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Comparison of computed tomography and magnetic resonance imaging in evaluation of skull lesions

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Abstract

Background: Computed tomography (CT) and magnetic resonance imaging (MRI) have been incorporated into the basic imaging tools for evaluation of skull lesions. Despite the known advantages and disadvantages of CT and MRI in various aspects of evaluating skull lesions, it is not always feasible to perform both CT and MRI in evaluation of the same patient. The purpose of this study is to compare CT and MRI in evaluation of various skull lesions and to determine which imaging modality out of the two is more appropriate in evaluation of skull lesions and their characterization.

Results: There was no statistically significant difference between CT and MRI for detection of number of lesions, distribution of lesions, margins of the lesions, nature of the lesions, zone of transition, cortical breach, intralesional calcification, intralesional hemorrhage, associated soft tissue, and invasion into brain parenchyma (p value > 0.05 in all these parameters). Dural involvement was picked up better on MRI as compared to CT (p value 0.031). Another advantage of MRI over CT was better characterization of lesions by diffusion weighted imaging.

Conclusion: CT and MRI are equally efficient in providing adequate diagnostic information in various skull lesions and each of them can be used independent of the other to characterize and diagnose the lesions of skull. The slight advantage of MRI over CT is detection of dural involvement.

Keywords: Computed tomography, Magnetic resonance imaging, Skull lesions, Diffusion weighted imaging

Background

Skull lesions are usually asymptomatic and incidentally discovered on radiological images obtained for other reasons [1]. They may also be discovered as a part of workup of local clinical symptoms or during staging of other diseases. Occasionally, patients with skull lesions may present as a palpable, visible or symptomatic lump. Clinical parameters such as the clinical history and age are important factors which help in radiological diagnosis [2]. Skull lesions can be categorized into true neoplasms (benign and malignant bone neoplasms), metastatic lesions and

non-neoplastic lesions, which represent congenital, traumatic, metabolic, hematologic, infectious, and idiopathic conditions [1]. Some of the lesions may extend beyond the skull into the scalp or the meninges. Other lesions may originate in the scalp or meninges and invade the adjacent skull bones. Some skull lesions have a predilection towards particular bones, and many have a tendency to involve extraosseous components [3].

Although histological confirmation is required for definitive diagnosis of skull lesions, it involves invasive procedures and cannot be used to determine the extent of lesion. Thus the diagnosis and therapeutic strategies applied to skull involved lesions predominantly depend on their imaging characteristics [4]. Skull X-ray is often the first imaging modality on which skull lesions are identified, but it plays a lesser role in diagnosis and its

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use is declining due to the availability of more accurate imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI) [5]. CT and MRI have been incorporated into the basic imaging tools for evaluation of skull lesions [3].

CT scan is commonly considered appropriate for bony lesion diagnosis, for evaluation of nature of the lesion (i.e. lytic or sclerotic), destruction of the inner or outer table, bony architectural change, calcification within the lesion, sclerotic margins, and the density of the lesion [6]. On MRI signal characteristics of the lesion, relation to brain parenchyma and soft tissues can be evaluated [7]. MRI helps to identify lesions at earlier stages while they are restricted to fat-containing diploic marrow and have not caused bony destruction, evaluate intracranial and extracranial soft-tissue extension, and to characterize matrix of the lesion [1]. Advanced MRI techniques, such as Diffusion weighted imaging (DWI) may supplement conventional imaging with respect to obtaining the physiological and functional information of skull lesions. Apparent diffusion coefficient (ADC) values of skull lesions inversely correlate with their cell density and can narrow the differential diagnoses for indeterminate skull lesions [8].

Although most of the skull lesions have no specific features, the imaging characteristics on CT and MRI (e.g., lytic, sclerotic, or mixed; diffuse or focal; single or multiple lesions) and clinical data (age, sex, and history of trauma, surgery or cancer) can guide the diagnosis and help to propose an appropriate therapeutic attitude [2]. Despite the known advantages and disadvantages of CT and MRI in various aspects, it is not always feasible to perform both CT and MRI in evaluation of the same patient and often the clinician and radiologist have to choose either CT or MRI. The aim of this study was to compare CT and MRI in evaluation of various skull lesions so that appropriate modality can be chosen for their characterization.

Methods

A single center, cross sectional study was conducted on 37 patients who presented to our department with symptomatic or asymptomatic skull lesions, after obtaining approval from the institutional ethics committee/review board. Informed consent was obtained prior to enrolment of patients into the study. Patients of all age groups and of either gender were included. All the patients were examined under a 32 slice CT scanner (Siemens Somatom Scope) in supine position and 1.5-Tesla MRI scanner (Philips Achieva D-stream) in supine position after placing a head coil.

CT scan protocol

- mAs: 270
- kVp: 130
- Slice thickness: 4–5 mm
- Scan time: 30–40 s
- Contrast enhanced CT: where required

MR imaging protocol: As described in Table 1

- Diffusion weighted sequence at b value 0, 500 and 1000 s/mm².
- Slice thickness: 4–5 mm
- Image interval: 1.5 mm
- Number of signal averages: 1–5
- Acquisition time: 15–25 min
- Post contrast sequences: where required

Patient inclusion criteria

1. Patients of all age groups and of either gender.
2. Patients who have symptomatic or asymptomatic skull lesions.
3. Patients who came for CT or MRI for evaluation of their skull lesions or for any other reason and in whom skull lesions were incidentally discovered on CT or MRI.

Exclusion criteria

1. Patients presenting with acute head trauma.
2. Pregnant females.
3. Patients with contraindication to MR imaging which are as follows:
 - a. Electronically, magnetically and mechanically activated implant e.g. cardiac pacemaker.
 - b. Ferromagnetic or electronically operated stapedial implants.

Table 1 MR imaging protocol

Sequences	TE (ms)	TR (ms)	FOV (mm ²)
T1 Weighted axial	8–25	400–550	210–230
T2 Weighted axial	90–120	3000–5000	210–230
DWI axial	100–150	5000–7500	210–230
FLAIR axial	100–125	6000–9000	210–230
SWI axial	13–15	500–700	210–230
T2 Weighted sagittal	90–120	3000–5000	220–260
T2 Weighted coronal	90–120	3000–5000	220–260
T1 Weighted sagittal and coronal (wherever required)	8–25	400–550	220–260

c. Cochlear implants.

