI; imaging; CSF*

I. Introduction

Advances in Magnetic Resonance Imaging (MRI) in the field of neuroimaging has exponentially increased with the advent of stronger magnet systems and biomedical technology in the past two decades. Newer applications are being utilized especially in 1.5 Tesla Magnet to detect even the minute brain pathology. This has helped by leading to a specific diagnosis or differential diagnosis creating a pathway for the treating physician for exact management.

Three-Dimensional Constructive Interference in Steady State (CISS-3D) is a gradient echo MRI sequence that is used for diagnosing certain pathologies when routine MRI sequences do not provide the necessary information.[3]It is a type of fast Gradient Recalled Echo (GRE) sequence where both longitudinal and transverse magnetizations are kept constant[5]. It is a modification of conventional MRI machine.

According to F. Roser et al[2], The high spatial resolution in this sequence is an improvement from the routine MR sequences. This is because in routine T2 weighted imaging, the thick slices result in partial volume averaging and hence the reduced spatial resolution. Lesions that are isointense with CSF on T1 and T2 weighted images can be missed or underestimated.The short echo time used in the 3D CISS sequence results in limited signal loss from magnetic susceptibility effects and the low flip angle reduces T1 weighting. The increased sensitivity of the 3D CISS sequence is a consequence of the accentuation of the T2 values between CSF and pathological structures, and the higher intrinsic resolution among neural structures, CSF and lesions surrounded by CSF.

It is useful to study the anatomical variations and diagnose various pathologies involving the cranial nerves,cisternal spaces, ventricular system, aqueductal stenosis and CSF rhinorrhea.[4]It provides a superior topographical information about the exact location of the pathology and its relation to the adjacent structures. This information is very useful in deciding the management of the condition[1]

II. Methodology

This was a hospital based prospective study done over a period of two years from July 2016 to September 2018 in the department of Radio Diagnosis at A.J. Institute of Medical Sciences. Clinically suspected patients with cranial nerve pathologies were investigated using MRI after taking an informed consent.
Based on the inclusion and exclusion criteria, 36 patients were selected for the study.
These patients underwent MRI of Brain which had T1w T2w and CISS 3D sequences was done.

PARAMETERS USED:
1.   **T2 W 3D CISS**
TR:5.98 TE: 2.67
Slice thickness: 0.70 mm
Flip Angle: 70 $^{\text{O}}$
Acquisition Time: 3 mins 29 sec for 64 slices per slab

---

2.   T2 W 2D TSE
TR:4220 TE: 117
Slice thickness: 5mm

T1 W 2D TSE
TR: 500   TE: 8.7
Slice thickness: 5mm
3.   T1 W 3D MPRAGE
TR:1740 TE:3.53
Slice thickness:1 mm
The findings were evaluated in Syngo MR Workstation and comparison was done between T2w and CISS 3D images.

III. Results And Discussion

20 (55 %) male patients and 16 (45 %) female patients were included in our study.

Cranial Nerve Pathologies included 14 cases ofInflammatory lesions of Cranial Nerves and 22 cases of Neurovascular conflict.

Inflammatory lesions of Cranial Nerves included Neuritis of the Optic, Oculomotor, Trigeminal and Facial Nerve.

CISS has been useful in identifying neuritis of the Cranial Nerves.Neuritis is suspected when there is thickening of the nerve, Abnormal signal Intensity and enhancement of the nerve.

The better utility of CISS is in diagnosing the neuritis of the Optic Nerve . This is because the nerve is surrounded by CSF. So, effacement of theperineural CSF is easily appreciated on CISS sequence. Also due to T2 weighting there is contrast difference between Brain parenchyma and CSF space. This results in better appreciation of the enhancement. Since enhancement of the nerve is one of the criteria for diagnosing neuritis, and in our study since there were very few cases with CISS 3D post contrast enhancement, it denotes that there is minimal role of these sequences in diagnosing the Inflammatory lesions of cranial nerves. sensitivity of CISS in picking up the inflammatory lesions was **66.6%** and specificity was **20%**. Therefore, in inflammatory lesions of cranial nerve, sequences like MPRAGE will play a role because of the fact that it has more T1 weighting and has better enhancement characteristics.

Role of CISS sequence in Neurovascular Conflict (NVC) :

Neurovascular Conflict can be defined as compression or distortion of a cranial nerve due to a redundant or aberrant vascular structure. NVC can be diagnosed if there is thinning or change in the course of the nerve.

The Cranial Nerves are thin structures that are difficult to visualise in T2 weighted sequences. Hence, they are of no value in evaluation of the same because it is of bigger slice thickness. Only when the nerves are thickened as in tumours they can be visualised on these sequences.

CISS 3D plays an important role in the diagnosis of NVC. The abnormal contact between the vessel and nerve can be clearly depicted by this sequence. It also helps in Grading of NVC.

