Diagnostic Accuracy of Magnetic Resonance Imaging in Evaluation of Uterine Scar in Previous Caesarean Section

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Abstract: ***Caesarean section (CS) is one of the most frequent abdominal surgical operations carried out in recent time. The World Health Organization suggests a medically adequate Caesarean delivery rate of 10%-15% to assure optimal prognosis for both mother and children.1[0]The present study aims at the evaluation of post-caesarean uterine scar using magnetic Resonance Imaging in assessment of post-caesarean uterine scar and tried to the grades of uterine scar and probability of scar ruptures.***

Keywords: caesarean section, MRI, lower sement caeserean section, vaginal birth after caeserean section, scar dehiscence, scar rupture

1. Introduction

Caesarean section (CS) is one of the most frequent abdominal surgical operations carried out in recent time. The World Health Organization suggests a medically adequate Caesarean delivery rate of 10%-15% to assure optimal prognosis for both mother and children.2[6] However Caesarean Section rate varies from about 20% to 50%, depending on the country and clinical environment. This variation is attributable to a combination of factors, including the medical training, patient choice and the risk of litigation. The increasing CS rate and its associated complications has stimulated an interest in the behaviour of CS scars and their associated potential morbidity.1

A worldwide increase in the rate of deliveries conducted by lower segment caesarean section (LSCS) has been documented over the last two decades with resultant increase in the proportion of women with previous caesarean births requiring obstetric care during repeat pregnancies. The challenge faced by an obstetrician is to decide between a repeat caesarean versus vaginal birth after caesarean (VBAC), as later leads to increased chance of uterine scar dehiscence/rupture during labor, and consequent high maternal and neonatal mortality and morbidity. Despite a high success rate of VBAC (50-85%) obstetrician remain apprehensive for scar rupture, hence patient mostly end having repeat caesarean deliveries.2

Uterine scar dehiscence may present as an acute event in the antenatal or intrapartum period, leading to significant fetal and maternal morbidity. The frequency of uterine rupture is estimated at 0.2–3.8% and that of uterine dehiscence is between 0.6 and 3.8%. Uterine rupture is a rare complication, but has the potential of causing severe fetal morbidity, including asphyxia, neurological sequelae and even death. Uterine rupture can also be responsible for maternal complications, such as genitourinary tract damage, hemorrhage, shock and hysterectomy. Therefore, it is important to improve the evaluation of the risk of uterine rupture before attempting vaginal delivery after a previous Caesarean section.3

The method currently used to predict CS scar rupture is ultrasonographic measurement of the thickness of the uterine segment in gestational week 36-38 as pioneered by Rozenberg[6] et al. The recent meta-analysis by KoK at al. supports the use of LUS thickness for predicting uterine rupture.4

Scar thickness and composition of scar tissue also play a significant role in scar dehiscence. Magnetic resonance imaging (MRI) imaging of CS scar has not been commonly reported because MRI is an expensive imaging tool and is not often requested for investigations of abnormal uterine bleeding or other noncancerous pathologies. However MRI is a safe imaging modality during pregnancy that provides accurate tissue differentiation without the need of contrast agents and independent of patient constitution or other ultrasound limitations. Magnetic resonance imaging (MRI) is known to have the best soft tissue contrast resolution among all imaging modalities and some early work has been proposed for evaluation of post-caesarean uterine scar using this technology. The period of healing and the related changes in the incision scar after caesarean sections play an important role either in timing of the next pregnancy or evaluation of section techniques. On the other hand, there is little knowledge about the MRI appearance of normal pelvis after caesarean sections. As opposed to ultrasonography, which is current gold standard for this purpose, MRI reduces the observer dependence and has superior multiplanar capability[2, 5]

Therefore, we sought to assess feasibility and reliability of LUS and scar imaging with 1.5 T MRI in a low-risk group of pregnant women after previous CS with inconspicuous ultrasound findings.

The present study aims at the evaluation of post-caesarean uterine scar morphology using multi-parametric MRI and comparing accuracy of MRI in assessment of post-caesarean uterine scar and tried to correlate the imaging morphology with the grades of uterine scar and probability of scar ruptures.

Aims and Objectives

To assess diagnostic accuracy of Magnetic resonance imaging in evaluation of uterine scar

2. Materials and Methods

This study was aimed to compare diagnostic accuracy of Magnetic resonance morphometry in assessment of post-caesarean uterine scar and correlation with operative finding and was carried out on patients being referred to Department of Radiodiagnosis from Obstetrics and Gynaecology department of Indira Gandhi Medical College and hospital, Shimla. Patient of gestational age 36-39weeks with history of previous caesarean section were included.

The research procedure was in accordance with the approved ethical standards of Indira Gandhi Medical College and Hospital, Shimla, Ethics Committee.

