Long-term complications of caesarean section. The niche in the scar: a prospective cohort study on niche prevalence and its relation to abnormal uterine bleeding

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Abstract

Objective
To study the prevalence of niches in the caesarean scar in a random population and its relation to postmenstrual spotting and urinary incontinence.

Design and setting
A prospective cohort study in a teaching hospital in the Netherlands.

Population
Nonpregnant women delivered by caesarean section (CS).

Methods
Transvaginal ultrasound (TVU) and gel instillation sonohysterography (GIS) were performed 6 to 12 weeks after CS. Women were followed by questionnaire and menstruation score chart at 6–12 weeks, 6 months and 12 months after the CS.

Main outcome measures
Prevalence of a niche 6–12 weeks after CS, using TVU and GIS. Secondary outcomes: relation to postmenstrual spotting and urinary incontinence 6 and 12 months after CS and niche characteristics, evaluated by TVU and GIS.

Results
Two hundred and sixty-three women were included. Niche prevalence was 49.6% on evaluation with TVU and 64.5% with GIS. Women with a niche measured by GIS reported more postmenstrual spotting than women without a niche (OR 5.48, 95% CI 1.14–26.48). Women with residual myometrium at the site of the uterine scar measuring < 50% of the adjacent myometrial thickness had postmenstrual spotting more often than women with a residual myometrial thickness of > 50% of the adjacent myometrial thickness (OR 6.13, 95% CI 1.74–21.63). Urinary incontinence was not related to the presence of a niche.

Conclusions
A niche is present in 64.5% of women 6–12 weeks after CS when examined by GIS. Postmenstrual spotting is more prevalent in women with a niche and in women with a residual myometrial thickness of < 50% of the adjacent myometrium.
Introduction

Concern regarding the association between delivery by caesarean section (CS) and long-term maternal morbidity is growing as the rate of CS continues to increase. In the Netherlands the CS rate increased from 7.4 to 15.8% \(^1\) during the period 1990–2008, and in the United States it increased from 21.2 to 32.8% \(^2\) from 1990 to 2011. The long-term complications of CS in relation to future reproduction have been comprehensively examined.\(^3,4\) In the past decade several papers have described a defect which can be seen on ultrasound at the site of the CS scar, known as a ‘niche’.\(^5,6\) A niche is defined as a triangular anechoic structure at the site of the scar, or a gap in the myometrium of the anterior lower uterine segment at the site of a previous CS.\(^7,8\) Niche prevalence depends on the method used for evaluation and the population investigated.\(^9–16\) In nonpregnant women the scar is visible with transvaginal ultrasonography (TVU) and contrast sonohysteroscopy using saline (saline infusion sonohysterography, SIS) or gel (gel instillation sonohysterography, GIS).\(^5,6\) There have been several reports of an association between abnormal bleeding and a niche.\(^8,10–12,15\) In particular, postmenstrual spotting seems to be a predominant symptom in women with a niche.\(^10,11\) However, most of these studies included symptomatic patients, resulting in a possible selection bias. Given the proximity of the niche to the bladder, it has been postulated that local accumulation of fluid and scarring might disturb bladder function.\(^11\) However, prospective studies assessing both bleeding symptoms and urinary symptoms in relation to the presence of a niche in a random population of women with a history of CS are scarce. As far as we are aware, none of the reported studies asked women to participate at the time of CS. The aim of our study was to determine the prevalence of niches in the CS scar in a random population of women enrolled immediately after CS, using both TVU and GIS 6–12 weeks after CS, and to examine the relation of the niche to postmenstrual spotting and urinary incontinence.

Methods

Study design and population

We conducted a prospective observational cohort study. The trial was registered in the Dutch trial register (trial number NTR-2887). The study was performed in St Antonius Hospital, Nieuwegein, a teaching hospital in the Netherlands. The protocol was approved by the local medical ethics committee (VCMO NL18722.100.07 R-07.14A/SCAR.). Participants were recruited between November 2007 and September 2010. Specially trained midwives asked all women aged over 18 who underwent a CS at St Antonius Hospital during the inclusion period to participate, consecutively and within 3 days of the CS. Exclusion criteria were twin pregnancies, known uterine anomalies or the suspicion of a uterine infection, defined as a positive culture or fever and abdominal pain with discharge. After providing written informed consent, all participants were evaluated by TVU followed by GIS 6–12 weeks after the CS. A GIS was not performed when there were
suspected placental remnants, intrauterine haematomas, intrauterine fluid accumulation or a possible pregnancy (i.e. a visit during the midluteal phase in women not using adequate contraception). Women were followed by questionnaires and menstruation score charts at 6–12 weeks, 6 months and 12 months after the CS.