Each patient's CT and MRI scan was then evaluated by two radiologists one with 20 years of experience and the other 3rd year radiology trainee. The CT and MRI scans were viewed separately and randomly with the observers blinded as in they did not know the patient identity or corresponding CT or MRI scan when viewing the scans. Each patient's CT and MRI scan was evaluated and compared for various points required for characterizing skull lesions including—Number of lesions (single or multiple), distribution of lesions (focal or diffuse), margins of the lesions (well defined or ill defined), nature of the lesions (lytic, sclerotic or mixed), zone of transition (narrow or wide), cortical breach, intralesional calcification, intralesional hemorrhage, dural involvement, associated soft tissue (intracranial, extracranial or both) and invasion into brain parenchyma. Diffusion restriction was evaluated on MRI only. Statistical analysis was carried out using SPSS 24.0 version. A p value of less than 0.05 was considered as significant.

Results

Out of 37 patients, 20 (54.1%) were females, 17 (45.9%) were males, and their ages ranged from 1 to 87 years with a mean age of 42.9 years. Various lesions encountered were: metastases [13 cases (35.1%); fibrous dysplasia [2 cases (5.4%); intraosseous hemangioma [2 cases (5.4%); multiple myeloma [2 cases (5.4%); osteoma [2 cases (5.4%); arachnoid granulations [2 cases (5.4%); carcinoma nasopharynx extending into skull base [2 cases (5.4%); atretic cephalocele [1 case (2.7%); calvarial tuberculosis [1 case (2.7%); chondroblastoma [1 case (2.7%); en-plaque meningioma with hyperostosis [1 case (2.7%); encephalocele [1 case (2.7%); eosinophilic granuloma [1 case (2.7%); epidermoid cyst [1 case (2.7%); fungal infection [1 case (2.7%); intraosseous lipoma [1 case (2.7%); leukemic infiltrates [1 case (2.7%); malignant mesenchymal tumor [1 case (2.7%)] and paget's disease [1 case (2.7%)]. The patients' main complaints were

swelling ($n=16$; 43.2%) and headache ($n=7$; 18.9%). Other presenting complaints included backache ($n=3$; 8.1%), body aches ($n=2$; 5.4%), exophthalmos ($n=2$; 5.4%), seizures ($n=2$; 5.4%) and altered sensorium ($n=1$; 2.7%). 4 patients (10.8%) were asymptomatic.

Number of lesions: Number of lesions detected were divided into one (solitary) or multiple (more than one). There was no statistically significant difference between CT and MRI for detection of number of lesions (p value 0.739) as indicated by Table 2.

Distribution of lesions: On the basis of distribution, lesions were divided into diffuse (involving more than one bone) or focal (limited to one bone). There was no statistically significant difference between CT and MRI for detection of distribution of lesions (p value 0.599) as indicated by Table 3.

Margins of lesions: Margins of lesions were divided into ill defined or well defined. There was no statistically significant difference between CT and MRI for detection of margins of lesions (p value 0.599) as indicated by Table 4.

Nature of lesions: On the basis of nature, lesions were divided into lytic, sclerotic or mixed. There was no statistically significant difference between CT and MRI for detection of nature of lesions (p value 0.717) as indicated by Table 5.

Zone of transition: Zone of transition was divided into narrow or wide. There was no statistically significant

Table 2 Number of lesions

No. of lesions	CT		MRI	
	No	%Age	No	%Age
Multiple	15	40.54	16	43.24
One	19	51.35	19	51.35
NA	2	5.41	2	2.70
NAD	1	2.70	0	2.70
Total	37	100.00	37	100.00

NA, not applicable; NAD, no abnormality detected

Table 3 Distribution of lesions

Distribution	CT		MRI	
	No	%Age	No	%Age
Diffuse	22	59.46	23	62.16
Focal	14	37.84	14	37.84
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 4 Margins of lesions

Margins	CT		MRI	
	No	%Age	No	%Age
Ill defined	21	56.76	22	59.46
Well defined	15	40.54	15	40.54
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 5 Nature of lesions

Nature of lesions	CT		MRI	
	No	%Age	No	%Age
Lytic	15	40.54	17	45.95
Mixed	16	43.24	14	37.84
Sclerotic	5	13.51	6	16.22
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 6 Zone of transition

Zone of transition	CT		MRI	
	No	%Age	No	%Age
Narrow	15	40.54	15	40.54
Wide	21	56.76	22	59.46
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 7 Cortical breach

Cortical breach	CT		MRI	
	No	%Age	No	%Age
No	12	32.43	14	37.84
Yes	24	64.86	23	62.16
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 8 Intralesional calcification

Intralesional calcification	CT		MRI	
	No	%Age	No	%Age
No	28	75.68	29	78.38
Yes	2	5.41	0	0.00
Blooming on SWI	0	0.00	2	5.41
NA	6	16.22	6	16.22
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

difference between CT and MRI for detection of zone of transition (p value 0.599) as indicated by Table 6.

Cortical breach: There was no statistically significant difference between CT and MRI for detection of cortical breach (p value 0.555) as indicated by Table 7.

Table 9 Intralesional hemorrhage

Intralesional hemorrhage	CT		MRI	
	No	%Age	No	%Age
No	29	78.38	29	78.38
Yes	1	2.70	0	0.00
Blooming on SWI	0	0.00	2	5.41
NA	6	16.22	6	16.22
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 10 Dural involvement

Dural involvement	CT		MRI	
	No	%Age	No	%Age
No	32	86.49	23	62.16
Yes	3	8.11	13	35.14
NA	1	2.70	1	2.70
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 11 Associated soft tissue

Associated soft tissue	CT		MRI	
	No	%Age	No	%Age
No associated soft tissue	20	54.05	20	54.05
Extracranial + intracranial soft tissue	6	16.22	8	21.62
Extracranial soft tissue only	9	24.32	7	18.92
Intracranial soft tissue only	0	0.00	1	2.70
NA	1	2.70	1	2.70
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Intralesional calcification: There was no statistically significant difference between CT and MRI for detection of intralesional calcification (p value 0.285) as indicated by Table 8.

