ISSN 2515-8260 Volume 10, Issue 1, 2023

ROLE OF 3D CONSTRUCTIVE INTERFERENCE IN STEADY STATE (CISS) MR IMAGING SEQUENCE OF EVALUATION OF CRANIAL NERVE LESIONS IN COMPARISON WITH OTHER MR IMAGING SEQUENCES

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ABSTRACT

Aim: The objective of the present study was to assess the role of 3D constructive interference in steady state (CISS) MR imaging sequence of evaluation of cranial nerve lesions in comparison with other MR imaging sequences.

Methods: The present study was conducted at Dr. D Y Patil Medical College and Hospital, Pimpri, Pune, Maharashtra from September 2020 to August 2023 and 70 patients were included in the study. Approval of institutional ethics committee was acquired before the initiation of the study.

Results: Most of the patients we encountered were within the age group of 31-60 years wherein there were 36 patients. Less than 30 years were 16 patients and more than 60 years were 18 cases. In the parameter lesion picked up CISS picked up in 20 cases, MPRAGE in 24 cases and T2, T1 in 0 cases. MPRAGE having a 100% pick up rate and CISS having 83%. In the parameter lesion picked up CISS picked up in 46 cases, MPRAGE in 40 cases, T2 in 34 and T1 in 34 cases.

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CISS had the best pick up rate with 100%. Overall, when we compare the MR sequences combining both the etiologies CISS was better in picking up the lesion, in assessing the signal intensity changes, in knowing the encasement of nerve and change in course of nerve. Only MPRAGE was better than CISS in identifying the enhancement characteristics of the nerve.

Conclusion: The CISS sequence is extraordinarily beneficial for assessing cranial nerve disorders. CISS sequencing revealed lesions in 83.3% of patients with an inflammatory etiology and 100% of those with a non-inflammatory cause. MPRAGE has detected lesions in 100 percent of instances with an inflammatory origin and in 87 percent of cases with an inflammatory aetiology. CISS sequence demonstrates neurovascular conflict with a 100 percent sensitivity rate. T2W and T1W sequences lack inflammatory etiologies and neurovascular conflict.

Keywords: brain pathology; magnetic resonance imaging (MRI); magnetic resonance cisternography (MRC); constructive interference in steady state (CISS)

INTRODUCTION

Three-dimensional (3D) constructive interference in steady state (CISS) is a fully refocused steady-state gradient-echo MRI sequence. This sequence is now freely available and is frequently used in MRI to investigate a wide range of pathologies when routine MRI sequences do not provide the desired anatomic information.[1] Hence, understanding its basic physics and clinical applications is essential. Because of the image characteristics described above, CISS sequence plays an important role in evaluating structures surrounded by CSF. It is useful for imaging lesions that are relatively isointense to CSF on T1W and T2W images.[2]

Three-dimensional CISS is routinely used in the assessment of cerebellopontine angle lesions, inner ear structures and the internal auditory canal (IAC).[3] With this sequence, the fine structure of the cranial nerves VII and VIII and the membranous labyrinth of the internal ear can be clearly demonstrated. This has facilitated detection of small intracanalicular lesions and diagnosis of the nerve of origin, depending upon the exact location in the IAC.

Constructive interference in steady state (CISS) is one of the most important sequences of the steady-state free precession (SSFP) family, and it is mainly used for the assessment of the central nervous system (CNS). The SSFP technique was introduced in magnetic resonance imaging (MRI) more than half a century ago, and it was first described by Carr in 1958, who explained its

basic physical principles concerning signal formation and properties.[4] Only at the end of the 20th century did the use of the sequence become popular. In general, the term "SSFP" includes all steady-state sequences and their variants, which are named with different terms by MR manufacturers and divided into various types for different gradient switching patterns.[5]

The 3D CISS sequence is used in addition to routine MRI sequences to study a wide range of pathologies, so as to obtain more detailed anatomic information. It is frequently used in the evaluation of numerous structures in the CNS, like cranial nerves (CNs), cisternal spaces, the cavernous sinus, the ventricular system, the spinal cord and related pathologies.[6] 3D CISS, due to its cisternographic effect and anatomical details it can provide, is widely used for the assessment of CNs. In particular, the 3D CISS sequence can provide high-resolution images owing to the excellent contrast between CSF and solid structures, thus playing an important role in distinguishing between CNs, small vessels and CSF into the cerebellopontine angle (CPA) and other CSF spaces.[7]

