Changes in Cesarean section scar dimensions during pregnancy: a prospective longitudinal study

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ABSTRACT

Objectives To describe changes in Cesarean section (CS) scars longitudinally throughout pregnancy, and to relate initial scar measurements, demographic variables and obstetric variables to subsequent changes in scar features and to final pregnancy outcome.

Methods In this prospective observational study we used transvaginal sonography (TVS) to examine the CS scar of 320 consecutive pregnant women at 11–13, 19–21 and 32–34 weeks' gestation. For scars visible on TVS, the hypoechoic part was measured in three dimensions and the residual myometrial thickness (RMT) was also measured. Analyses were carried out using one-way repeated measures ANOVA and mixed modeling. The incidence of subsequent scar rupture was recorded.

Results The CS scar was visible in 284/320 cases (89%). Concerning length and depth of the hypoechoic part of the scar and RMT, the larger the initial scar measurement, the larger the decrease observed during pregnancy. For the hypoechoic part of the scar, the width increased on average by 1.8 mm per trimester, while the depth and length decreased by 1.8 and 1.9 mm, respectively (false discovery rate \( P < 0.0001 \)). Mean RMT in the first trimester was 5.2 mm and on average decreased by 1.1 mm per trimester. Two cases (0.62%) of uterine scar rupture were confirmed following a trial of vaginal delivery; these had a mean RMT of 0.5 mm at second scan and an average decrease of 2.6 mm over the course of pregnancy.

Conclusion This study establishes reference data and confirms that the dimensions of CS scars change throughout pregnancy. Scar rupture was associated with a smaller RMT and greater decrease in RMT during pregnancy. There is the potential to test absolute values and observed changes in CS scar measurements as predictors of uterine scar rupture and outcome in trials of vaginal birth after Cesarean section. Copyright © 2012 ISUOG. Published by John Wiley & Sons Ltd.
the operator. However, a more objective quantitative approach is desirable if CS scar assessment is to be reproducible. We have previously proposed a standardized approach for assessment of the hypoechoic portion of the scar based on objective measurements in addition to measurement of RMT.

Various methods have been developed with the aim of correlating measurements of the lower uterine segment (LUS) during pregnancy with risk of uterine rupture or dehiscence\(^{10-13}\). In some studies, the thickness of the entire LUS was measured using transabdominal sonography, while in others only the muscular layer was measured using TVS. Measurement of the muscular layer of the LUS appears to be clinically important. Jastrow et al. conducted a systematic review on this topic and concluded that there is a strong association between smaller LUS measurements in pregnancy and risk of uterine scar complications, proposing that LUS thickness as evaluated by sonography might serve as a predictor of uterine rupture\(^{16}\). However, no cut-off values have been developed and tested, underlining the need for more standardized measurement techniques and nomenclature.

The ability to predict likely success of a trial of labor would be clinically useful\(^{15}\). A number of groups have attempted to select patients more likely to undergo successful vaginal birth after Cesarean section (VBAC) according to demographic variables as well as findings on physical examination at the time of admission for delivery. Growing evidence suggests that complete healing of the previous CS scar and myometrial thickness of the LUS are important factors in achieving an uneventful pregnancy outcome\(^{17}\).

In this prospective study we describe changes in dimensions of the hypoechoic part and RMT of CS scars that occur throughout the course of pregnancy. We also investigated some of the factors that might be associated with larger scars using previously published methods of scar measurement.

METHODS

The study was conducted at the ultrasound department of a London university teaching hospital and was approved by the local research and ethics committee. Informed consent was obtained from all women. Between June 2010 and July 2011, 389 non-selected consecutive pregnant women were enrolled. We included women with singleton gestations who had undergone at least one previous low-transverse CS. Women with multiple gestations (\(n = 19\)) and those with a history of classical CS (\(n = 11\)) were excluded from the study. Thirty cases had a mid-trimester miscarriage, 17 cases withdrew from the study after subsequent scans and nine cases were lost to follow-up. The final study cohort consisted of 320 women who were examined using a Voluson E8 Expert (GE Healthcare Ultrasound, Milwaukee, WI, USA) ultrasound system equipped with a 5–9-MHz transvaginal probe.

All participating women underwent TVS at 11–13, 19–21 and 32–34 weeks’ gestation, coinciding with routine first-trimester screening, anomaly screening and growth assessment scans when possible. At the first scan visit, demographic data were recorded and an obstetric and medical history was obtained. This included the number of previous CSs and whether any had been complicated by postpartum infection. The operators performing scans were blind to this clinical information.