Study design: Prospective observational comparative study

Study duration: 15 July 2019 to 15 July 2020

No of cases: 30

Inclusion Criteria:
- Age 20 to 35 years
- Gestational age 36-39 weeks
- Having atleast one previous caesarean section
- All Booked and un-booked antenatal patient

Exclusion criteria:
- Patient with multiple pregnancies
- Polyhydramnios
- Oligohydramnios
- Low lying placenta
- Patients with history of uterine surgery other than caesarean section
- Having contra-indication to MRI

Protocol for magnetic resonance imaging

MRI was done on a 1.5-Tesla system (Siemens Healthcare Avanto) with an actively shielded whole body superconducting magnet. Imaging was done using an 8-channel Torso phased-array body coil with the patient in the supine position and a moderately full urinary bladder.

Signal improvement was done by addition of integrated spine elements. Saturation bands were applied over the abdomen to eliminate bowel peristalsis and fetal movement artefacts. The focus of imaging was tapered down on pelvis with the field of view just enough to cover the area (40cm).

Standard protocol was followed consisting of T1W and T2W imaging sequences in axial and sagittal planes remaining perpendicular to the long axis of the scar.

Following sequences obtained:
- T1 Axial
- T1 Sagittal
- T2 Axial
- T2 Sagittal
- DW and ADC map sagittal

Initial single shot localizers was taken in to define the uterine scar (similar to the method followed by sonography), followed by oblique images which were exactly perpendicular to scar. This exercise was done to eliminate errors of over and underestimation due to foreshortening or widening of the region in either plane. The measurements were taken in T2 mid-sagittal image at the thinnest portion of the scar (Figure 1).

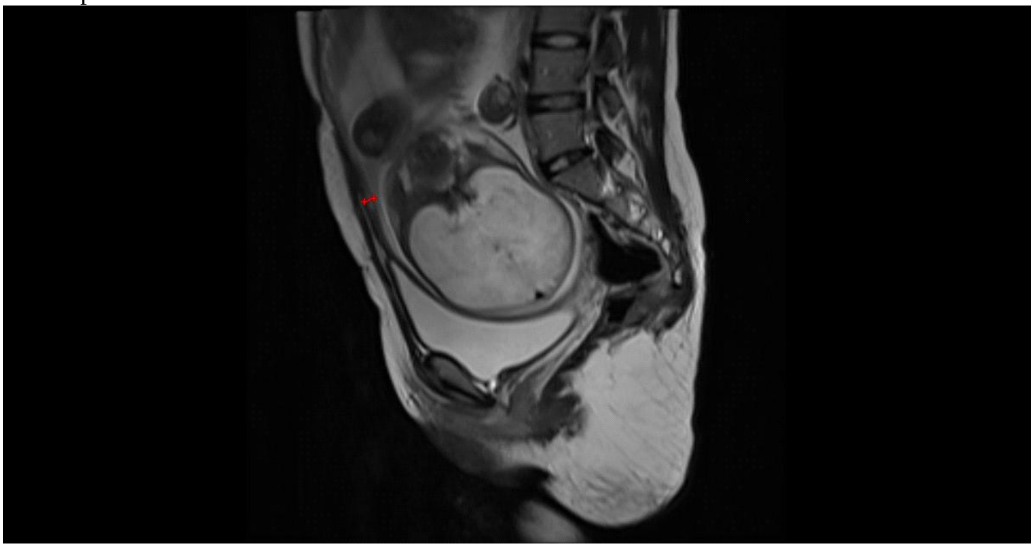

Figure 1: Method of measuring scar thickness on sagittal T2 WI

Intraoperative assessment: Patient undergoing repeated LSCS after delivery of baby and placenta measurement of lower flap of incision line was measured by vernier calliper and in 3 reading were noted down.

Average of 3 readings taken was recorded with the vertical bar of the calliper being as parallel to the interface as possible. The examination was aborted in case a uterine contraction and was repeated after 30 seconds.

Protocol for surgical scar grading

The LUS was assessed and graded according to the system developed by Qureshi et al.7 during surgery:
Grade I: Well-developed LUS.
Grade II: Thin LUS, content not visible.
Grade III: Translucent LUS, content visible.
Grade IV: Well-circumscribed defect either dehiscence or rupture.
Grades IV and III will be considered abnormal LUS intraoperatively, and grades I and II will be considered normal.

Based on the surgical grading of the scar, patients in the study group were divided into four groups:
1) Group I-Patients with Surgical Grade I scars
2) Group II-Patients with Surgical Grade II scars
3) Group III-Patients with Surgical Grade III scars
4) Group IV-Patients with Surgical Grade IV scars

Statistical Ananlysis

Data was entered into MS excel spreadsheet, cleaned and transferred to EPIINFO Version 7.2 software. The values of continuous variables were presentedas Mean + SD. Pearson correlation test and chi-square test was used for data analysis. A P value < 0.05 was considered significant. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) was calculated.

