Original Research Paper

Volume - 13 | Issue - 08 | August - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Radio-Diagnosis

UTILITY OF THREE DIMENSIONAL (3D) CONSTRUCTIVE INTERFERENCE IN STEADY STATE (CISS) MAGNETIC RESONANCE (MR) IMAGING SEQUENCE IN DEMONSTRATING OPTIC NERVE PATHOLOGIES

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ABSTRACT The anatomy of optic nerves is complex and the use of CISS MR sequence helps in demonstrating the fine structure of these nerves. Where conventional magnetic resonance (MR) imaging sequences like T1w, T2w sequences with or without fat suppression provide excellent soft-tissue resolution, they may lack the spatial resolution necessary to define smaller structures such as optic nerves. CISS sequences allow much higher spatial resolution and clearer depiction of optic nerves. Out of the patients assessed, thirteen patients had optic neuritis, twelve patients had intracranial lesions involving the optic nerves and five patients had optic nerve tumors. In thirteen patients with optic neuritis, T1w sequence could identify the lesion in only five patients and CISS sequence identified the lesion in ten patients. However coronal T2w fat suppressed sequence identified the lesion in all thirteen patients with better information compared to CISS sequence in three patients. In twelve patients with intracranial lesions affecting optic nerves; even though other conventional sequences picked up the lesions, CISS sequence gave extra information which could not be provided by conventional sequences in eight patients. In indecently picked up lesions of bulbar and pseudobulbar palsy CISS sequence helped in better delineating and differentiating extraocular muscle and tendons. Out of the five patients of optic nerve tumours all sequences picked up the lesion, but CISS sequence gave extra information regarding extent of involvement, extension into the orbital fissure etc. CISS sequence is better compared to conventional MR sequences for evaluation of optic nerve pathologies. In suspected inflammatory optic neuritis T2W coronal fat suppressed sequence was better than CISS sequence in 23% of the patients. In cases of optic nerve tumours and extracranial lesions involving optic nerves, CISS sequence was much better in delineating the pathology and also to assess the extent of involvement.

KEYWORDS : ciss, optic nerve, neuritis, optic nerve tumours

INTRODUCTION

Cranial nerves have a complex anatomy and the use of 3D Constructive interference in steady state (CISS) MR sequence helps in demonstrating the fine structure of cranial nerves. Whereas traditional Magnetic Resonance (MR) imaging sequences provide excellent soft-tissue resolution, the spatial resolution required to define smaller structures is lacking [1]. CISS sequence has a higher spatial resolution where the tiny intracranial structures are clearly depicted. CISS sequence can be obtained in any plane, hence useful for assessing the complex pathways of cranial nerves. Image contrast in CISS is determined by the T2/T1 ratio of the tissues. Increased signal intensity is produced by tissues with both long T2 relaxation times and short T1 relaxation times. Because of the high T2/T1 ratio, both water and fat have high signal on this sequence. There is an excellent contrast between cerebrospinal fluid (CSF) and other structures [2]. Because of these image characteristics CISS plays an important role in evaluating optic nerves which are surrounded by CSF. The aim of the present study is to assess the role of 3DCISSMR sequence in demonstrating optic nerve pathologies and comparing it with other conventional MR.

CISS sequence is a type of Gradient Recalled Echo sequence (GRE). It is a coherent or steady-state GRE sequence where the transverse magnetization is not spoiled but refocused to form a steady state. Steady state is achieved by keeping the TR time shorter than the T2 relaxation time. This short TR time prevents the transverse magnetization from fully decaying and a portion of the transverse magnetization is left behind before the next excitation pulse occurs. This remaining transverse magnetization is added to the longitudinal magnetization in the next RF pulse and the entire thing is again flipped into the transverse plane. This process is repeated many times till a constant transverse and longitudinal magnetization is achieved. This is when the steady state is achieved. The characteristics of the steady state depends on certain factors. One being the initial amount of flip angle. As the flip angle increases the degree of steady state also increases because the amount of initial transverse magnetization is increased and so in is the residual transverse magnetization. A flip angle of 50-80 degrees is usually used to get the best signal. The other factor which affects is the TE because as the TE is increased the T2* weighting increases.

CISS sequence is performed with a shorter TR of msec and two runs of SSFP sequence are done.