Transvaginal ultrasound
All TVU and GIS procedures were performed at St Antonus Hospital by three experienced examiners (L.V., S.V., M.S.). TVU was performed using a 7.5-MHz transducer (Philips Sonicare HD 11.XE, Philips Medical Systems, Eindhoven, the Netherlands). Women were examined after emptying their bladder. The uterus, uterine scar and niche, if present, were examined in a standardized way. The position, length and width of the uterus and double thickness of the endometrium were registered in the midsagittal plane. A niche was defined as an anechoic space (with or without fluid) at least 2 mm deep at the presumed site of the CS scar. The uterus was screened for the presence of CS scar(s) using parallel sagittal planes going from left to right until the plane with the largest niche depth was defined. The uterus was also scanned in the transverse plane. When a niche was identified, it was measured in the sagittal plane in which the niche had the greatest depth: the depth, and the residual myometrium at the site of the scar and the adjacent normal myometrium were measured in real time (see Figure 1). In cases when more than one CS scar was present the largest niche was measured.

Gel instillation sonography
A speculum was inserted and a catheter (SIS Rudigoz Catheter, CCD International, Paris, France) was placed inside the uterus. Gel (Endosgel, Farco-Pharma GmbH, Köln, Germany) was flushed inside the uterine cavity and cervix while retracting the catheter. A maximum amount of 10 cm³ was instilled, or less if uterine cramps occurred or reflux was observed from the cervix. The speculum was removed, the vaginal probe was reinserted and the presence of a niche was recorded in the sagittal plane where the niche had the greatest depth. Niche characteristics were measured and recorded as described above (Figure 1). The shape was classified according to the previous classifications published by Bij de Vaate et al.11 The presence of uterine polyps or fibroids or other intrauterine abnormalities was noted.

Figure 1  Schematic presentation of niche measurement. The following measurements were performed: (1) niche depth (in the sagittal plane); (2) RM (residual myometrium), from the serosal surface of the uterus (without the white lining of the serosa) to the apex of the niche, perpendicular to the endometrium (in sagittal and transverse planes); (3) AMT (adjacent myometrial thickness). Adapted from Bij de Vaate et al.11
**Data collection**

The characteristics of participants, including contraceptive use, breastfeeding, bleeding characteristics before pregnancy, detailed obstetric history (dates of previous CS, indication and characteristics of the last pregnancy and CS) were noted immediately after informed consent was given. Current contraceptive use and bleeding pattern were recorded at the 6- to 12-week visits after the CS. Women completed and returned a questionnaire 6 and 12 months after the CS. The questionnaire included questions on current medication or contraceptive use, breastfeeding, bleeding pattern (including duration of menstruation, postmenstrual spotting, vaginal discharge and urinary incontinence). They were also asked to complete a validated menstrual score chart, the Pictorial Blood Assessment Chart (PBAC). All data were recorded in a web-based database by two research nurses. The results of the ultrasound scans were not recorded in the case notes, and women and their doctors were not informed of the ultrasound findings. All women who underwent TVU were included in the analyses. Only women who underwent both TVU and GIS were included in the comparison of TVU and GIS measurement outcomes. The primary outcome was the prevalence of a niche as measured by TVU and GIS 6–12 weeks after CS. Secondary outcome measures included details of the bleeding pattern, including postmenstrual spotting (defined as more than 2 days of brownish discharge after the end of the menstrual period), number of days of menstrual bleeding, urinary incontinence at 6 and 12 months after CS and the relation of these to a niche, and niche characteristics (i.e. depth, residual myometrium and the ratio of the residual myometrium divided by the total thickness of the adjacent anterior myometrium) identified by TVU and GIS.

**Statistical analyses**

Data were analysed using Statistical Package for the Social Sciences version 20 (SPSS Inc., Chicago, IL, USA). Differences in baseline characteristics were compared using the chi-square test, Fisher’s exact test, Student’s t test or the Mann–Whitney U test, depending on the type and distribution of the variables. Logistic regression analysis was planned to analyse the relationship between the presence of a niche and postmenstrual spotting. Potential confounders were predefined and included age, breastfeeding, body mass index (BMI), BMI above 25 kg/m², oral contraceptive use and use of the levonorgestrel intrauterine system (LNG-IUS). These potential confounders were tested using univariate analysis. All tests were two-sided. A two-tailed P value < 0.05 was considered statistically significant.

