Morphological description of uterine scar one year after cesarean section by T2 3D SPACE 3.0T MR

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Aims and objectives

Cesarean section rate has been increased worldwide [1], compared with vaginal birth, cesarean section may cause more obstetric and gynecologic complications such as uterine rupture, placenta previa, endometriosis. Prior cesarean section (p-CS) scar refers to the remaining and healed scar tissue after hysterotomy, certain morphological features such as too thin or large niche could lead to catastrophic uterine rupture or postmenstrual spotting[2]. To accurately depict p-CS scar feature and predict high risk morphological form could assist clinical decision of repeat CS or trial of labor, but only limited research has focused on MR imaging of prior CS scar before next pregnancy, most studies and clinical practice of the scar images were obtained by ultrasound late in the third trimester. Although the World Health Organization (WHO) recommends 33 mouths minimum inter-birth interval to reduce adverse maternal and child health incidence[3], some researches shows that the actual average birth spacing time could be as short as 11-14 mouths in rural area or low socioeconomic class due to poor use of contraception[4-6]. Pelvic MR have higher soft tissue resolution compared with ultrasound and CT, and is wildly used in clinical settings. Three dimensional (3D) high-sampling-efficiency technique [sampling perfection with application optimized contrast using different flip angle evolutions (SPACE)] image has high spatial resolution compared with conventional T2WI evaluating female pelvis [7]. Considering short birth-interval time, the aim of this study is to depict the detailed morphological features of p-CS scar one year after p-CS and before next pregnancy using T2 3D-SPACE MR.
Methods and materials

Ethics Statement

This prospective study was approved by the ethical committee of our institution. The institutional review board waived the requirement of informed volunteer consent. Information gathered on this population was performed in compliance with Health Insurance Portability and Accountability Act (HIPAA) guidelines.

Subject Data

The inclusion criteria were: 20-45 years old woman, one year ± one month after prior Cesarean section. And the exclusion criteria were: history of uterine rupture or perforation; pregnancy status; MR contradiction.

37 volunteers were enrolled, and two were intolerant to MR scan, 35 volunteers (age range 26-41 years; mean±SD, 33±3.5 years) completed pelvic 3.0T MR scan 12±1 months after p-CS.

Preparation and MR Imaging Acquisition

MR scan were performed in the peri-ovulation phase, since endometrium is relatively thick thus easier to evaluate. To decrease MR artifact by air in rectum and sigmoid, ten ml glycerine enema was injected into rectum within two hours before MR scanning. We chose prone and feet-first position to reduce the small intestinal motion artifacts. The parameters of T2 3D SPACE sequence were listed in Table 1.

Images reviewing and measurement

T2 3D Space Images were reviewed using the 3D post-processing software which can rotate freely to any plane for detailed analysis. Two experienced radiologists (10 year and 6 year experiences) evaluated all 3D-SPACE images independently.

Scar tissue were recognized as low signal intensity on T2W-3D sequence images. Minimal scar thickness (from uterine cavity to uterine serosa coat near bladder), scar length (parallel to uterine long axis) and uterine posterior wall thickness at the same level of scar were all measured on mid-saggital plane; scar width (left to right diameter) was measured on axial plane (Fig 1). Scar position was evaluated using relative distance from inferior boundary of scar to external cervix os (Fig 2A), which was measured by curve distance along the endometrium and cervical inner surface. Presence of endometrium adjacent to scar (Fig 3) was recorded. Divide minimal scar thickness by corresponding posterior uterine wall thickness, we obtained relative change of p-CS scar wall (Fig 2B). Scar shape were classified as "U" shape, "V" shape and mixed shape, judging from the transitional region from scar to normal uterine or cervical wall (Fig 4).
**Statistical Analysis**

Statistical analysis was performed using SPSS 19.0. One-way analysis of variance was used to evaluate the differences of the anatomic and positions of the scar between subjects with or without endometrium. Intra-class correlation coefficient (ICC) was applied for reliability between different evaluators. P-values of less than 0.05 were considered statistically significant.
**Images for this section:**

**Fig. 1:** Fig 1 Diameter measurement of scar, images of a 34 years volunteer. A, T2W 3D image, midline sagittal view of uterine scar, the yellow arrow indicates the height of scar, and the blue arrow measures the minimal thickness of scar. B, T2W 3D image, axial view of the scar, yellow arrow indicate the width of the scar.