Initially a positive and negative flip angle is used while in the later run it is kept constant. The mutually shifted banding artifacts from both the runs are later combined to obtain an image with reduced artifacts [3]. As a result CISS has many advantages like a shorter acquisition time, good spatial resolution and higher signal to noise ratio making it insensitive to motion related artifacts and susceptibility [4].

The T2/T1 ratio of the tissue determines the image contrast on CISS sequence. Tissues with a long T2 and short T1 show high signal, like water and fat. Since the CSF mainly consists of water we get a very high signal from it [2].

Coming to the anatomy of optic nerve, it mainly consists of four segments: retinal, orbital, canalicular and cisternal. The retinal segment is near the globe. The orbital segment is situated within the orbit and surrounded by the orbital fat. The canicular portion is present within the optic canal [5]. The cisternal segment is present in the suprasellar cistern. The orbital portion is surrounded by the CSF and meninges. The normal mean sizes of the optic nerve not including the surrounding CSF are as follows: nerves 3.0 x 5.9 mm; chiasm 3.5 x 15.0 mm [6].

MATERIALS AND METHODS

Sample Size: 30 patients.
Study Design: retrospective and prospective study.

Inclusion Criteria: Patients of all age groups suspected with
1. Clinically detected patients with diminished vision.
2. Optic nerve neoplasm.
3. Intracranial tumors involving optic nerves.

Exclusion Criteria:
a. Patients with :
1. Intracranial aneurysm clips or Intra-orbital metal fragments.
2. Any mechanically, magnetically or electrically activated implants, (including cardiac pacemakers, bio stimulators, neurostimulators, cochlear implants, and hearing aids).

b. Patients with contraindications to contrast agent.

SEQUENCES –T2 W 3D CISS*, T1W 3D MP-RAGE*, T2W 2D TSE, T1W 2D TSE*
*- with contrast Gadolinium dimeglumine 0.5M (0.1ml per kg body weight)

METHODOLOGY

Inflammation of optic nerve was identified by increased signal intensity, post contrast enhancement and thickness. Tumours were analyzed for extension into the surrounding structures, displacement of optic 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 identified. Note of any additional information exclusively obtained from CISS sequence over other sequences regarding nerve infiltration, surrounding parenchymal involvement, vascular conflict etc was made. Prior to MRI scan relevant clinical information was attained in the patient proforma regarding primary tumours elsewhere or pertaining to ophthalmic 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

30 patients with symptoms of cranial nerve symptoms underwent MRI evaluation. 13 patients were found to have inflammatory etiology, 12 patients had intracranial lesions involving the optic nerves and 5 patients had optic nerve tumors.

In 13 patients with optic neuritis, conventional sequences could identify the pathology in only 5 sequences, CISS sequence identified the pathology in 10 patients and MPRAGE sequence identified pathology in all 13 patients.

Non-inflammatory lesions were evaluated for lesion identification, signal intensity changes, enhancement after contrast administration. In 12 patients with intracranial lesions affecting optic nerves; even though other conventional sequences identified the lesions, CISS sequence gave extra information which could not be provided by conventional sequences in 8 patients.

Out of the 5 patients of optic nerve tumors all sequences identified the lesion but CISS sequence gave extra information regarding extent of involvement, extension into the orbital fissure etc.

DISCUSSION

Role of CISS sequence in inflammatory pathologies of cranial nerves:
In our study we encountered 13 patients with optic neuritis. In all cases T1w and T2w sequence did not pick up the lesion denoting that there is no role of these sequences in optic neuritis. MPRAGE has a sensitivity of 100%. CISS could visualize the lesion and signal intensity changes were observed in 76.9% (10/13) cases while enhancement on CISS was noted in only 53.8%(7/13). This supports the fact that MPRAGE having more T1w has better enhancement characteristics.

CISS sequence has an intrinsic T1 weighting due to which the post contrast enhancement is better appreciated within the nerve parenchyma than conventional post contrast T2 sequences. Since it also has inherent T2 weighting there is contrast difference between the brain parenchyma and CSF space resulting in better appreciation of the enhancement. MPRAGE being a post contrast 3D T1 weighted thin section sequence reveals better enhancement (Figure 1,2). Eventhough CISS sequence has T1 weighting it is not as heavily T1 weighted as MPRAGE. Moreover CSF shows low signal on T1 sequences therefore enhancement of the nerves can be identified easily as there is striking contrast between the low signal CSF and high signal enhanced nerve parenchyma.