**Results**

Between November 2007 and September 2010, 350 women gave informed consent to participate in the study within 3 days of their CS at St Antonius Hospital. Of these, 276 were willing to receive a TVU at 6–12 weeks, and 263 women could be included. TVU was used to examine 263 women and 197 underwent both TVU and GIS (see Figure 2). Two women underwent a second CS during the study period, but only the results of the first
CS and the related TVU and GIS were included in the study. TVU and GIS were performed at a mean of 7.6 ± 1.7 (SD) weeks after CS. In total, 72% (191/263) of all women who underwent a TVU completed the questionnaire at 6 months and 69% (172/249) of the women who received a questionnaire at 12 months after the CS completed it.

Of all the women who completed the questionnaire at 12 months, 45 were pregnant again. Of the women who underwent both a TVU and GIS the response rate was 73% at 12 months. Baseline characteristics and sonography results at 6–12 weeks after CS are shown in Table 1. The majority of the women (71%) analysed had had only one previous CS. Sixty-four (24%) had had two and eleven (4%) had had three previous CSs. One CS was carried out by a J-shaped or ‘hockey stick’ incision. All other women had a transverse lower
Niche prevalence and abnormal uterine bleeding

The uterus was closed in two layers in four women and in one layer in all others. Most CSs (55%) were performed because of an emergency. During the sonographic evaluation at 6–12 weeks after CS, 55% of women were breastfeeding and 77% were amenorrhoeic. At the 6- to 12-week interval, the women reported using the following methods of contraception: no contraception 36%, oral contraceptives 10%, progesterone only pill 3%, sterilisation 4%, condoms 42% and other 5%. The difference in contraceptive use was not statistically significant between patients with or without a niche. There were no differences regarding the rate of primary or emergency CS, age or parity between women who were included in our analyses and those who refused to participate or those who did not undergo a GIS or did not complete the questionnaire at 12 months.

Niche prevalence and characteristics

Niche prevalence was 49.6% when evaluated by TVU and 64.5% by GIS. In three women it was not possible to identify the scar in the uterus with TVU. With GIS all scars were visible. In women with one CS, 62% who underwent GIS had a niche, compared with 68.2% of women with two CSs and 77.8% of women with three CSs. Sonographic characteristics of the uterus are shown in Tables 1 and 2. The length and width of the uterus were no different between women who had or did not have a niche. The niche was deeper when examined by GIS than by TVU (2.32 ± 3.35 mm and 3.03 ± 3.1 mm, respectively; \( P < 0.001 \)). The thickness of the residual myometrium at the site of the uterine scar was approximately 2 mm less in women with a niche compared with those without a niche, as measured by TVU and GIS (\( P < 0.001 \) and \( P = 0.005 \), respectively; see Table 1). The mean ratio between the thickness of the residual myometrium at the site of the niche and the thickness of the adjacent myometrium was 0.74 ± 0.58 in all women who underwent GIS. The ratio was less than 0.5 in 22% of these women. Most niches detected by GIS had a semicircular shape (55%), 24% had a triangular shape, 10% had a droplet shape, 6% were inclusion cysts and 7% had another shape.