3. Observations and Results

A prospective study was conducted in department of Radio-diagnosis Indira Gandhi Medical College and hospital, Shimla (H. P) from July 2019 to July 2020. Thirty pregnant women with previous history of atleast one lower segment caesarean section were included in the study. Four patients had full term normal vaginal deliveries. MRI could not be done in one claustrophobic patient, hence total of 5 patients were excluded from the study. Finally 25 patients were included in the study and results are as follows.

1) Age distribution of the patients:

Age of the patients ranged from 20 years to 35 years. Mean age was 27 years. Minimum age was 22 years and maximum age was 35 years. Most of the patients (48%) were between 20 to 25 years.

Table 1: Showing Age distribution of the patients

Age Group (years)	No of patients	Percentage (%)
20-25	12	48%
25-30	10	40%
30-35	3	12%

2) Number of Previous LSCS

Table 2: Patients with number of previous LSCS

No of previous LSCS	No of patients	Percentage (%)
1	17	68%
2	6	24%
3	2	8%

In our study 17 patient (68%) had single time previous LSCS, 6 patient (24%) had two time previous LSCS and only 2 patient (8%) had three time previous LSCS.

3) Patients were divided into four groups based upon the surgical grading of scar and are labelled as group I, group II, group III and group IV:

Table 3: Number of patients in different groups

Surgical Group	No of patients	Percentage (%)
I	6	24%
II	9	36%
III	10	40%
IV	0	0%

In our study 10 patient (40%) were in surgical group III scar, 9 patient (36%) had surgical group II scar and 6 patient (24%) had surgical group I scar. No patient in surgical group IV scar.

4) Mean LSCS scar thickness as measured on MRI and surgery were calculated in each group. These mean values of LSCS scar thickness were comparedwith different groups.

Group I

Table 4: Showing thickness of LSCS scar on MRI in surgical Group I patients

Patient no	Group I Scar thickness (mm)	
	Intra-operative	MRI
Patient 1	3.2	4.4
Patient 5	4.2	3.5
Patient 6	4.0	3.4
Patient 10	3.4	3.8
Patient 20	3.4	3.9
Patient 22	3.9	3.2
Mean	**3.78**	**3.53**
SD	**0.33**	**0.27**

Table 5: Comparison of Mean Scar thickness (mm) between Intra-operative and MRI in Grade I group.

Technique	Mean	SD	Mean difference	t value	P value
Intra-operative	3.78	0.33	0.25	1.105	0.319 NS
MRI	3.53	0.27			

Statistical Analysis: Paired t test.
S: indicates significant at 5% level of significance
NS: Not significant

In Group I women Mean scar thickness was 3.53±0.27mm on MRI.
On comparing the mean Scar thickness (mm) in group I, the difference was insignificant for MRI versus intraoperative (p < 0.319).

Group II:

Table 6: Showing Thickness of LSCS scar on MRI in surgical Group II patients

Patient no	Grade II Scar thickness (mm)	
	Intra-operative	MRI
Patient 2	3.1	3.0
Patient 7	2.8	3.1
Patient 12	2.8	2.5
Patient 16	2.6	2.7
Patient 17	3.0	3.1
Patient 21	3.0	3.6
Patient 23	3.0	2.3
Patient 24	3.8	3.4
Patient 25	3.2	3.6
Mean	**2.97**	**3.14**
SD	**0.20**	**0.65**

Table 7: Comparison of Mean Scar thickness (mm) between Intra-operative and MRI in Group II patients

Technique	Mean	SD	Mean difference	t value	P value
Intra-operative	2.97	0.20	-0.17	0.979	0.356 NS
MRI	3.14	0.65			

Statistical Analysis: Paired t test.
S: indicates significant at 5% level of significance

In Group II women Mean scar thickness was 3.14±0.65mm on MRI.

On comparing the mean Scar thickness (mm) in group II, the difference was insignificant MRI versus intraoperative (p< 0.356).

Group III:

Table 8: Showing thickness of LSCS scar on MRI in surgical Group III patients

Patient no	Grade III Scar thickness (mm)	
	Intra-operative	MRI
Patient 3	2.2	2.1
Patient 4	2.3	2.5
Patient 8	1.5	3.0
Patient 9	2.2	3.2
Patient 11	2.4	2.7
Patient 13	1.8	2.9
Patient 14	1.6	2.8
Patient 15	2.2	3.7
Patient 18	2.1	2.3
Patient 19	2.5	3.4
Mean	**2.08**	**2.86**
SD	**0.34**	**0.49**

Table 9: Comparison of Mean Scar thickness (mm) between Intra-operative and MRI in Group III patients

Technique	Mean	SD	Mean difference	t value	P value
Intra-operative	2.08	0.34	-0.78	4.233	0.002 S
MRI	2.86	0.49			

Statistical Analysis: Paired t test.
S: indicates significant at 5% level of significance
NS: Not significant

In Group III women Mean scar thickness was 86±0.49 mm on MRI.