In our study we experienced 100% sensitivity with MPRAGE in identifying the cranial nerve pathology and enhancement. In comparison between CISS and MPRAGE sequence there was a highly significant statistical difference with P value of less than 0.001 and Friedman test value of 32.116 and so MPRAGE should be included in all MR examinations during evaluation of inflammatory lesions of cranial nerves.

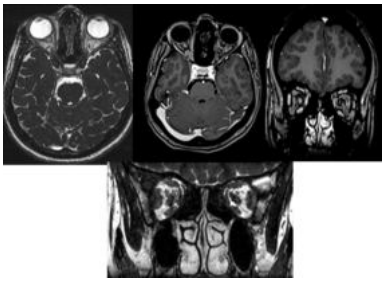

Figure 1 : Axial and coronal images of CISS and MPRAGE sequences. MPRAGE shows diffuse enhancement and thickening of the right optic nerve. No enhancement in the CISS sequence.

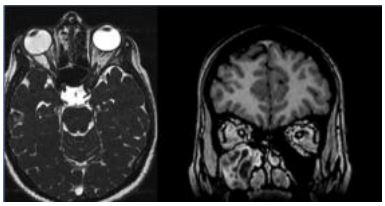

Figure 2: Axial CISS and MPRAGE images showing enhancement in the retro bulbar portion of the right optic nerve.

Role Of CISS Sequence In Primary Optic Nerve Tumors

Optic nerve Glioma is the most common tumor of optic nerve. Optic nerve glioma should be differentiated from the meningioma in the intraorbital region. Optic nerve glioma is also associated with neurofibromatosis type 1[7]. Bilateral optic nerve gliomas are almost pathognomic of neurofibromatosis type 1[8]. Intracanalicular extension of optic nerve Glioma is better assessed on CISS sequence as compared to MPRAGE sequence(Fig 3). This is because of high spatial resolution of CISS sequence and since canalicular portion and optic chiasm are surrounded by CSF, they can be easily identified on CISS sequence.

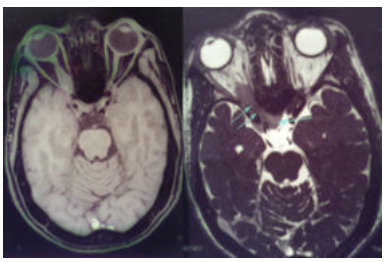

Figure 3: Axial sections of MPRAGE and CISS sequence in a patient with right optic nerve glioma. Involvement of canalicular portion and chiasmatic portion of right optic nerve is better visualized on CISS sequence (arrow).

Role Of CISS Sequence In Intracranial Tumors Involving Optic Nerves

Meningioma can also occur from the meningeal layer covering the optic nerve within the orbit. Intraorbital meningiomas are common and cause proptosis and visual symptoms. It can be identified by the tram track sign where the non enhancing optic nerve is seen within the enhancing tumor mass [9]. Intracannalicular Meningiomas although rare are easily missed. In these patients even thin layer of en-plaque tumor has significant visual symptoms if it is situated within the cannalicular segment. This is because the tumour has no place to grow due to bony constraints. These tumours are extremely small despite significant symptoms and hence can be easily overlooked [10].

Optic sheath meningiomas are usually fusiform shaped. They surround the optic nerve. The bright signal of CSF on CISS images seen surrounding the optic nerve is obliterated. Also, since it obliterates the CSF space a small fluid pocket is usually seen proximal to the extent of tumour which appears hyperintense because of inherent high signal of CSF of CISS sequence [11]. On the other hand, MPRAGE being a T1w sequence suppresses the CSF signal.

Pituitary tumors especially macroadenomas can enlarge superiorly and involve the optic nerve and chiasm. Figure 4 shows a large

pituitary adenoma involving the optic nerves. The mass is displacing the nerves superiorly and stretching them. It is also stretching the optic chiasm and indenting the optic tracts. These optic nerves are seen only on CISS and MPRAGE sequence and not on other sequence. They are even better delineated on CISS sequence as demonstrated in figure 4.