Traditional Magnetic Resonance (MR) imaging sequences may lack the spatial resolution required to distinguish smaller structures such as cranial nerves.[8] There are disagreements between studies evaluating the superiority of the CISS sequence in assessing the extent and involvement of cranial nerve neoplasia and in recognizing cranial nerve lesions in their non-cisternal segments compared to other conventional MR imaging sequences.[9-11]

The objective of the present study was to assess the role of 3D constructive interference in steady state (CISS) MR imaging sequence of evaluation of cranial nerve lesions in comparison with other MR imaging sequences.

MATERIALS AND METHODS

The present study was conducted at Dr. D Y Patil Medical College and Hospital, Pimpri, Pune, Maharashtra from September 2020 to August 2023 and 70 patients were included in the study. Approval of institutional ethics committee was acquired before the initiation of the study.

INCLUSION CRITERIA: All age group patients suspected with

1. Clinically detected cranial nerve palsies.
2. Cranial nerve neoplasm.
3. Traumatic cranial nerve palsies.
4. CNS infections involving cranial nerves.

ISSN 2515-8260 Volume 10, Issue 1, 2023

EXCLUSION CRITERIA:

A. Patients with:

1. Intracranial aneurysm clips or Intra-orbital metal fragments.

2. Any electrically, magnetically or mechanically activated implants (including cardiac pacemakers, bio stimulators, neurostimulators, cochlear implants and hearing aids), non-MRI compatible orthopedic implants.

B. Patients having known contraindications to contrast agent.

C. Post-operative patients.

D. Patients with history of claustrophobia.

Following parameters were used:

	TR	TE	SLICE THICKNESS
T2 W 3D CISS	5.8	2.7	0.7mm
T1W 3D MP-RAGE	2100	6.7	1mm
T2W 2D TSE	4010	114	5mm
T1W 2D TSE	695	17	4mm

METHODOLOGY

Inflammation of cranial nerves were identified by increased signal intensity, post contrast enhancement, thickness etc. Tumors were analyzed for extension into the surrounding structures, displacement of nerves, size of the nerves, post contrast enhancement etc. These characteristics were assessed on each of the said MRI sequences and analysis was done on which sequence the lesion could be picked up. Note of any additional information exclusively obtained from CISS sequence over other sequences regarding nerve infiltration, surrounding parenchymal involvement, vascular conflict etc was made and the same was analyzed. Prior to MRI scan relevant clinical information was attained in the patient proforma regarding primary tumors elsewhere or pertaining to relevant cranial nerve examination. All the cases were clinically followed up with respect to improvement or any surgical intervention done.

Statistical analysis was performed using SPSS ver.17.0. Test of significance will be done using Chi Square Test with a confidence interval of 95% and power of 90%. $P<0.05$ will be considered significant.

RESULTS

Table 1: Distribution of patients by etiology

AGE	Inflammatory lesions of cranial nerves	Non-Inflammatory lesions of cranial nerves	Total
< 30 Yrs	8 (33.3%)	8 (17.4%)	16 (22.9%)
31 – 60 Yrs	16 (66.7%)	20 (43.5%)	36 (51.4%)
60 Yrs	0 (0%)	18 (39.1%)	18 (25.7%)
TOTAL	24 (100%)	36 (100%)	70 (100%)

Most of the patients we encountered were within the age group of 31-60 years wherein there were 36 patients. Less than 30 years were 16 patients and more than 60 years were 18 cases. I

Table 2: Inflammatory lesions of cranial nerves and non-inflammatory lesions of cranial nerves

Inflammatory lesions	**N**		**Y**	
	freq	**%**	**freq**	**%**
lesion picked up CISS	4	16.7%	20	83.3%
lesion picked up MPRAGE	0	0%	24	100.0%
lesion picked up T2w	24	100.0%	0	0%
lesion picked up T1w	24	100.0%	0	0%
Non-Inflammatory lesions	**N**		**Y**	
	freq	**%**	**freq**	**%**
lesion picked up CISS	0	.0%	46	100.0%
lesion picked up MPRAGE	6	13.0%	40	87.0%
lesion picked up T2w	12	26.1%	34	73.9%
lesion picked up T1w	12	26.1%	34	73.9%