On comparing the mean Scar thickness (mm) in group III, the difference was significant for MRI versus intraoperative (p < 0.002).

Group IV: There were no patients in Group IV

Table 10: Comparison of Mean Scar thickness of different groups in MRI

MRI	Mean	SD	Mean difference	t value	P value
Group I	3.53	0.27	0.39	1.384	0.190 NS
Group II	3.14	0.65			
Group I	3.53	0.27	0.67	3.063	0.008 S
Group III	2.86	0.49			
Group II	3.14	0.65	0.28	1.086	0.293 NS
Group III	2.86	0.49			

Statistical Analysis: Unpaired t test.
S: indicates significant at 5% level of significance
NS: Not significant

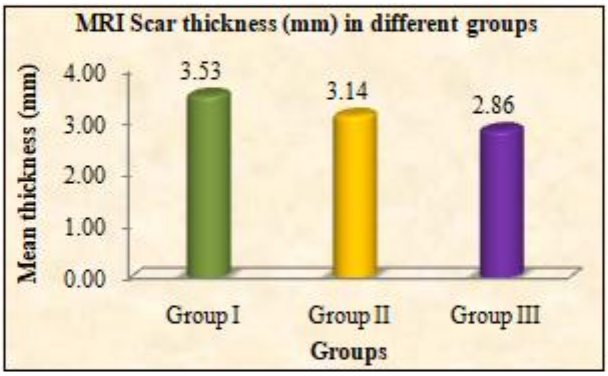

Figure 2: Showing MRI mean scar thickness of group I, group II and group III group

Comparison of mean Scar thickness of different groups in MRI, difference was significant for Group I-III (p< 0.008) and insignificant for Group I-II (p<0.190) and Group II-III (p<0.293).

Table 11: Comparison of Mean Scar thickness (mm) between normal (Group I + II) and Abnormal (Group III)

Variables	Group	Mean	Std. Deviation	Mean difference	t value	P value
Intra-operative	Group I + II	3.29	0.48	1.21	6.901	0.000 S
	Group III	2.08	0.34			
MRI	Group I + II	3.30	0.55	0.44	2.039	0.05 S
	Group III	2.86	0.49			

Statistical Analysis: Unpaired t test.
S: indicates significant at 5% level of significance
NS: Not significant

On comparing Mean Scar thickness (mm) between normal scar (Group I + II) and abnormal scar (Group III), the difference was significant for intraoperative (p<0.000) and MRI (p< 0.05).

5) Appearance of LSCS scar on MRI

Table 12: Appearance of LSCS scar on MRI

Sequences	Appearance	No of patients
T1 WI	Isointense	3
	Hypointense	22
	Hyperintense	0
T2WI	Isointense	1
	Hypointense	0
	Hyperintense	24
DWI	With Restriction	0
	Without Restriction	25

Appearance of LSCS scar on MRI in our study, on T1WI images 22 patients had hypointense signal intensity, 3 patients had isointense signal intensity. On T2WI images 24 patients had hyperintense signal and one had isointense signal intensity. On DWI images none of the patients shown diffusion restriction.

Table 13: ROC curve analysis

ROC curve analysis	Intra-operative		MRI	
Associated criterion	≤2.5	95% C. I	≤3	95% C. I
Sensitivity	100.00	69.2-100.0	70.00	34.8-93.3
Specificity	100.00	78.2-100.0	73.33	44.9-92.2
+PV	100.00	--	63.60	40.8-81.6
-PV	100.00	--	78.60	57.6-90.8
P value	<0.0001 S		0.0298 S	

Statistical Analysis: ROC curve (AUC) analysis.

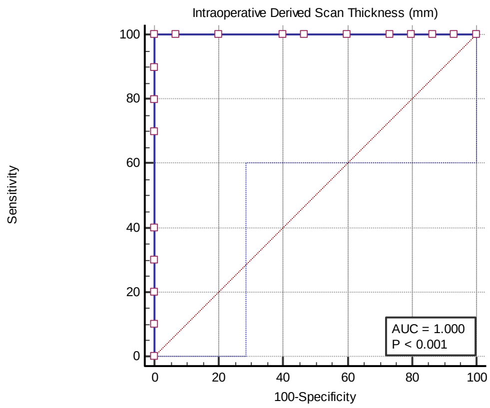

Figure 3 (a)