The delineation and measurements of the CS scar using ultrasound were carried out according to methods reported previously\(^{17}\) (Figures 1 and 2). LUS was assessed using ultrasonography in real-time to identify the area likely to contain the CS scar. Two components of CS scars were assessed: the hypoechoic part or ‘apparent defect’ and the scar contained in any residual myometrium, which for measurement purposes is expressed as RMT. As a relationship between scar appearance and function has not been shown, we have chosen to avoid using the term ‘deficiency’ or ‘defect’ as a morphological descriptor.

When the CS scar was visible, three measurements were taken in the sagittal plane, the width and depth of the hypoechoic part and RMT, while the length of the hypoechoic part was measured in the transverse plane. This method was applied at each scan and data were recorded prospectively on an Excel spreadsheet.

Statistical analysis

The median and 25th–75th percentile for width, depth and length of the hypoechoic part of the CS scar and RMT were calculated for each trimester. These scar characteristics were compared over the three trimesters using one-way repeated measures ANOVA. The corresponding P-values were corrected for multiple testing with the false discovery rate (FDR) approach of Benjamini and Hochberg\(^{18}\).

An initial graphic exploration suggested approximately linear trends for scar dimensions over time. In order to draw conclusions from our sample about typical scar

![Figure 1 Sagittal ultrasound image showing anatomical location of features measured to quantify size of component parts of a Cesarean section scar using transvaginal sonography in first trimester of pregnancy. A, width of hypoechoic part; B, depth of hypoechoic part; C, residual myometrial thickness; D, uterovesical fold; E, internal cervical os.](image-url)
characteristic patterns in the population as a whole, we fitted mixed models per scar characteristic. Each mixed model contained two fixed-effects parameters (average intercept and slope of the scar characteristic against time) and two correlated random effects (deviations in intercept and slope among pregnancies). To assess the association of change in scar characteristics with demographic variables and obstetric history, interaction terms between these variables and time were added to the mixed models, with use of a likelihood ratio test to compare fitted models with and without the interaction term in each case. All analyses were performed with R for statistical computing (www.r-project.org).

RESULTS

A total of 320 women were included in the study. The CS scar was visible in 284/320 cases (89%). When the scar was deemed visible at the 12-week scan, it continued to be visible in 100% of cases at 20 weeks and in 272/284 cases (96%) at 34 weeks. In the group with a visible CS scar (n = 284), 153 women had a history of more than one previous CS and therefore were assigned to undergo elective repeat CS at ≥ 39 weeks’ gestation. Of these, 17 women developed premature uterine contractions at < 39 weeks’ gestation, resulting in semi-elective CS, and 136 women progressed beyond 39 weeks’ gestation and underwent a repeat CS procedure as initially planned. Women in the group with visible CS scar with a history of one previous CS (n = 131) were counseled and offered a trial of VBAC at ≥ 38 weeks’ gestation, of which 10 women required prelabor CS at < 38 weeks’ gestation for various clinical reasons, 74 women (61%) had successful trials of labor and 47 women required intrapartum emergency CS because of failed trials of labor. In the cohort of women selected for trial of VBAC there were two (0.62%) cases of scar rupture and five (1.5%) cases of dehiscence confirmed at repeat CS. The breakdown of patients for both visible and non-visible scar groups is demonstrated in Figure 3. Demographic data and obstetric variables are shown in Table 1.

Non-visible scars (n = 36) at the 12-week scan remained non-visible on subsequent scans. Scar visibility was related to position of the uterus, with 81% (n = 29) of non-visible scars found among the 42 women in whom the uterus was retroverted. Within the group with visible scars, there was one woman among the 153 who had undergone more than one previous CS in whom more than one scar was visible. In this case measurements of the larger scar were taken.

Change in scar size during pregnancy

Mixed modeling of scar changes over time showed an average increase of 1.8 (95% CI, 1.7–1.9) mm in the width of the hypoechoic part of the scar per trimester. Depth and length of the hypoechoic part decreased over time, with average decreases of 1.8 (95% CI, 1.7–1.9) mm and 1.9 (95% CI, 1.8–2.0) mm per trimester, respectively. RMT decreased by an average of 1.1 (95% CI, 1.0–1.2) mm per trimester. Changes in scar dimensions are illustrated in Figure 4 and Table 2. In the two cases of reported scar rupture, the decrease in RMT between first and second trimesters was 2.7 and 2.5 mm, respectively. Mean RMT in these cases was 0.5 mm at the second trimester scan, in comparison to 3.6 mm for the other cases.

Relationship between initial scar size and change during pregnancy

For the modeling of scar changes over time, random effects representing variation in the intercept and slope of the ‘dimensions vs time relationship’ were considered to be dependent because the initial scar size may be correlated with subsequent change in size throughout pregnancy. We found that the larger the initial dimensions of the scar, the more the scar decreased in size between all three trimesters of pregnancy. This association held for both depth and length of the hypoechoic segment of the scar (correlation coefficients for random effects intercept and slope = −0.887 and −0.904 for scar depth and length, respectively) and RMT (correlation coefficient, –0.720).