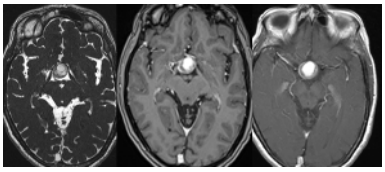

Figure 4: Axial CISS, MPRAGE and T1 sections reveal a pituitary macroadenoma. The tumour is indenting the optic nerve and chiasm which is seen on CISS and MPRAGE sequence but not on T1 sequence.

Figure 5 shows a large pituitary mass lesion with bleed within as evidenced by T1 hyperintensity suggesting pituitary apoplexy. In such cases there is sudden enlargement of the gland. It can enlarge and involve the optic nerve or occulomotor nerve. In figure 5 the gland is expanding superiorly and left laterally to involve the cisternal portion of left optic nerve and occulomotor nerve. The nerve is displaced laterally by the nerve. The involvement of the nerve is seen only on MPRAGE and CISS sequence and better appreciated on CISS sequence.

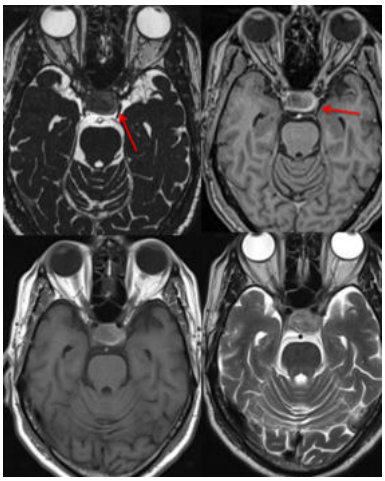

Figure 5: axial CISS, MPRAGE, T1 and T2 sequence shows a large pituitary lesion showing hyperintensity on T1 sequence which indicated bleed within. The mass in indenting the left occulomotor nerve as seen in CISS and MPRAGE sequence (arrow).

Many intraorbital tumors can affect the orbital portion of optic nerve. They can cause compression, indentation and change in course of optic nerve.

Figure 6 shows a large cavernous angioma of right orbit which is having extension into the optic canal. This extension can be better visualized on CISS images where it is compressing the canalicular portion of right optic nerve. Figure 7 shows a large orbital lympangioma indenting onto the orbital portion of right optic nerve and causing change in course of optic nerve.

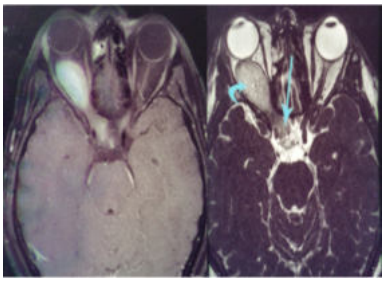

Fig6: Axial MPRAGE and CISS sequence images showing a large cavernous angioma of right orbit (Curved arrow). There is intracanalicular and cisternal extension of the lesion which is better visualized on CISS sequence (Straight arrow).

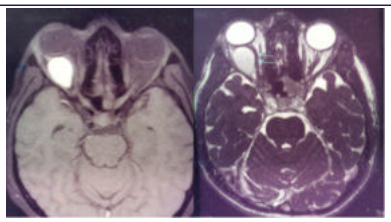

Fig7: Axial MPRAGE and CISS sequence images showing a large right orbital lympangioma causing indentation and changes in course of right optic nerve (Straight arrows).

In our study in comparison between CISS and MPRAGE sequence there was a highly significant statistical difference with P value of less than 0.001 and Friedman test value of 52.491 and so CISS sequence is better than other sequences in evaluating non inflammatory lesions of cranial nerves.

CONCLUSION

MR examination is essential in evaluating optic nerve lesions. On MR examination not just any sequence but dedicated thin section 3D sequences should be employed for their detection. The fact that which among the T1w or T2w sequence is superior for the detection of optic nerve lesions, is very debatable. CISS as a combination of both T1 and T2 weighting is explored in the detection of optic nerve lesions. It is also compared with thin section T1 sequence and conventional sequences. We have encountered that CISS sequence is superior to other sequences in detecting primary cranial optic tumors or other extra axial tumors involving the optic nerves. However, in the case of optic neuritis MPRAGE was superior to CISS in detecting the lesion. Hence during initial evaluation both the CISS and MPRAGE sequences should be included in the MR protocol, while for follow up cases the required sequence can just be employed.

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