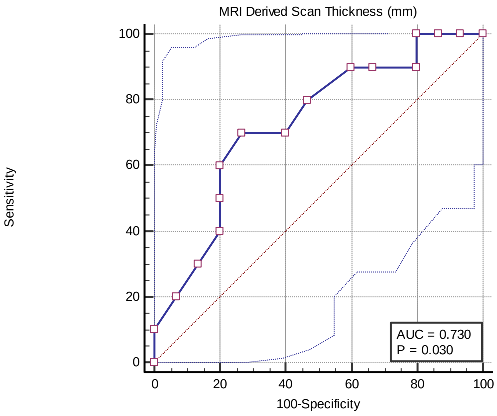

Figure 3 (c)

Figure 3 (a-b) showing AUC of intraoperative derived scar thickness (a) and AUC of MRI derived scar thickness (b).

The ROC analysis assigned a cut-off value of 2.5 mm for intra-operative, while that for MRI-derived scar thickness cut-off value was 3 mm for the differentiation of a normal scar from an abnormal one. These thresholds carried a sensitivity of 100% (intraoperative) versus 70% (MRI), specificity of 100% (intraoperative) versus 73% (MRI), PPV of 100 % (intraoperative) versus 63 % (MRI), and NPV of 100% (intraoperative) versus 78% (MRI). Accordingly, MRI had a high AUC (intraoperative= 1.000 versus MRI = 730). Accordingly, the diagnostic accuracy of MRI for differentiating a normal from an abnormal uterine scar was 70%.

Surgical validation of magnetic resonance imaging-derived scar thickness

Intra-operative assessment of uterine scar revealed that 24% (n = 6) of the women had a group I scar, 32% (n = 8) had Group II, and 44% (n = 9) had Group III scar and none of the patient had group IV uterine scar. Hence, 44% of the patients had an abnormal scar while in 66% the scar was normal. The difference between the MRI-derived mean scar thickness in women with normal scar from abnormal scar was statistically significant (p<0.050). the mean scar thickness 3.30 mm ± 0.55mm for normal versus 2.86mm ± 0.49mm for abnormal. Final validation of our data was done on the basis of surgical findings.

Case No.1

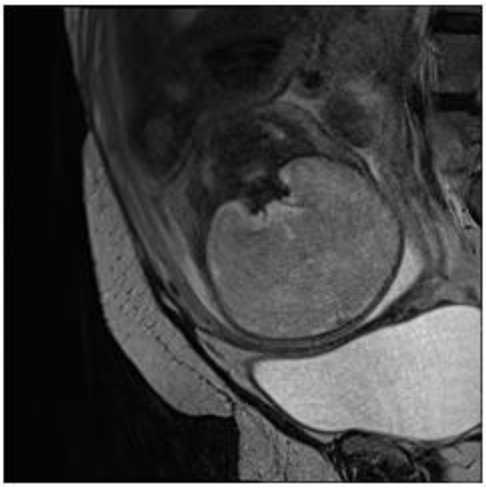

Figure 4 (a)

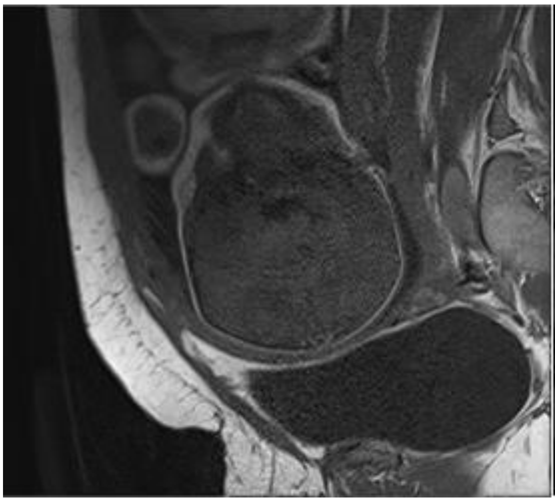

Figure 4 (b)

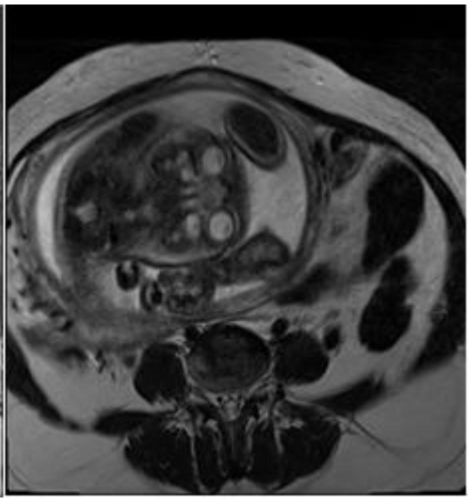

Figure 4 (c)

Figure 4 (a-c): T2W Sagittal (a), Sagittal T1W (b) and T2 Axil (c) images of a 35 years old G3P2+0 pregnant women having previous two times LSCS showing thick T2 hyperintese surgical Group I scar.