Influence of demographic variables on change in scar size

Throughout pregnancy, there was a trend towards enhanced increase in width and enhanced decrease in
Cesarean section scars during pregnancy

Study population \( (n = 320) \)

Visible scars \( (n = 284) \)

\[ \geq 2 \text{ previous CS: Planned CS at } \geq 39 \text{ weeks} \quad (n = 153) \]

\[ 1 \text{ previous CS: Planned VBAC at } \geq 38 \text{ weeks} \quad (n = 131) \]

\[ \text{ERCD} \quad (n = 136) \]

\[ \text{Semi-elective CS } < 39 \text{ weeks} \quad (n = 17) \]

\[ \text{Successful VBAC } \geq 38 \text{ weeks} \quad (n = 74) \]

Non-visible scars \( (n = 36) \)

\[ 1 \text{ previous CS: Planned VBAC at } \geq 38 \text{ weeks} \quad (n = 22) \]

\[ \geq 2 \text{ previous CS: Planned CS at } \geq 39 \text{ weeks} \quad (n = 14) \]

\[ \text{Semi-elective CS } < 39 \text{ weeks} \quad (n = 3) \]

\[ \text{Failed VBAC} \quad (n = 47) \]

\[ \text{Successful VBAC } \geq 38 \text{ weeks} \quad (n = 18) \]

Figure 3 Outcomes of the study population. CS, Cesarean section; EmRCD, emergency repeat Cesarean delivery; ERCD, elective repeat Cesarean delivery; VBAC, vaginal birth after Cesarean section.

Table 1 Demographics and obstetric history of the study population \( (n = 284) \)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median (IQR) or n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33 (29–36)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26 (24–31)</td>
</tr>
<tr>
<td>History of diabetes mellitus</td>
<td>12 (4.2)</td>
</tr>
<tr>
<td>Chronic steroid use</td>
<td>12 (4.2)</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>24 (8.4)</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>67 (23.6)</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>193 (68.0)</td>
</tr>
<tr>
<td>Obstetric history</td>
<td></td>
</tr>
<tr>
<td>1 previous CS</td>
<td>207 (72.9)</td>
</tr>
<tr>
<td>2 previous CSs</td>
<td>72 (25.3)</td>
</tr>
<tr>
<td>≥ 3 previous CSs</td>
<td>5 (1.8)</td>
</tr>
<tr>
<td>Previous VBAC</td>
<td>35 (12.3)</td>
</tr>
<tr>
<td>Previous postpartum infection</td>
<td>33 (12.3)</td>
</tr>
</tbody>
</table>

BMI, body mass index; CS, Cesarean section; IQR, interquartile range; VBAC, vaginal birth after Cesarean section.

...length of the hypoechoic part of the scar with increasing maternal age (with a better model fit when including an interaction term between maternal age and trimester of scan as compared to the initial mixed effects models with only trimester as an independent variable; FDR \( P \)-values of the likelihood ratio test = 0.11; Table 3). Ethnicity, body mass index and history of diabetes mellitus were not significantly associated with a change in scar dimensions throughout pregnancy. Steroid use was associated with a smaller decrease in depth of the hypoechoic part of the scar (FDR \( P \)-value = 0.07) over time, but with an enhanced decrease in RMT over time (FDR \( P \)-value = 0.08; Table 3).
DISCUSSION

We have shown that the dimensions of CS scars are not static and change in a similar way over the course of pregnancy in the majority of women. We have observed that the larger the depth and length of the hypoechoic ‘apparent defect’ in the first trimester of pregnancy, the greater the decrease in these dimensions over the remainder of the pregnancy. The same relationship holds for RMT. Our data also show that in women with a previous successful VBAC the hypoechoic ‘apparent defect’ of CS scars is smaller while RMT is larger. Our observations establish the natural history of both the hypoechoic ‘apparent defect’ and RMT components of CS scars that can be visualized using ultrasound.

To date, the literature has focused on appearance of CS scars in the non-pregnant state or on single assessments of scar size or morphology. However, our study shows that the first time that both the size of the hypoechoic part of CS scar and RMT change as pregnancy progresses. Accordingly, any interpretation of scar morphology and size, as well as changes in scar size, must take into account the gestational age at which observations are carried out.