Bleeding pattern and urological symptoms

The questionnaire at 6 months was completed by 191 women. Information on the menstrual cycle was available for only 59 women. Given the large proportion of women who were still breastfeeding or who did not yet have a regular menstrual cycle we decided not to analyse the outcomes at 6 months. The questionnaire at 12 months was completed by 172 women. Menstrual pattern could not be analysed in 45 of these women due to a subsequent pregnancy. Ten of these women completed the information on the basis of their menstruation pattern before pregnancy. Information on the menstrual cycle and contraceptive use was available for 137 women, of whom 17 were amenorrhoeic due to use of LNG-IUD or other hormonal contraceptive. Postmenstrual spotting was reported by 13 out of 45 (28.9%) women with a niche detected by GIS compared with two women out of 29 (6.9%) without a niche detected by GIS (OR 5.48, 95% CI 1.14–26.48) (see Table 3). Including only primiparae, again postmenstrual spotting was reported more frequently in women with a niche detected by both TVU or GIS compared with those without a niche.
<table>
<thead>
<tr>
<th>Table 1  Characteristics of the study participants</th>
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<tr>
<td><strong>Baseline characteristics</strong></td>
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<tr>
<td>All women (n = 263)</td>
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<tr>
<td>Niche (TVU) (n = 129)</td>
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<td>No niche (TVU) (n = 131)</td>
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<tr>
<td><strong>P value</strong>*</td>
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<tr>
<td>Niche (GIS) (n = 127)</td>
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<tr>
<td>No niche (GIS) (n = 70)</td>
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<tr>
<td><strong>P value</strong></td>
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<tr>
<td><strong>Age (years), mean (±SD)</strong></td>
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<tr>
<td>32.46 (±4.15)</td>
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<td>32.66 (±4.16)</td>
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<tr>
<td>32.26 (±4.15)</td>
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<tr>
<td>0.44</td>
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<tr>
<td>32.51 (±4.11)</td>
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<tr>
<td>32.73 (±3.85)</td>
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<tr>
<td>0.72</td>
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<tr>
<td><strong>Parity, mean (±SD)</strong></td>
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<tr>
<td>1.54 (±0.70)</td>
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<tr>
<td>1.55 (±0.73)</td>
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<tr>
<td>1.54 (±0.68)</td>
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<tr>
<td>0.96</td>
</tr>
<tr>
<td>1.57 (±0.78)</td>
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<tr>
<td>1.50 (±0.68)</td>
</tr>
<tr>
<td>0.52</td>
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<tr>
<td><strong>BMI (kg/m²), mean (±SD)</strong></td>
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<tr>
<td>25.70 (±5.58)</td>
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<td>26.15 (±5.48)</td>
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<tr>
<td>25.28 (±5.66)</td>
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<tr>
<td>0.29</td>
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<tr>
<td>25.98 (±5.83)</td>
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<tr>
<td>24.98 (±5.19)</td>
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<tr>
<td>0.29</td>
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<tr>
<td><strong>Number of CSs, mean (±SD)</strong></td>
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<tr>
<td>1.33 (±0.56)</td>
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<tr>
<td>1.35 (±0.57)</td>
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<tr>
<td>1.31 (±0.54)</td>
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<tr>
<td>0.55</td>
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<tr>
<td>1.35 (±0.59)</td>
</tr>
<tr>
<td>1.26 (±0.50)</td>
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<tr>
<td>0.26</td>
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<tr>
<td><strong>Visit at 6–12 weeks after CS</strong></td>
</tr>
<tr>
<td><strong>Weeks after CS, mean (±SD)</strong></td>
</tr>
<tr>
<td>7.58 (±1.74)</td>
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<tr>
<td>7.40 (±1.40)</td>
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<tr>
<td>7.74 (±2.01)</td>
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<tr>
<td>0.12</td>
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<tr>
<td>7.66 (±1.77)</td>
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<tr>
<td>7.72 (±1.92)</td>
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<tr>
<td>0.82</td>
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<tr>
<td><strong>Breastfeeding, number (percentage)</strong>*</td>
</tr>
<tr>
<td>142 (55%)</td>
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<td>67 (52%)</td>
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<td>75 (59%)</td>
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<tr>
<td>0.38</td>
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<tr>
<td>64 (53%)</td>
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<tr>
<td>41 (61%)</td>
</tr>
<tr>
<td>0.29</td>
</tr>
<tr>
<td><strong>Ultrasoundographic results at 6–12 weeks after CS</strong></td>
</tr>
<tr>
<td><strong>Double endometrial thickness TVU (mm), mean (±SD)</strong></td>
</tr>
<tr>
<td>5.49 (±3.80)</td>
</tr>
<tr>
<td>5.61 (±3.85)</td>
</tr>
<tr>
<td>5.36 (±5.77)</td>
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<tr>
<td>0.61</td>
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<tr>
<td>5.36 (±3.57)</td>
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<tr>
<td>4.86 (±3.33)</td>
</tr>
<tr>
<td>0.34</td>
</tr>
<tr>
<td><strong>Uterus length TVU (cm), mean (±SD)</strong></td>
</tr>
<tr>
<td>7.18 (±1.43)</td>
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<tr>
<td>7.29 (±1.52)</td>
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<tr>
<td>7.07 (±1.32)</td>
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<tr>
<td>0.23</td>
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<tr>
<td>7.09 (±1.38)</td>
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<tr>
<td>7.11 (±1.47)</td>
</tr>
<tr>
<td>0.92</td>
</tr>
<tr>
<td><strong>Uterus width TVU (cm), mean (±SD)</strong></td>
</tr>
<tr>
<td>4.23 (±0.94)</td>
</tr>
<tr>
<td>4.26 (±0.81)</td>
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<tr>
<td>4.19 (±1.07)</td>
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<tr>
<td>0.59</td>
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<tr>
<td>4.27 (±0.84)</td>
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<tr>
<td>4.17 (±1.20)</td>
</tr>
<tr>
<td>0.49</td>
</tr>
<tr>
<td><strong>Thickness of myometrium at site of CS scar (mm), mean (±SD)</strong></td>
</tr>
<tr>
<td>9.59 (±4.18)</td>
</tr>
<tr>
<td>8.51 (±3.90)</td>
</tr>
<tr>
<td>10.73 (±4.18)</td>
</tr>
<tr>
<td>&lt;0.001</td>
</tr>
<tr>
<td>8.59 (±3.81)</td>
</tr>
<tr>
<td>10.20 (±3.59)</td>
</tr>
<tr>
<td>0.005</td>
</tr>
</tbody>
</table>