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**Fig. 2:** Fig 2A, T2W 3D image, midline sagittal view of a 29-year-old uterine scar, from the lower edge to the cervix os, four short line length were added to calculate the curve distance. B, T2W 3D image, midline sagittal view of a 37-year-old uterine scar, 2D=two dimensional diameter. 2D 1 measures the minimal scar thickness. and 2D 2 measures the junction zone thickness at the same level of scar center, 2D 3 measures the outer myometrium thickness at the same level. Corresponding posterior wall thickness=2D 2+2D 3. Relative change of p-CS scar wall ratio=#2D 1/#(2D 2+2D 3). B, T2W 3D image, axial view of the scar, yellow arrow indicate the width of the scar.

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**Fig. 3:** Fig 3 existence of endometrium adjacent to the scar. A, T2W 3D image, midline sagittal view of a 28-year-old woman, note the high signal intensity endometrium area inside the scar. B, 33-year-old woman, note the small area with higher intensity than endometrium, it should be uterine cavity fluid occupying inner surface of the scar.

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**Fig. 4:** Fig 4# Examples of different scar shape A, "U" shape scar of a 32-year-old volunteer. The green box is the transitional zone, which is from the edge of the scar to the adjacent normal thickness. Blue arrow measures the longitudinal axial diameter of the inferior transition zone, yellow arrow refers to the vertical axial diameter. The ratio is obtained from dividing blue arrow by yellow arrow, in this case, both superior and inferior
ratio are smaller than 0.8. B, "V" shape scar of a 27-year-old volunteer. As fig 4A, the yellow arrow=vertical diameter, the blue arrow=longitudinal diameter of transitional zone, the blue/yellow ratio is larger than 0.8, and is classified as "V" shape, note the shape of the inferior transitional zone is about the same as superior one. C, mixed shape scar of a 37-year-old volunteer. The superior is "U" shape while the inferior is "V" shape. We classified the uncoordinated as mixed group.

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Table 1. Imaging parameters of T2 3D SPACE
TR=Repetition time; TE=Echo Time; FOV=Field of View

<table>
<thead>
<tr>
<th>Plane</th>
<th>T2 3D SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR (ms)</td>
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</tr>
<tr>
<td>TE (ms)</td>
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<td>Distance factor</td>
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<td>Flip Angle (° )</td>
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<td>Voxel size (mm)</td>
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<tr>
<td>Acquisition time</td>
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</tr>
</tbody>
</table>

Table 1

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Results

Inter observer reliability test

Two scars were found in only one volunteer who underwent Cesarean section twice, both set of scar parameters were measured. The intra-class correlation coefficients range from 0.779 to 0.905, the lowest was posterior wall thickness and the highest was minimal scar thickness.

Scar morphological measurement

Scar length was 0.66±0.45cm, width was 1.18±0.53cm and minimal scar thickness was 0.44±0.22cm. Scar volume was assumed as cuboid and calculated by multiplication of thickness, width and length, which was 0.35±0.36cm3.

Scar location and relative change of scar wall

Curve distance from scar lower edge to external cervical os was 3.47±1.05cm. Research showed the normal anterior and posterior uterine wall thickness is similar to one another in normal woman [8], we use posterior wall thickness at the same level of scar center to represent anterior wall thickness before prior Cesarean section. Divide Scar thickness by corresponding posterior uterine wall, we got the relative change ratio, which was 0.37±0.19. Endometrium within scar Presence of endometrium within scar was 33.3% (12/36).

Scar shape classification

We observed the transitional zone length from scar to adjacent normal thickness wall differed a lot from person to person, so a new model of classification basing on the longitudinal axis to vertical axis of superior or inferior transitional region ratio was raised. Scars were divided into "U" shape, if both longitudinal axis-vertical axis ratios were smaller than 0.8 (21/32, 65.6%); "V" shape, if both ratios were equal or larger than 0.8 (7/32, 21.9%) and mixed shape, whose superior and inferior ratio were not coordinate (4/32, 12.5%).
Conclusion

3D-SPACE MR can provide overall and detailed p-CS scar anatomy before next pregnancy, thus could assist making clinical decision.

Scar shape classification was raised for further research to determine if it is related to pregnant uterine rupture.
Personal information

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References