Intralesional hemorrhage: There was no statistically significant difference between CT and MRI for detection of intralesional hemorrhage (p value 0.406) as indicated by Table 9.

Dural involvement: Dural involvement was picked up better on MRI as compared to CT (p value 0.031) as indicated by Table 10.

Table 12 Invasion into brain parenchyma

Invasion into brain parenchyma	CT		MRI	
	No	%Age	No	%Age
No	32	86.49	33	89.19
Yes	3	8.11	3	8.11
NA	1	2.70	1	2.70
NAD	1	2.70	0	0.00
Total	37	100.00	37	100.00

Table 13 Diffusion restriction

Diffusion restriction	CT		MRI	
	No	%Age	No	%Age
No	0	0.00	20	54.05
Yes	0	0.00	17	45.95
NA	37	100.00	0	0.00
Total	37	100.00	37	100.00

Associated soft tissue: Associated soft tissue was divided into extracranial, intracranial, both or none. There was no statistically significant difference between CT and MRI for detection and classification of associated soft tissue (p value 0.771) as indicated by Table 11.

Invasion into brain parenchyma: There was no statistically significant difference between CT and MRI for detection of invasion into brain parenchyma (p value 0.797) as indicated by Table 12.

Diffusion restriction: DWI done on MRI (Not applicable for CT) revealed diffusion restriction to be present or absent in various skull lesions. 17 lesions showed restricted diffusion and 20 showed no diffusion restriction as indicated by Table 13.

Discussion

Skull lesions are usually clinically silent and are discovered incidentally on radiographs, CT or MRI studies of patients done for other clinical reasons [9]. Occasionally, skull lesions may present as a palpable or symptomatic swelling/lump [10]. Since various skull lesions can occur due to a number of neoplastic, inflammatory, congenital, and traumatic etiologies, a well-organized approach to their characterization and diagnosis is essential [11]. Skull lesions may originate from the bones of skull or may occur as a result of invasion of skull by scalp based lesions, brain parenchymal based lesions or lesions at the base of skull such as nasopharyngeal carcinoma, lymphoma etc. [12]. Skull radiographs are usually the first imaging modality used to evaluate skull lesions however, due to various limitations of plain radiographs

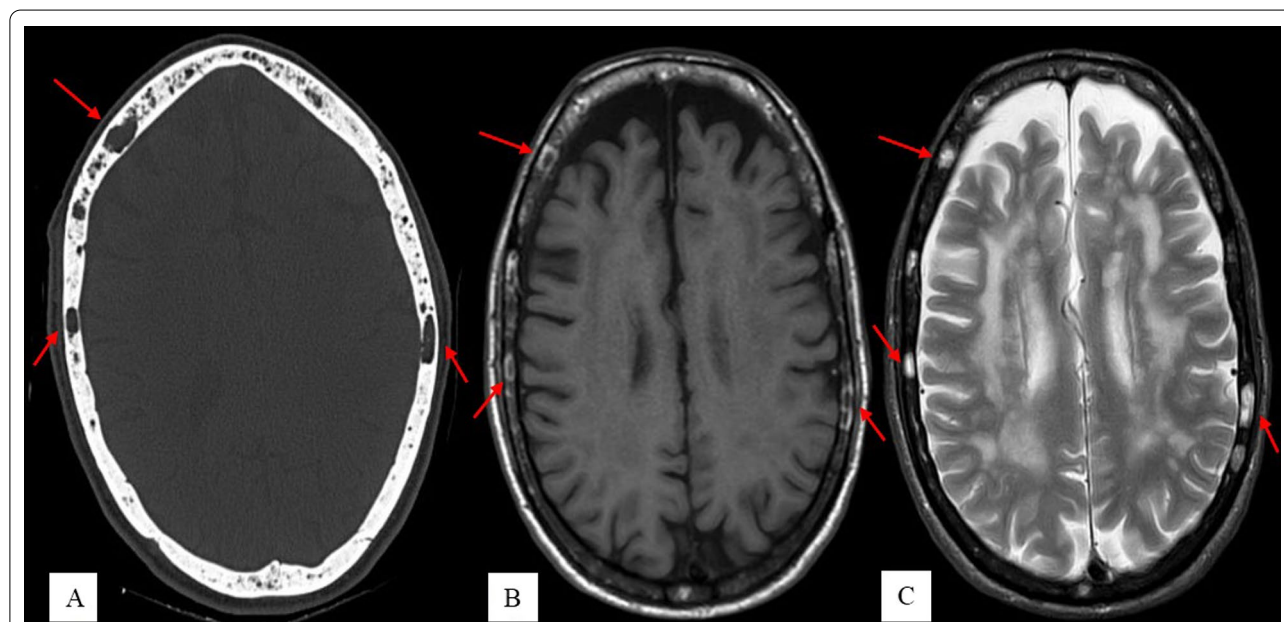
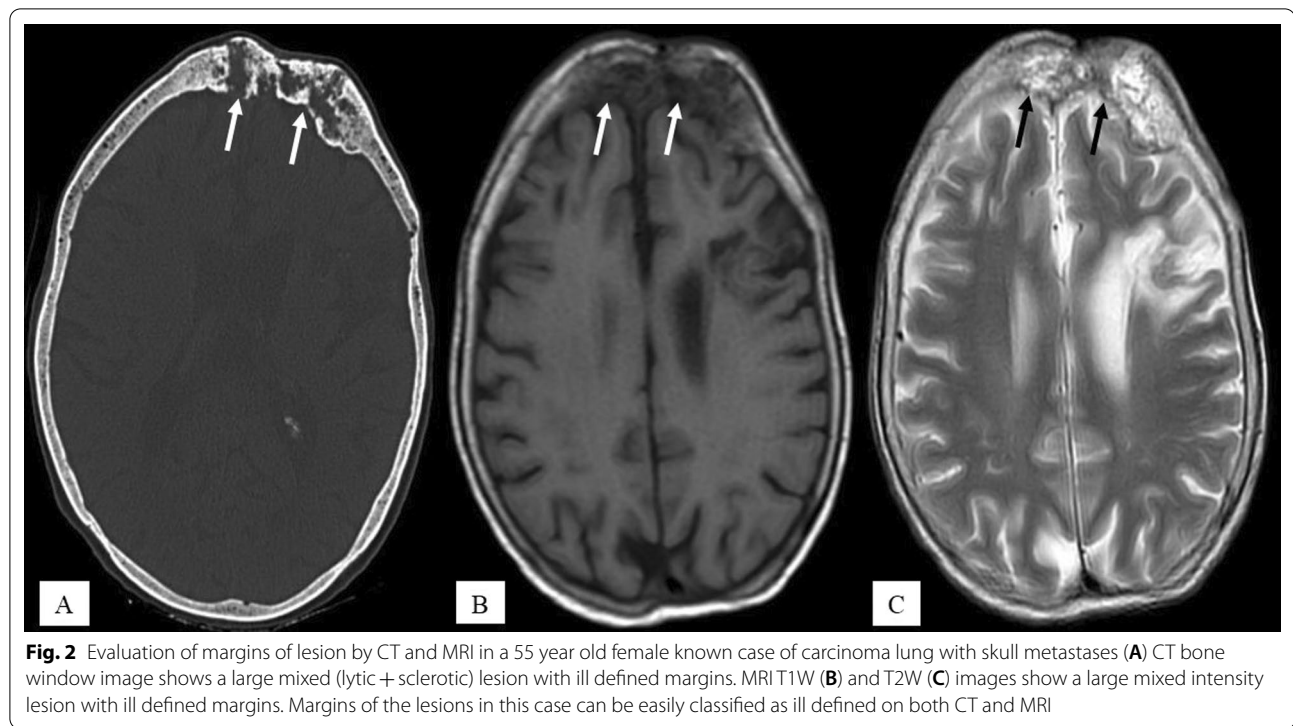