In our study, Neurovascular Conflict could be evaluated only in CISS sequence in majority of cases. Out of the 22 cases, 18cases were diagnosed precisely on CISS 3D and correlated with the clinical diagnosis and follow up. In this study, CISS sequence was the best sequence for evaluation of NVC with a sensitivity of 85%

FALLACIES OF CISS 3D:
CISS 3D Sequences has some intrinsic disadvantages. Motion artefact is one of them. This leads to blurred images on movement by the patient or when the patient swallows. Other causes of motion artefact maybe due to rapid breathing or cardiac motion. Another limitation is the long acquisition time of approximately 7-8 minutes.

IV. Conclusion

* CISS 3D Sequence is extremely useful in evaluating Cranial Nerve pathologies
* CISS 3D is 66.6 % sensitive and 20 % specific in diagnosing the Inflammatory Pathologies of cranial nerves.
* CISS sequence is 85 % sensitive in demonstrating Neurovascular Conflict.
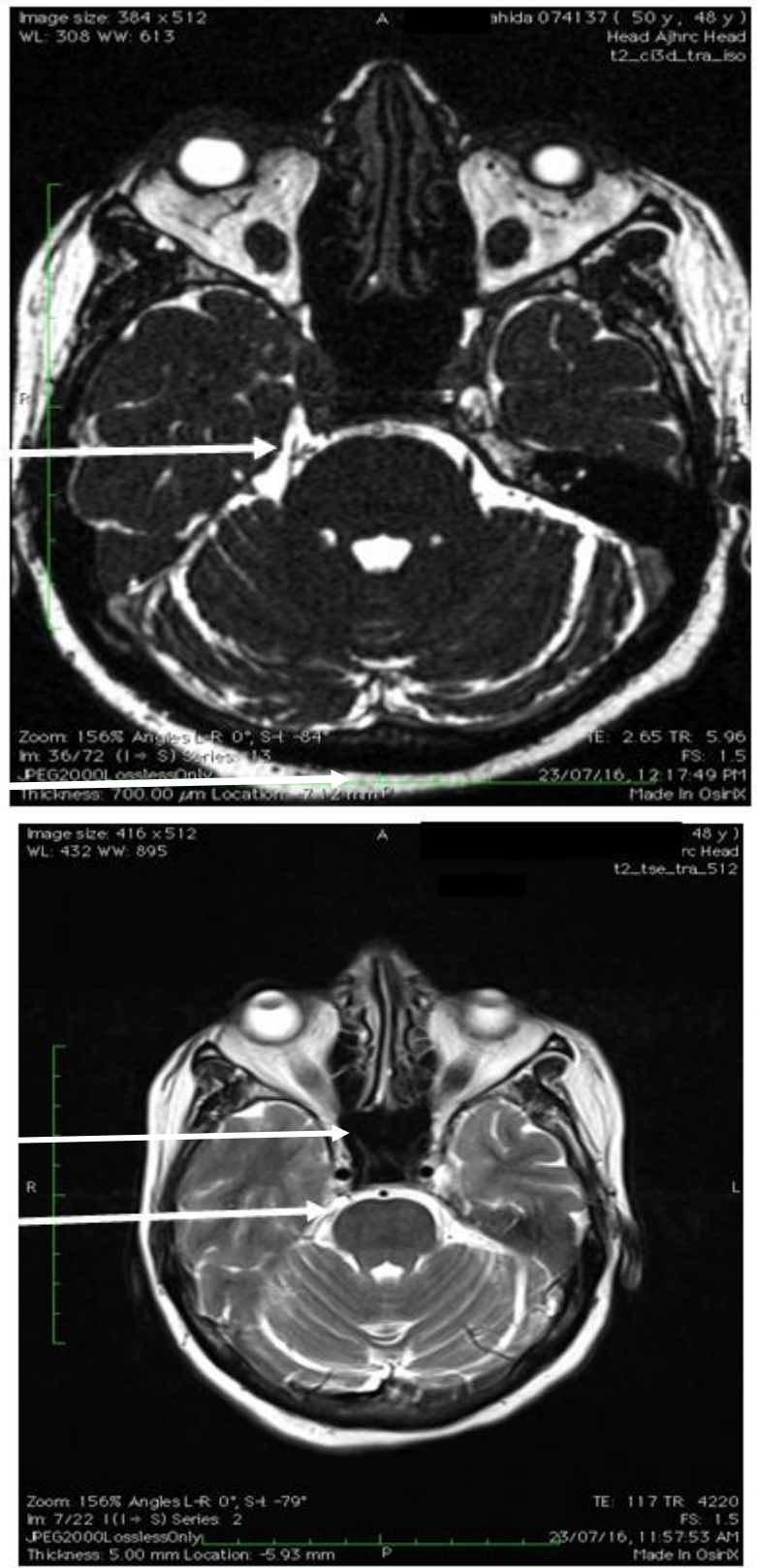
IMAGE GALLERY:

Figure 1: a, b
CASE OF NEUROVASCULAR CONFLICT
T2 Weighted image did not show any significant findings (b) but the CISS 3D Image showed a vessel indenting on the 5thCranial Nerve (arrow) (a)
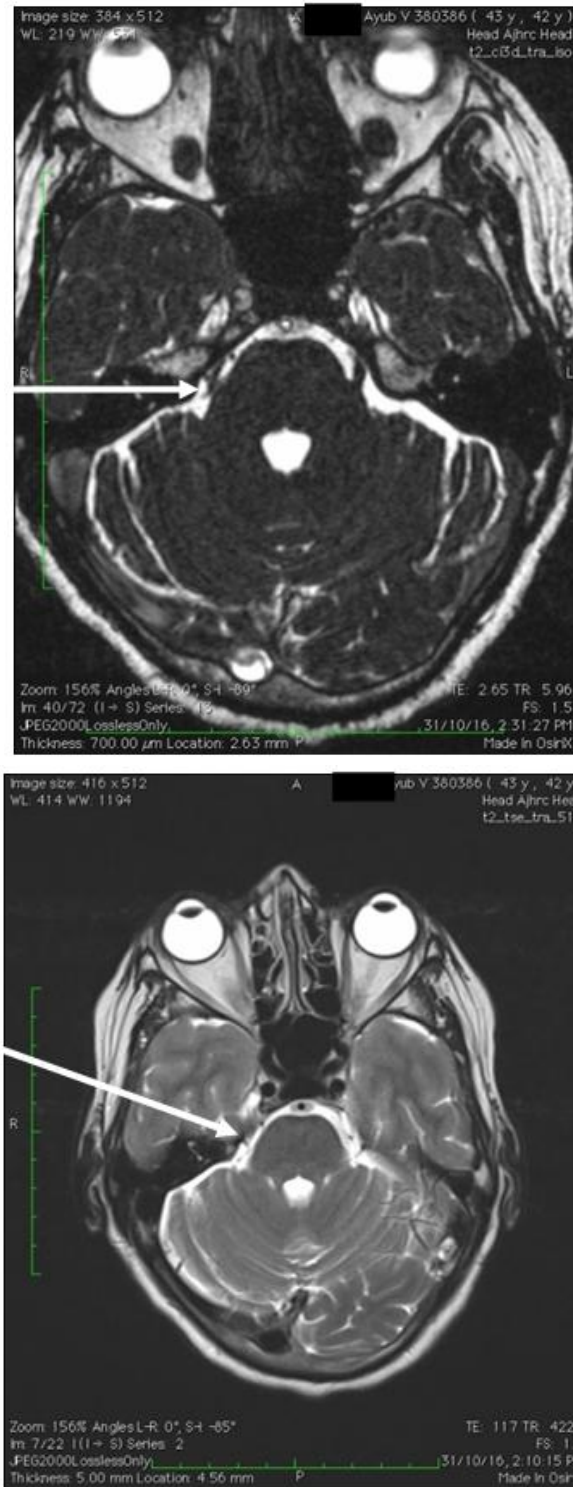
Figure 2: a, b
CASE OF NEUROVASCUALR CONFLICT
T2 Weighted Images showed no obvious abnormality (b)
CISS 3D showing a Vascular loop indenting on the Right Trigeminal Nerve and displacing it (suggestive of grade 2 NVC) (a)

References

[1]. Hingwala D, Chatterjee S, Kesavadas C, Thomas B, Kapilamoorthy TR. Applications of 3D CISS Sequence for problem solving in Neuroimaging. Indian J Radiol Imaging.2011;21(2):90-97.

[2]. Roser F, Ebner FH, Danz S, Reither F, Ritz R, Dietz K, Naegele T, Tatagiba MS. Three- Dimensional Constructive Interference in Steady State Magnetic Resonance Imaging in syringomyelia: advantages over conventional imaging. J Neurosurg Spine 2008 May;8 (5): 429-35

[3]. Gupta SK, Gupta A, Mahajan A, Gupta R, Tandon VR, Gupta N. Clinical Insights in Trigeminal Neuralgia. JK Science Clinical Guide. 2005;7:181-84

[4]. Besta R, Uday Shankar Y, Kumar A, Rajasekhar E, Bhanu Prakash S. MRI 3D CISS- A Novel Imaging Modality in Diagnosing Trigeminal Neuralgia- A Review. J ClinDiagn Res. 2016 Mar;10 (3): ZE01- ZE03.

[5]. Chavhan GB, Babyn PS, Jankharia BG, Cheng H-LM , Shroff MM. Steady State MR imaging sequences : Physics, Classification and Clinical Applications. Radiographics. 2008; 28(4):1147-60