Case No.2

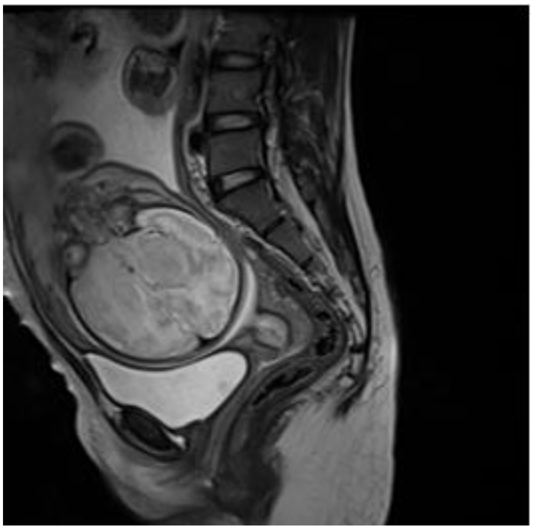

Figure 5 (a)

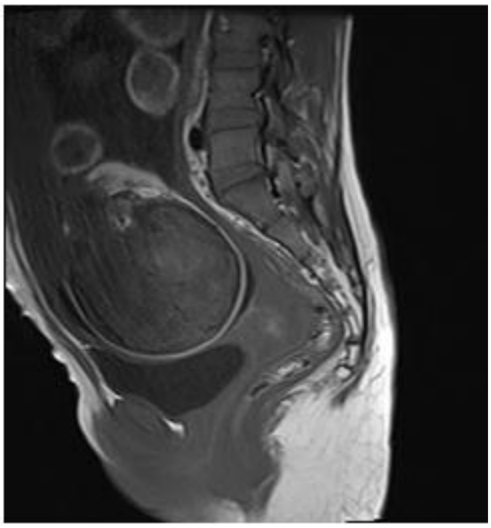

Figure 5 (b)

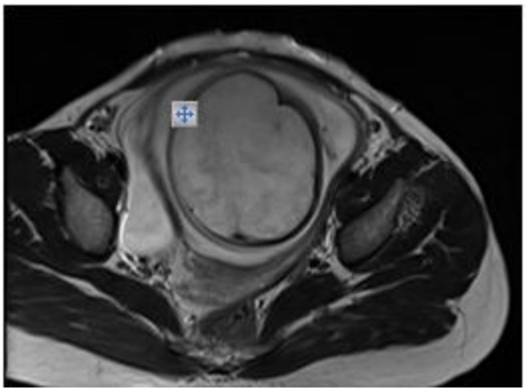

Figure 5 (c)

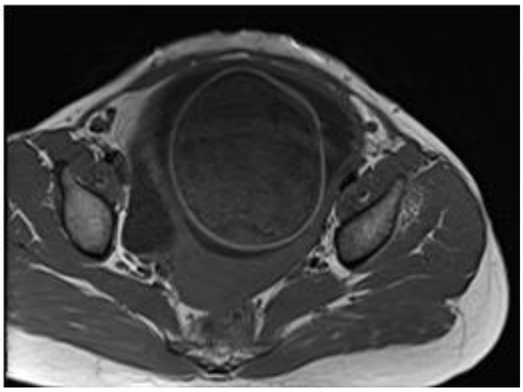

Figure 5 (d)

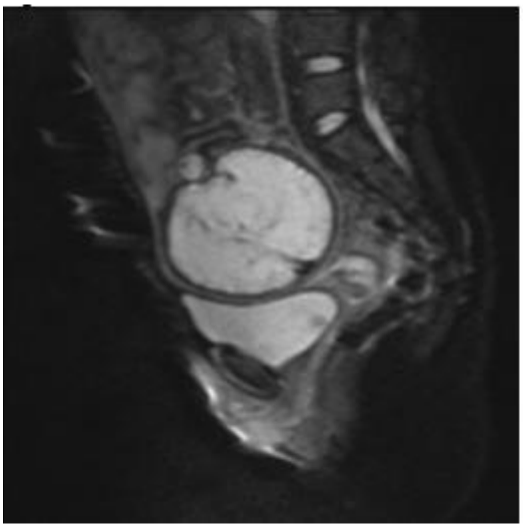

Figure 5 (e)

Figure 5 (f)

Figure 5 (a-f): T2W Sagittal (a), Sagittal T1W (b) and T2 Axil (c), Axil T1W (d), DW Sagittal trace (e), DW ADC Sagittal (f), images of a 28 years old G3P2+0 pregnant women with previous two times LSCS showing thin T2 hyperintense surgical Group II scar without diffusion restriction in DWI.