Fig. 1 Detection of number of lesions by CT and MRI in a 72 year old male known case of multiple myeloma (A) CT bone algorithm image shows multiple ill defined lytic lesions within the diploic space. MRI T1W (B) and T2W (C) images at the same level show multiple lesions appearing hypointense on T1W and hyperintense on T2W image. Both CT and MRI were able to depict multiple lesions in skull bones



in characterizing the skull lesions their role in diagnosing various skull lesions is limited. CT and MRI are preferred imaging modalities for evaluation of skull lesions and provide more accurate diagnostic information. However, in majority of clinical scenarios it is not always possible to perform both CT and MRI in evaluation of same skull lesion due to various factors such as availability, cost and concern of radiation exposure especially in paediatric population and pregnant females. In such scenarios, it is often the radiologist who has to make a decision. So there is a need to determine which imaging modality out of CT and MRI is more appropriate in evaluation of skull lesions and their characterization. In our study we have compared CT and MRI along various parameters which are required to characterize and diagnose a skull lesion. This provides the answer to the question whether to perform CT or MRI when faced with various clinical dilemmas.

The assessment of number of lesions is important in characterization of skull lesions as they point towards the diagnosis. Commonly encountered solitary (single) lesions of skull include traumatic lesions, osteoma, cavernous hemangioma, lipoma, osteomyelitis, epidermoid cyst, dermoid cyst and encephalocele. Multiple lesions represent more malignant or widespread systemic disease process such as metastases, multiple myeloma, lymphoma, paget's disease, hyperparathyroidism and bone marrow hyperplasia. CT and MRI can help in identifying

the number of lesions and aid in assessing response to therapy and diagnosing local recurrence [1]. In our study, the number of lesions that were detected in various cases by CT and MRI were almost same (p value 0.739) (Fig. 1). CT detected multiple lesions in 15 cases and solitary lesions in 19 cases where as MRI detected multiple lesions in 16 cases and solitary lesions in 19 cases. Uggas et al. concluded that multiple lesions are associated with malignant diseases like metastases and multiple myeloma more frequently [5]. Similar results were found in our study where 10 out of 16 cases with multiple lesions were metastases and 2 cases with multiple lesions were multiple myeloma.

In a study done by Mitsuya et al., skull metastatic skull tumors were classified on the basis of distribution into circumscribed and diffuse. Circumscribed lesions were the ones which were confined to one bone and diffuse lesions were the ones which crossed a suture to involve another bone [13]. Similarly in our study we classified skull lesions into diffuse (involving more than one bone) and focal (involving single bone). The presence of multifocal lesions or diffuse osseous involvement is suggestive of an underlying systemic cause or widespread disease process [14]. A focal calvarial lesion can be due to primary bone condition, congenital condition or a manifestation of underlying systemic disease. The diffuse or extensive lesions are Paget's disease, bone marrow hyperplasia (thalassemia), metastases, bone marrow turnover