Inflammatory lesions were evaluated using three imaging criteria which included lesion picked up, signal intensity changes and enhancement after contrast administration with a score of 1 for each parameter. Inflammatory lesions were observed only in optic nerves II and III. 12 cases of cranial nerve II and 3 cases of cranial nerve III were observed. In the parameter lesion picked up CISS picked up in 20 cases, MPRAGE in 24 cases and T2, T1 in 0 cases. MPRAGE having a 100% pick up rate and CISS having 83%. Non-inflammatory lesions were evaluated using five imaging criteria which included lesion picked up, signal intensity changes, enhancement after

contrast administration with a score of 1 for each parameter. Inflammatory lesions were observed only in optic nerves II and III. 46 cases of various cranial nerves were evaluated. In the parameter lesion picked up CISS picked up in 46 cases, MPRAGE in 40 cases, T2 in 34 and T1 in 34 cases. CISS had the best pick up rate with 100%.

Table 3: Inflammatory lesions of cranial nerves and Non inflammatory lesions of cranial nerves picked up by different sequences

Inflammatory lesions	**N**		**Y**	
	freq	**%**	**freq**	**%**
lesion picked up CISS	0	.0%	46	100.0%
lesion picked up MPRAGE	6	13.0%	40	87.0%
lesion picked up T2w	12	26.1%	34	73.9%
lesion picked up T1w	12	26.1%	34	73.9%
Non-Inflammatory lesions	**N**		**Y**	
	freq	**%**	**freq**	**%**
lesion picked up CISS	0	0%	46	100.0%
lesion picked up MPRAGE	6	13.0%	40	87.0%
lesion picked up T2w	12	26.1%	34	73.9%
lesion picked up T1w	12	26.1%	34	73.9%

In the parameter lesion picked up CISS picked up in 46 cases, MPRAGE in 40 cases, T2 in 34 and T1 in 34 cases. CISS had the best pick up rate with 100%. In the parameter signal intensity changes CISS picked up in 46 cases, MPRAGE in 40 cases, T2 in 34 and T1 in 34 cases. CISS had the best pick up rate with 100%.

Table 4: Distribution of various parameters in different sequences

		n	**%**
lesion picked up	**CISS**	66	94.29
	MPRAGE	64	91.43
	T2w	34	48.57
	T1w	34	48.57
signal intensity	**CISS**	66	94.29
	MPRAGE	64	91.43

	T2w	34	48.57
	T1w	34	48.57
enhancement	**CISS**	56	80.00
	MPRAGE	60	85.71
	T2w	32	45.71
	T1w	34	48.57
nerve encasement	**CISS**	44	100.00
	MPRAGE	32	72.73
	T2w	6	13.64
	T1w	4	9.09
change in course of nerve	**CISS**	34	100.00
	MPRAGE	14	41.18
	T2w	6	17.65
	T1w	2	5.88

Overall, when we compare the MR sequences combining both the etiologies CISS was better in picking up the lesion, in assessing the signal intensity changes, in knowing the encasement of nerve and change in course of nerve. Only MPRAGE was better than CISS in identifying the enhancement characteristics of the nerve.

Table 5: Cranial nerve distribution of lesions

Cranial Nerve	**Inflammatory lesions of cranial nerves**	**Non-Inflammatory lesions of cranial nerves**	**Total**
1	0 0%	2 4.3%	2 2.9%
2	18 75.0%	6 13.0%	24 34.3%
3	6 24.0%	2 4.3%	8 11.4%
4	0 0%	4 8.7%	4 5.7%
5	0	12	12