Case No. 3

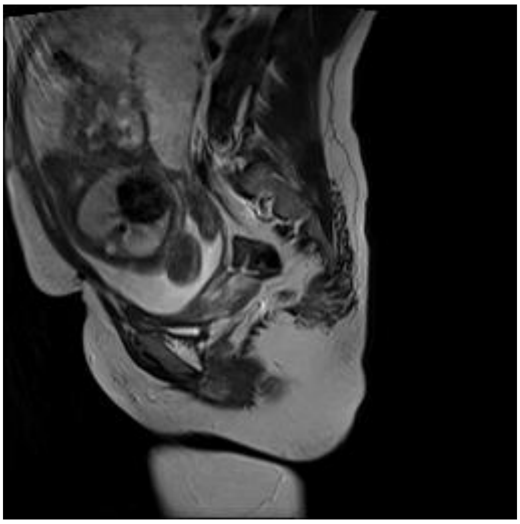

Figure 6 (a)

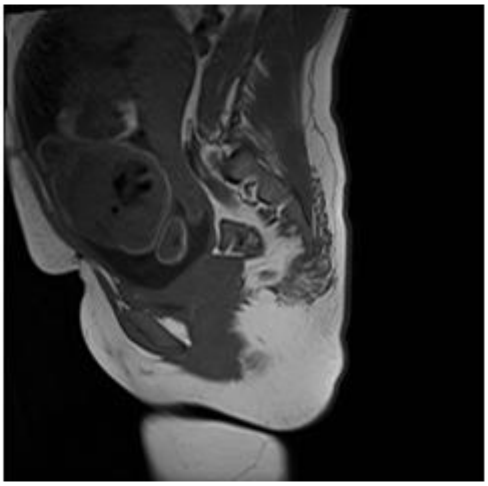

Figure 6 (b)

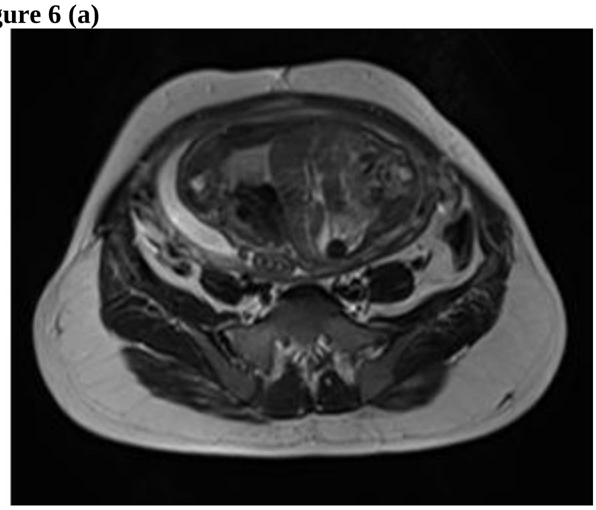

Figure 6 (c)

Figure 6 (a-c): T2W Sagittal (a), Sagittal T1W (b) and T2 Axil (c) images of a 23 years old G3P2+0 pregnant women with previous two times LSCS showing T2 iso to hypointense thin surgical Group III scar.

4. Discussion

The present study was undertaken to assess diagnostic accuracy of Magnetic resonance imaging in evaluation of LSCS scar in pregnant women while taking surgical measurement as gold standard. The study was performed in 25 pregnant women with history of at least 1 prior LSCS. Age of the patients were ranged from 22-35 years. Mean age was 27 years. Minimum age was 22 years and maximum age was 35 years. Most of the patients (48%) were between 20 to 25 years. All MRI measurements were done between 36-39 weeks of gestation. Seventeen women in the study had single time previous LSCS, 6 had two time previous LSCS and only 2 women had history of three time previous LSCS. Eighty percent women (n=20) had >2 years of interval between the consecutive caesarean sections and most of them had elective caesarean section, 20% (n=5) women had <2 years interval between consecutive caesarean sections and had undergone emergency caesarean section. Our study suggested that the incidence of abnormal scar (Group III) increased in proportion to increase in the number of prior LSCS. The incidence of abnormal scar (Group III) also increased with decrease in the interval between consecutive pregnancies. Highest incidence of abnormal scar was seen among patients with <2 years of interval between consecutive pregnancies.

Based upon the surgical scar thickness, women in our study were categorized into four groups-Group I: women with grade I scar thickness, Group II: women with grade II scar thickness, Group III: women with grade III scar thickness and Group IV: women with grade IV scar thickness. In our study, 6 women belonged to group I, 9 women to group II and 10 women belonged to group III. Group IV scar thickness was not seen in any women of our study group.