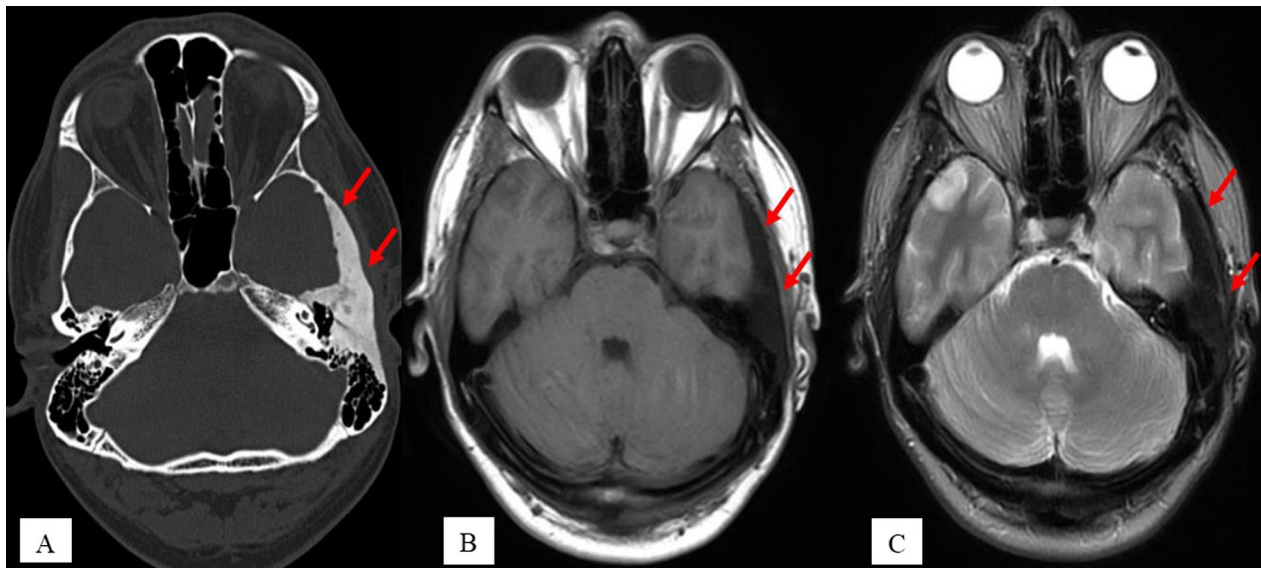


Fig. 3 Determination of nature of lesion by CT and MRI in a 25 year old male (A) CT bone algorithm image shows well defined expansile sclerotic lesion giving ground glass appearance involving squamous and mastoid part of left temporal bone. MRI shows expansile sclerotic lesion involving squamous and mastoid part of left temporal bone appearing hypointense on both T1W (B) and T2W (C) images. This was a case of fibrous dysplasia. Both CT and MRI were able to classify the nature of the lesion to be sclerotic in this case

abnormalities (hyperparathyroidism), myeloma, Langerhans histiocytosis and fibrous dysplasia. Focal lesions can be dermoid cyst, epidermoid cyst, osteomyelitis, aneurysmal bone cyst, osteoma or hemangioma. In our study, CT scan detected diffuse distribution in 22 cases and focal in 14 cases. MRI detected diffuse distribution in 23 cases and focal in 14 cases. There was no statistically significant difference between CT and MRI for detection of distribution of lesions (p value 0.599). Diffuse lesions in our study were metastases (12 cases), multiple myeloma (2 cases), carcinoma nasopharynx extending into skull base (2 cases), paget's disease (1 case), malignant mesenchymal tumor (1 case), calvarial tuberculosis (1 case), fungal infection (1 case), arachnoid granulations (1 case), en-plaque meningioma with hyperostosis (1 case) and leukemic infiltrates (1 case). Focal lesions included intraosseous hemangioma (2 cases), osteoma (2 cases), fibrous dysplasia (2 cases), atretic cephalocele (1 case), chondroblastoma (1 case), intraosseous lipoma (1 case), metastases (1 case), epidermoid cyst (1 case), encephalocele (1 case), arachnoid granulations (1 case) and eosinophilic granuloma (1 case).

The type of margins can be well defined or ill defined. A lesion with clearly demarcated margins with narrow zone of transition suggests slow growth, whereas an ill-defined margin with a wide zone of transition suggests a more aggressive lesion [15]. In our study, ill-defined margins were detected in 21 cases by CT and in 22 cases by MRI and well defined margins were detected in 15

cases by both CT and MRI. All the cases with ill defined margins had wide zone of transition. There was no statistically significant difference between CT and MRI for detection of type of margin (p value 0.599) and detection of zone of transition (p value 0.599) (Fig. 2). Tu et al. concluded that presence of cortical defects or break through or ill-defined lesion were important factors in differentiating benign and malignant lesions [16]. Another study conducted by Gomez et al., they concluded that benign lesions have well defined margins with a narrow zone of transition whereas malignant lesions have poorly defined margins with a wide zone of transition [17]. Similar results were found in our study where all 15 cases with well-defined margins were found to be benign diseases including fibrous dysplasia, intraosseous hemangioma, osteoma, arachnoid granulations, atretic cephalocele, calvarial tuberculosis, chondroblastoma, encephalocele, eosinophilic granuloma, epidermoid cyst and intraosseous lipoma whereas ill-defined margins were present mainly in malignant diseases, except for fungal disease and paget's disease.

The nature of lesion can be lytic, sclerotic or mixed (lytic + sclerotic). The presence of lytic lesion represents aggressive nature of lesion and a sclerotic lesion may suggest a long standing lesion with remodelling [16]. In our study, CT detected lytic lesions in 15 cases, mixed lesions in 16 cases and sclerotic lesions in 5 cases whereas MRI detected lytic lesions in 17 cases, mixed lesions in 14 cases and sclerotic lesions in 6 cases. There was no