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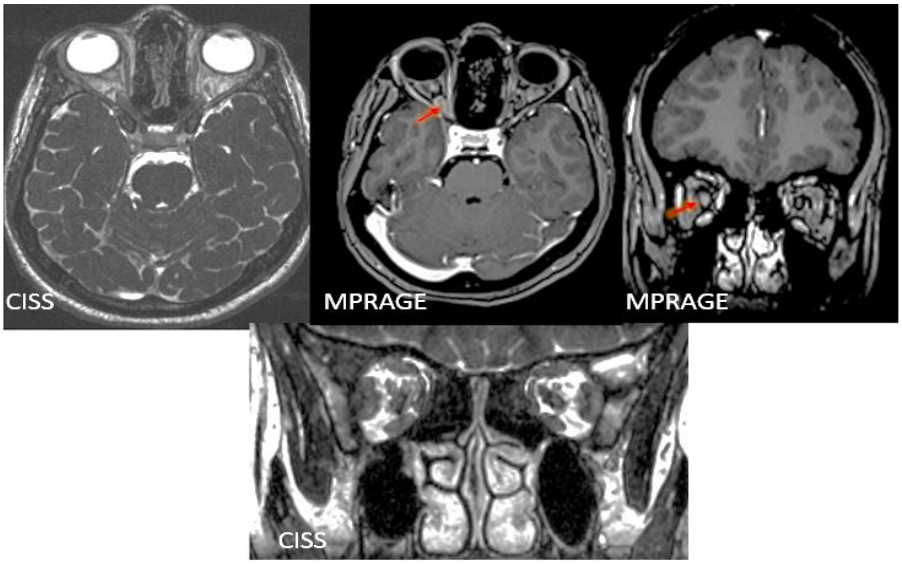
	0%	26.1%	17.1%
6	0 0%	2 4.3%	2 2.9%
7	0 0%	2 4.3%	2 2.9%
7, 8	0 0%	12 26.1%	12 17.1%
9, 10	0 0%	4 8.7%	4 5.7%
Total	24 100 %	46 100%	70 100%

Among the various cranial nerve lesions encountered, optic nerve was the most frequently affected nerve with 24 cases of optic nerve lesions encountered overall. Among the inflammatory lesions optic nerve was the most frequently affected nerve. Among the non-inflammatory lesions trigeminal and 7th and 8th nerve complex were the most frequently encountered with 12 cases of each.

Figure 1: Axial and coronal images of CISS and MPRAGE sequences. MPRAGE shows diffuse enhancement and thickening of the right optic nerve. No enhancement in the CISS sequence



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DISCUSSION

In our analysis, we identified twelve inflammatory lesions of the cranial nerves. Observations revealed 12 instances of cranial nerve II and 3 instances of cranial nerve III. They were rated on the basis of whether or not the lesion was visible, signal intensity alterations, and post-contrast enhancement. T1W and T2W sequences did not detect the lesion in any of the instances, indicating that these sequences play no function in inflammatory lesions of the cranial nerves. MPRAGE has 100 percent sensitivity for all three parameters. CISS was able to visualize the lesion, and signal intensity changes were observed in 83.3% of instances (10/12), whereas enhancement was found in only 58% of cases (7/12). In the majority of patients, we saw only grade I NVC, where the artery was in close proximity to the cranial nerves, and a diagnosis of NVC was made based on clinical association. In a few instances, indentation and alterations in the nerve's path were identified, and it could be said with a degree of certainty that neurovascular conflict exists. In a small number of cases of grade III NVC, signal intensity variations were also seen within the nerve. In these instances, microvascular decompression surgery was conducted with graft implantation between the nerve and artery. NVC was verified on the table during surgery at that location, a nerve was found to be thinning.

Similar to Gultekin et al.[12] and Kamble Jayaprakash Harsha et al.[13], we found that CISS as a steady-state sequence was superior for identifying the location of vascular compression in our investigation. CISS sequence for NVC was superior to MPRAGE in every way. Aside from big arteries such as the basilar and vertebral arteries, MPRAGE was unable of identifying the NVC for smaller arteries such as the AICA and SCA.

Schwannomas, gliomas, etc., are examples of primary cranial nerve tumours. Because the olfactory and visual nerves are not coated by Schwann cells, schwannomas do not affect them. The most prevalent tumour affecting the olfactory nerve is esthesioneuroblastoma. In the superior recess of the nasal cavity, they emerge from the basal layer of the olfactory epithelium. Common tumours of the optic nerve are gliomas of the optic nerve. Intraorbital glioma of the optic nerve should be distinguished from meningioma. Additionally, type 1 neurofibromatosis is linked to optic nerve glioma.[14] Nearly diagnostic of neurofibromatosis type 1 are bilateral optic nerve gliomas.[15] Meningiomas of the optic nerve sheath are the most dissimilar to gliomas of the optic nerve. Meningioma's early subdural development leads the tumour to encircle the nerve. The tram-track sign is most apparent on fat-suppressed T1-weighted magnetic resonance

imaging, when the optic nerve shows as a negative defect in contrast to the surrounding enhancement in the optic nerve sheath region on either side.[16]