The strengths of this study are the relatively large sample size and the prospective design. A weakness is that in 11% of scans the CS scar was not visible to operators. It seems likely that a poorly visible scar has an absent cavity surface of the lower segment is brought together and the position of the uterus; when retroverted the internal discrepancy may relate to tension being put on the scar by the uterus was retroverted in the majority, while the scar was almost always visible when the uterus was anteverted. This difference may relate to tension being put on the scar by the position of the uterus; when retroverted the internal cavity surface of the lower segment is brought together and a smaller scar may result, hence limiting its visibility. From a practical clinical viewpoint, this study was designed
to fit in with routine clinical management, i.e. nuchal translucency measurement in the first trimester, fetal biometry and anomaly screening in the second trimester and scans for fetal growth assessment in the third trimester where applicable. The time slot was not increased to accommodate additional transvaginal ultrasound scans; thus, the addition of TVS in this context would be unlikely to add significantly to a unit’s workload.

Our data demonstrate that the length of the hypoechoic part of the scar showed a greater rate of decrease during pregnancy in women who had undergone previous VBAC, but that there was less of a decrease in RMT over time in these women. On the other hand, there were two cases of uterine scar rupture and five cases of dehiscence in the group of women who had a trial of VBAC in this study. It is interesting to note that the two cases of scar rupture involved one previous CS and these women were offered a trial of VBAC. However, both underwent emergency CS for suspected uterine scar rupture that was confirmed intraoperatively. In retrospect, these cases can be seen as having demonstrated a different pattern of changes in RMT in comparison to the rest of the cohort. Both women had an RMT of 0.5 mm in the second trimester, and a decrease in RMT between the first and second trimesters of 2.7 and 2.5 mm, respectively. This difference is important, as these cases could have been identified as being at high risk of failing a trial of VBAC from as early as 20 weeks’ gestation.

The observation of changes in dimensions of different parts of CS scars over the course of pregnancy offers a novel potential approach to evaluating scar integrity. This could be helpful as the use of single parameters may be problematic. It was reported previously that LUS thickness of < 2.3 mm is associated with a higher risk of complete uterine rupture and a systematic review by Jastrow et al. on the diagnostic accuracy of sonographic LUS measurements at 36–39 weeks to predict uterine scar rupture revealed that the optimal cut-off values for partial thickness ranged from 1.4 – 2.0 mm. However, due to the heterogeneity of the studies included in the review, the authors were unable to recommend ideal cut-off values to be used in practice.

We have previously shown that there is good interobserver agreement for measurement of both the hypoechoic part of CS scars and RMT in all three trimesters of pregnancy. Therefore, should either the scar measurements at a specific gestational age or the rate of change in scar size be a predictor of scar integrity, it may be possible to develop a reproducible ultrasound-based test that might contribute to selection of women suitable for a trial of VBAC. A prospective study to evaluate the relationship between these ultrasound features and scar performance in labor is needed to address this possibility.

It is interesting to note that smoking, infection following a previous CS and the number of previous CSs had no significant effect on changes in scar dimensions during pregnancy, although these factors might be expected to affect scar healing.

Maternal age also had a significant impact on changes in scar dimensions during pregnancy. The greater the age of the patient, the more pronounced was the decrease in length and the increase in width of the hypoechoic part of the scar over the course of pregnancy. It is well known that the physiological changes associated with aging place older patients at higher risk of poor wound healing, and that reduced skin elasticity and collagen replacement influence healing. Steroid use was associated with a lesser decrease in depth of the hypoechoic part of the scar but a greater decrease in RMT. Interestingly, there was a significant difference in the change in RMT between women with a previous successful VBAC and the rest of the study group. The overall decrease in RMT measurements throughout pregnancy was less in women who had undergone a previous successful VBAC, while the length and depth of the hypoechoic part of the scar decreased more rapidly in this group. These observations may help shed light on the mechanism of CS scar integrity. Reduction in size of the hypoechoic ‘apparent defect’ may not imply scar weakness. The finding that RMT reduces less rapidly in women who have had a successful VBAC suggests that RMT may be a more important indicator of scar integrity.

Giving women choice and control with regard to childbirth is a significant driver in modern obstetrics and it is axiomatic that women’s decisions should be informed. While achieving a vaginal delivery after a previous CS is considered the optimal outcome, attempting a VBAC when there is little or no chance of success may not be a choice that a woman would want to make. Furthermore, predicting serious complications such as rupture and dehiscence is important because of the accompanying morbidity. We have described reference data relating to CS scars throughout pregnancy. Our observations suggest that RMT remains relatively static and greater in women who have had a previous successful VBAC. Conversely, the opposite was true in the small number of cases in the study group with adverse scar outcomes. These differences could be observed as early as at 20 weeks’ gestation. These findings support the view that absolute measurements and changes in scar dimensions between 12 and 20 weeks’ gestation have the potential to be incorporated into algorithms used to advise women regarding the likely success of a trial of VBAC.

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REFERENCES