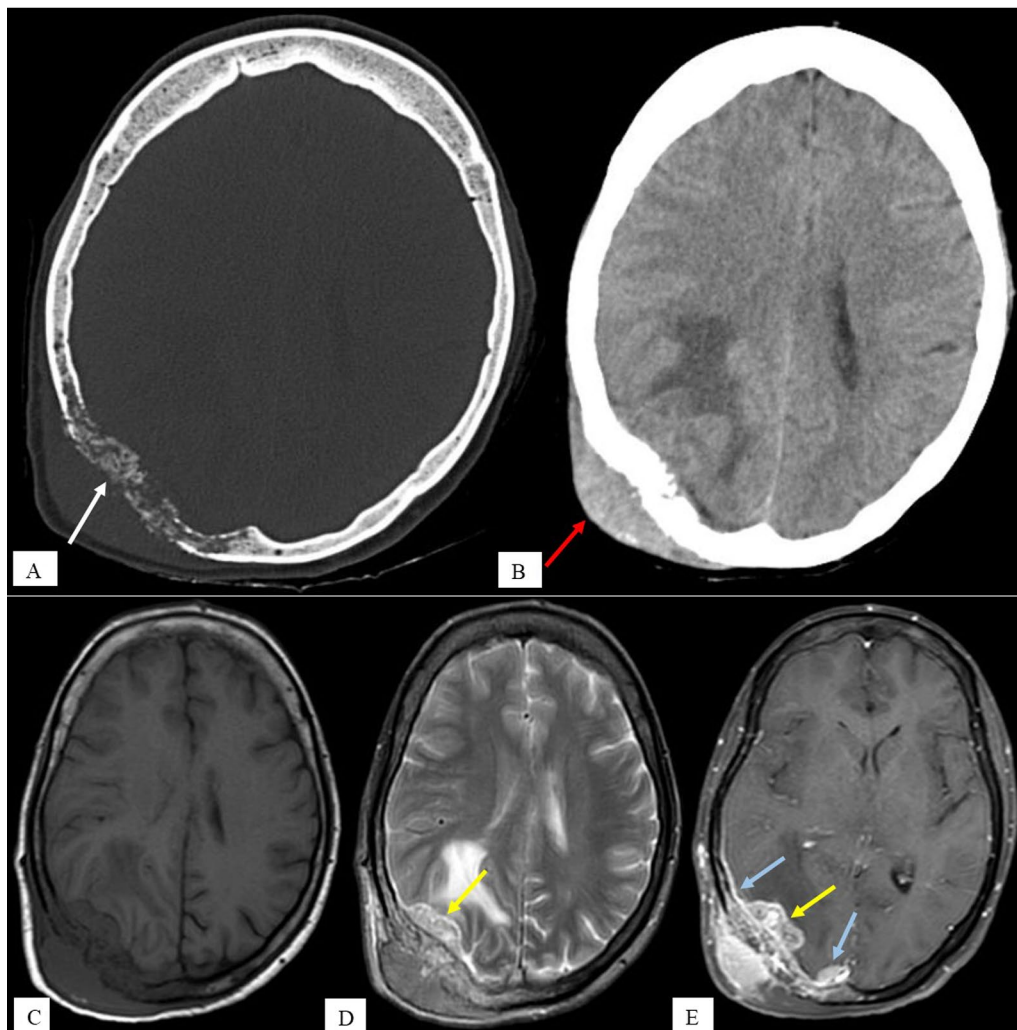


Fig. 4 Evaluation of dural involvement in a 51 year old lady with skull metastases from carcinoma breast- CT bone window (A) and soft tissue window (B) images show a large mixed (lytic + sclerotic) lesion (white arrow) in right parieto-occipital region with associated heterogeneous soft tissue mass (red arrow). No obvious dural involvement can be seen on CT. MRI T1W (C), T2W (D) and post contrast T1W (E) images clearly show enhancing adjacent dural thickening (yellow arrows) with dural tail sign (blue arrows)

statistically significant difference between CT and MRI for detection of nature of lesions (p value 0.717). The lytic lesions found in our study were malignant mesenchymal tumor, eosinophilic granuloma, encephalocele (defect in bone), epidermoid cyst (defect in bone), multiple myeloma, metastases, intraosseous lipoma, atretic encephalocele (defect in bone) and fungal disease. The sclerotic lesions included fibrous dysplasia (ground glass matrix on CT), metastases, meningioma and osteoma. The mixed lesions were found to be metastases, nasopharyngeal carcinoma extending into the skull base, paget's disease, multiple myeloma, fibrous dysplasia, intraosseous hemangioma and calvarial tuberculosis. Although there was no statistically significant difference between CT and

MRI in determining the nature of lesion, CT still offered some advantage in evaluating the nature for example in cases with fibrous dysplasia typical ground glass matrix was seen on CT whereas on MRI, we could classify it as only sclerotic lesion (appearing hypointense on both T1W and T2W images) (Fig. 3).

Detection of cortical breach is important as benign lesions can be contained within the cortical tables but aggressive lesions extend through tables destroying bone [3]. We found that CT scan detected cortical breach in 24 cases (64.86%) and MRI detected in 23 cases (62.16%) but there was no statistically significant difference (p value 0.555). According to Garfinkle et al., CT is better than MRI in determining the involvement of each of the