We again categorised women of different scar thickness groups (i. e Group I, Group II, Groups III and Group IV) into normal scar group (Group I & Group II) and abnormal scar group (Group III and Group IV). The results of our study suggests that MRI ($p < 0.05$) can accurately categorise LSCS scar into normal (Group 1 & Group 2) and abnormal scar (Group 3 & Group 4). These results are comparable with results of study done by Satpathy et al.1[9] on 30 pregnant women. In their study, MRI-derived thickness in women with normal scar (4.03 mm ± 0.85 mm for MRI) had a statistically significant difference ($p < 0.05$) from that of an abnormal scar (2.64 mm ± 0.84 mm for MRI).

The mean scar thickness of Group I was 3.53±0.27 mm on MRI, Group II was 3.14±0.65 on mm MRI and of Group III was 2.86±0.49mm on MRI and were comparable with study done by Satpathy et al.1[0] in 30 pregnant women with previous LSCS.

In their study the mean scar thickness for grade I was 4.15 mm on MRI, for Grade II was 3.86 mm on MRI and for grade III was 2.64 mm on MRI.

In Group II, the mean scar thickness difference was insignificant for MRI versus intraoperative ($p < 0.356$) which suggests that scar thickness on MRI are comparable with scar thickness measured intra-operatively.

In group III, the mean scar thickness difference was significant for MRI versus intraoperative ($p < 0.002$) which suggests that scar thickness measured on MRI were not in concordance with the scar thickness measured intra-operatively.

MRI in our study accurately differentiated Group I scar from Group III scar ($p < 0.008$) while MRI could not accurately differentiate the Group I scar from Group II scar ($p < 0.190$) and Group II normal scar from Group III scar ($p<0.293$).

The results of our study assigned a cut of value of 3 mm on MRI to differentiate normal scar (Group I & Group II) from abnormal scar (Group III). These threshold carried sensitivity, specificity, PPV & NPV of 70%, 73%, 63% and 78% for MRI respectively. The diagnostic accuracy of MRI was 70%. These results are comparable with study done by Satpathy et al[8]**.** Their study assigned a cut-off value of scar thickness 3.45 mm on MRI for the differentiation of a normal scar from an abnormal one. The threshold carried sensitivity, specificity, PPV & NPV of 88.9%, 90.4%, 95.6% & 77.7% for MRI respectively. Diagnostic accuracy of MRI was 90%. The study done by Deepika et al.1[0] assessment of lower segment caesarean scar by Transvaginal ultrasound and MRI in 40 pregnant women results shows slight variation and found the mean scar thickness of 3.36±1.2 mm on TVS and 5±1.12 mm on MRI. The minimum scar thickness was 1.2 mm on TVS and 1.6 mm on MRI. The maximum scar thickness was 5.1 mm on TVS and 5.7 mm on MRI.

On MRI examination in our study, it was observed that 22 women had hypointense & 3 women had isointense appearance of LSCS scar on T1 weighted images. On T2 weighted images, 24 women had hyperintense & 1 women had isointense appearance of LSCS scar. On DWI, none of patients showed diffusion restriction with no signs of rupture detected on MRI. We could not assess the integrity of the scar by T1, T2 appearance and by diffusion weighted image appearance. This observation is in agreement with the study done by Hoffman et al.9 on 25 pregnant women and suggested that the scar integrity cannot be assessed by T1 and T2 signal intensity because we cannot calculate T1/T2 signal intensity ratios as these are affected by numerous factors such as field inhomogeneity, patient position or used MRI scanner.

Very few studies were performed to evaluate the role of MRI in evaluation of uterine scar. The purpose of our study was to find out the value of MRI in evaluation of uterine scar. However MRI results of our study were different from the prospective study done by Ishan Kumar et al[2] in 2016 in 30 pregnant women with previous LSCS to assess the accuracy of 3T MRI for evaluation of post-caesarean uterine scar and to predict scar dehiscence during repeat CS. Their results assigned a cut off value of 3.45 mm with sensitivity of 100% and specificity of 91% in prediction of abnormal scar and concluded that MRI derived parameters may be utilized for differentiation of an abnormal post-caesarean uterine scar from a normal one.

Our study showed that MRI can be used for evaluation of uterine scar.

5. Study Limitations

Our study had its limitations. It was small sample study conducted on 25 patients. However I will recommend to conduct the similar study with more number of patients to evaluate the further role of MRI.

6. Conclusion

The present study concluded that MRI can accurately diagnose normal from abnormal scar. The cut off value of normal scar from abnormal scar is 3 mm on MRI. The diagnostic accuracy of MRI in our study is slightly low 70%. Thus ultrasound can be used as first imaging modality to evaluate LSCS compared to MRI, because of their higher accuracy, easy availability and cost effectiveness.

A major limitation of the study is small sample size and a similar study with more number of patients to evaluate the further role of MRI is recommended.

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