Meningioma is the most prevalent kind of intracranial tumour. Meningioma may also arise from the meningeal layer protecting the optic nerve in the orbit. Common intraorbital meningioma symptoms include proptosis and vision disturbances. It may be diagnosed by the indication on the tram track where the non-enhancing optic nerve can be seen within the enhancing tumour mass.[16] Although, uncommon intracanalicular meningiomas are often ignored. If the tumour is located inside the cannalicular segment, even a tiny layer of en-plaque tumour produces substantial visual problems in these individuals. As a result of skeletal restrictions, the tumour has nowhere to develop. Due to the fact that these tumours are little yet manifesting serious symptoms, they are readily missed.[17] Typically, meningiomas of the optic sheath have a fusiform appearance. They encircle the optic nerve entirely. On CISS pictures around the optic nerve, the brilliant signal of CSF is no longer visible. In addition, as it obliterates the CSF space, a tiny fluid pocket is often observed proximal to the extent of the tumour, which looks hyperintense on CISS due to CSF.[18] These meningiomas can affect the third, fourth, and fifth nerves as they cross the lateral section of the cavernous sinus. In this instance, all sequences identify the lesion, but only the CISS sequence reveals left trigeminal nerve involvement. The lesion is seen on MPRAGE as a big mass lesion. On an MPRAGE sequence, the trigeminal nerve is not separately visible.

In our investigation, there was a very significant statistical difference between the CISS and MPRAGE sequences, with a P value of less than 0.001 and a Friedman test value of 52,491, indicating that the CISS sequence is superior to other sequences for assessing non-inflammatory cranial nerve injuries. CISS had a mean value of 4.91 on the non-inflammatory lesion grading system, while MPRAGE had a score of 3.75. The average score for both the T2 and T1 sequences is below 2.5. Preoperative examination of vestibular schwannoma is crucial for determining postoperative prognosis, as mentioned by Kocaoglu M. et al.[19] Akiko yagi et al. investigated the visibility of normal cranial nerves in the cavernous sinus of 38 healthy individuals using contrast-enhanced CISS and T1 sequences. Contrast-enhanced 3D CISS MR imaging detected intracavernous segments of CNs III, IV, V1, V2, and VI in 76 (100%), 46 (61%), 70 (92%), 67 (88%), and 73 (96%) of 76 cavernous sinuses, respectively. They reached the conclusion that contrast-enhanced 3D CISS MR imaging provides unambiguous pictures of

normal CNs in the cavernous sinus. In a comparison between contrast-enhanced CISS and contrast-enhanced T1-weighted MR imaging, contrast-enhanced CISS provided considerably greater CNS detectability.[20] Seitz J. et al. conducted the only investigation on the visualisation of lesions of all twelve cranial nerves. They examined MPRAGE with and without contrast, CISS, 3D T2w TSE, 2d T2w TSE, and 2d T1w TSE with fat saturation sequences, but we omitted non-contrast MPRAGE and 3D T2w TSE from our investigation. CISS was the best sequence for viewing the cranial nerves in the cisternal segments.[21]

CONCLUSION

The CISS sequence is extraordinarily beneficial for assessing cranial nerve disorders. CISS sequencing revealed lesions in 83.3% of patients with an inflammatory etiology and 100% of those with a non-inflammatory cause. MPRAGE has detected lesions in 100 percent of instances with an inflammatory origin and in 87 percent of cases with an inflammatory aetiology. CISS sequence demonstrates neurovascular conflict with a 100 percent sensitivity rate. T2w and T1w sequences lack inflammatory etiologies and neurovascular conflict. Only in big tumors that impact the cranial nerves do they manifest. CISS sequence vividly depicts the size, borders, and perineural dissemination of the tumor, which are not exhibited by MPRAGE or other sequences. MPRAGE sequence, on the other hand may falsely demonstrate perineural spread. CISS sequence demonstrates the relationship of the tumor to nearby tissues such as cranial nerves and arteries more clearly.

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