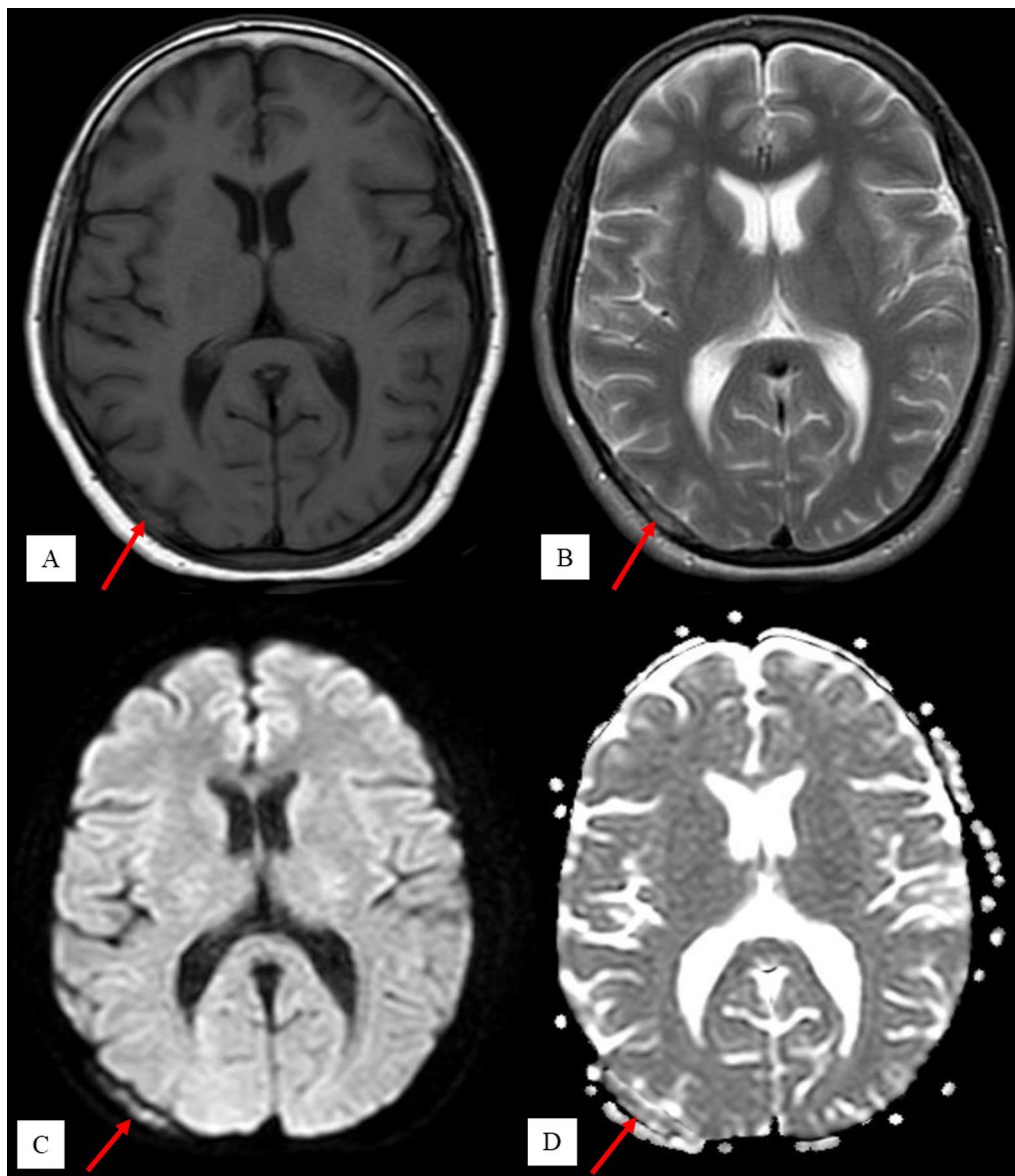


Fig. 5 Demonstration of diffusion restriction in skull lesion in 60 year old female with skull metastases from carcinoma breast- An ill defined lesion appearing hypointense on T1W (A) and hyperintense on T2W (B) images is seen in right parieto-occipital region. The lesion shows restricted diffusion appearing hyperintense on diffusion weighted image (C) and hypointense on ADC map (D). Mean ADC value was $0.636 \times 10^{-3} \text{ mm}^2/\text{s}$

two skull tables [3] but it was different from our study as there was no significant difference in detection of cortical breach by CT and MRI. Intralesional hemorrhage was seen in 1 case and intralesional calcification was seen in 2 cases. There was no statistically significant difference between CT and MRI for detection of intralesional calcification (p value 0.285) and intralesional hemorrhage (p value 0.406).

It is important to determine involvement of dura in skull bone lesions as it is an important prognostic feature

[18]. Calvarial neoplasms with aggressive behaviour may grow intracranially to involve the dura mater with possible secondary brain involvement [19]. In our study, MRI detected dural involvement in 35.14% cases (13 cases) in comparison to CT, which could only detect dural involvement in 8.11% cases (3 cases) (Fig. 4). This difference was statistically significant (p value 0.031). We found that dural involvement is picked better by MRI which was similar to conclusion by Antony et al. that pachymeningeal enhancement, synonymous with dural enhancement,

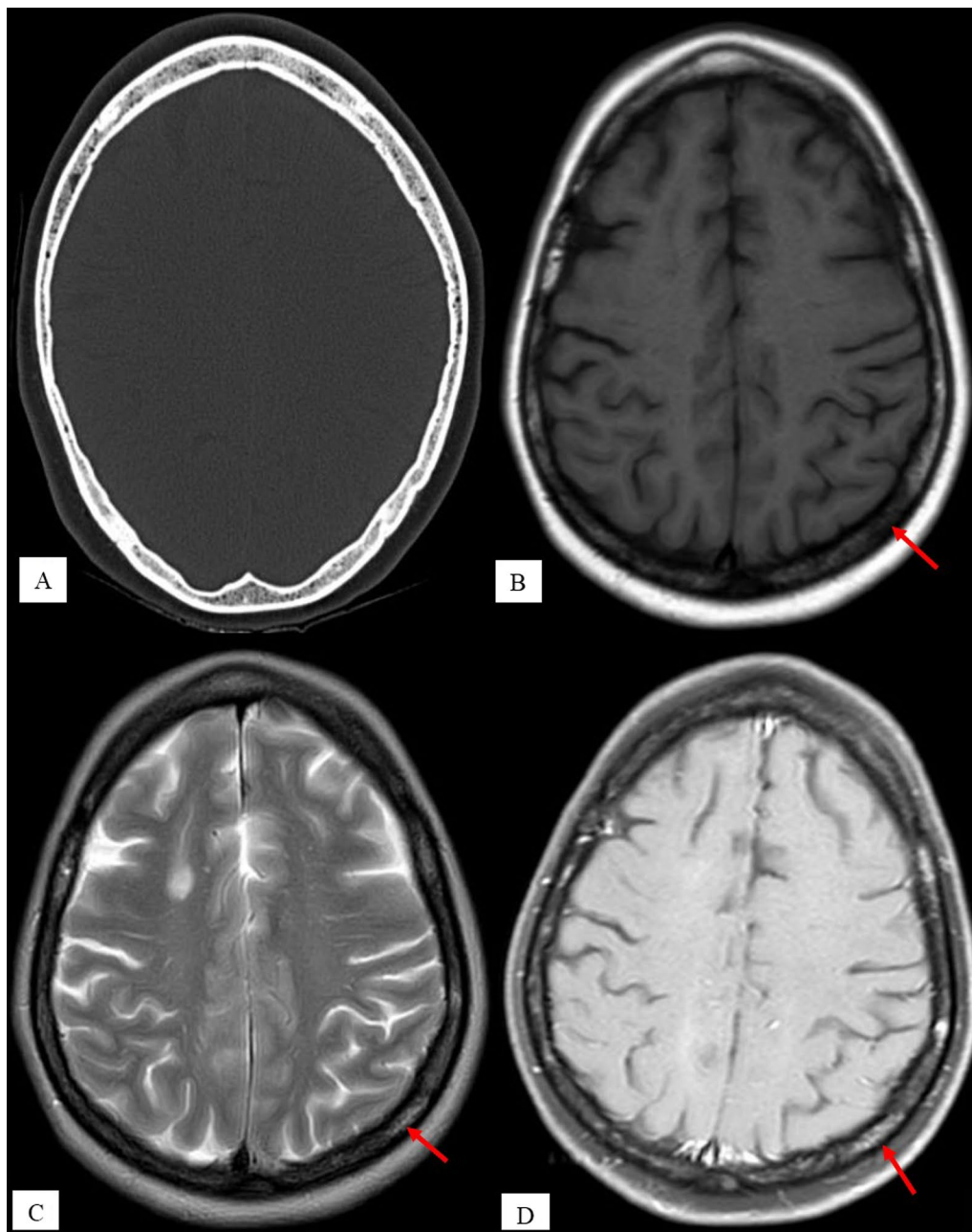


Fig. 6 Detection of lesions confined to bone marrow by MRI in a 38 year old female known case of leukemia- CT bone window image (A) shows no abnormality. MR images demonstrate altered marrow signal intensity with few areas appearing hypointense on T1W (B) and hyperintense on T2W (C) images, showing enhancement on post contrast T1W images (D). These lesions represent leukemic infiltrates which were not picked up by CT

is a radiological feature best appreciated on MRI [20]. In a study done by Kraus et al., dura was more accurately assessed by MRI than CT scan in 7 out of 22 cases [21]. It was similar to our study where dural involvement was better picked up on MRI in 10 out of 13 cases as compared to CT. In a study done by Arana et al., they

found that malignant lesions presented more with dural involvement as compared to benign lesions [10]. Similar results were found in our study as dural involvement was seen in 11 cases presenting with metastases and 1 case of multiple myeloma. Only 1 benign lesion demonstrated dural involvement and it was a case of meningioma.

Extracranial or intracranial soft tissue and invasion into brain parenchyma is a sign of advanced and aggressive disease usually malignant in nature [3]. Out of 37 cases, 20 cases (54.05%) didn't show any associated soft tissue on both CT and MRI. CT detected extracranial soft tissue in 9 cases and both intracranial and extracranial soft tissue in 6 cases. MRI detected both intracranial and extracranial soft tissue in 8 cases, only extracranial soft tissue in 7 cases and only intracranial soft tissue in 1 case. Both CT and MRI showed invasion into brain parenchyma in 3 cases i.e., in cases of metastases (two cases of carcinoma breast and one case of carcinoma parotid). In a study done by Amaral et al. they stated that MRI is better modality to detect lesion extension into intracranial and extra-axial spaces [22]. Lloret et al. also concluded that MRI is better imaging modality for evaluation of intracranial and extracranial soft tissue extension [12]. In a study done by Yalçın et al., they stated that MRI is better than CT in demonstrating lesions that have an associated soft tissue component and parenchymal involvement [7]. However, in our study we found no statistically significant difference between CT and MRI for detection of associated soft tissue (p value 0.771) and invasion into brain parenchyma (p value 0.797).

MRI offers additional advantage in characterization of skull lesions with DWI. DWI can help in identifying highly cellular malignant lesions which reveal restriction of diffusion [5]. ADC (Apparent Diffusion Coefficient) values in malignant skull lesions are significantly lower than ADC values in benign lesions [23]. In a study conducted by Tu et al., they concluded that malignant skull lesions show restricted diffusion with mean ADC value significantly lower than that of benign entities [16]. Similar results were seen in our study with 17 lesions demonstrating restricted diffusion and out of these 17 cases 13 were malignant diseases (including metastases, carcinoma nasopharynx extending into skull base, multiple myeloma and malignant mesenchymal tumor) (Fig. 5).

Although CT and MRI were comparable in evaluating most of the above mentioned characteristics of skull lesions, we encountered one case in which CT could not detect any abnormality within the skull bones whereas MRI showed multiple T2 hyperintense lesions within the diploic space showing enhancement on post contrast T1W images. This patient was a known case of leukemia. The lesions in skull represented leukemic infiltrates (Fig. 6). These findings are in accordance with the conclusion of study conducted by Amaral et al. [22] which states that MRI can show abnormalities of bone marrow even before development of cortical destruction which is only picked later on by CT.

Limitations of the study

One of the limitations of our study was the limited number of patients. Another limitation was that the majority of patients attending our institution are cancer patients. This reflects in our study as most of our cases were metastases.

Conclusions

CT and MRI are equally efficient in providing adequate diagnostic information in various skull lesions. The slight advantage of MRI over CT is detection of dural involvement and DWI which can help in further tissue characterization. Early lesions limited to diploic space may only be picked up by MRI. Apart from these few exceptions, CT and MRI can be used independent of each other to characterize and diagnose the lesions of skull. Since both CT and MRI are comparable in characterization of skull lesions, CT can be used where cost or availability of MRI is an issue and it can be avoided in pediatric population and pregnant females where MRI can be used. MRI can also be preferred where repeated follow ups are required to avoid excessive radiation exposure.

Abbreviations

ADC: Apparent diffusion coefficient; CT: Computed tomography; DWI: Diffusion weighted imaging; MRI: Magnetic resonance imaging; NA: Not applicable; NAD: No abnormality detected.

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Nil.

Authors' contributions

VA: Conceptualization, methodology, validation, formal analysis, writing—original draft, review and editing, visualization, supervision and project administration. BSS: Conceptualization, methodology, formal analysis, writing—original draft, review and editing, visualization and project administration. KS: Conceptualization, methodology, validation and supervision. All the authors have read and approved the submitted version and have agreed both to be personally accountable for their contributions and to ensure that the questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author.

Declarations

Ethics approval and consent to participate

This study is in accordance with the ethical standards of Institutional Review Board and the Declaration of Helsinki. The full name of the IRB/IRC Issuing committee: Research and ethical committee SGRDIMSAR, Amritsar. The reference number of IRB/IRC approval: SGRDU/cont/thesis/20–805. Yes, the study has obtained written informed consent from the study participants.

Consent for publication

Yes.

Competing interests

The authors declare that they have no competing interests.

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