BMI, body mass index; CS, caesarean section; TVU, transvaginal ultrasound; GIS, gel instillation sonohysterography. *P value between niche and no niche during TVU. **P value between niche and no niche during GIS. ***No information on breastfeeding for 13 patients at 6–12 weeks after CS.
[31% versus 4% (OR 9.7, 95% CI 1.1–85.6) for TVU and 32% versus 0% for GIS]. Women with a ratio of residual myometrium of less than half of the adjacent myometrium (ratio < 0.5) measured by TVU or GIS reported postmenstrual spotting more often than women with a ratio of more than 0.5 (OR 7.2, 95% CI 1.74–21.62 and OR 6.1, 95%CI 1.94–26.70, respectively) (see Table 4).

Using univariate analyses none of the predefined confounders or baseline characteristics were related to postmenstrual spotting, all had a $P$ value above 0.1 (LNG-IUD use $P$ = 0.11; oral contraceptive use $P$ = 0.24; breastfeeding $P$ = 1.0; age $P$ = 1.0; BMI $P$ = 1.0; BMI > 25 kg/m² $P$ = 0.40) and therefore the planned logistic regression was not performed. We did not find any significant differences between women with or without a niche concerning the existence of (combined) urinary incontinence, urge incontinence or stress incontinence (see Table 3).

### Discussion

**Main findings**

All CS scars could be identified using GIS. Using this technique the prevalence of niches at the site of these CS scars was high (64.5%) in a random population. Comparing the results of GIS with TVU, niche prevalence was higher, measured niche depth was greater and residual myometrium was thinner when detected by GIS. Postmenstrual spotting 1 year after CS was strongly related to the presence of a niche detected by both TVU and GIS. One out of three women with a niche detected by GIS reported postmenstrual spotting compared with one out of ten women without a niche. Postmenstrual spotting was related to a residual:adjacent myometrium ratio of < 50%, which might indicate that this is a relevant parameter for niche size. The prevalence of urinary incontinence was not related to the presence or absence of a niche.

### Table 2 Comparison of transvaginal ultrasound (TVU) and gel instillation sonohysterography (GIS) results (n = 197)*

<table>
<thead>
<tr>
<th></th>
<th>TVU</th>
<th>GIS</th>
<th>$P$ value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niche depth of all women, mean (±SD)**</td>
<td>2.32 (±3.35)</td>
<td>3.03 (±3.1)</td>
<td>&lt;0.001 (0.38–1.02)</td>
</tr>
<tr>
<td>Niche depth of women with niche on GIS, mean (±SD)**</td>
<td>3.43 (±3.67)</td>
<td>4.77 (±2.64)</td>
<td>&lt;0.001 (0.92–1.79)</td>
</tr>
<tr>
<td>Residual myometrial thickness of all women, mean (±SD)</td>
<td>9.58 (±4.39)</td>
<td>9.11 (±3.8)</td>
<td>0.06 (–0.24 to 0.96)</td>
</tr>
<tr>
<td>Residual myometrial thickness of women with niche on GIS, mean (±SD)</td>
<td>9.30 (±4.67)</td>
<td>8.59 (±3.75)</td>
<td>0.03 (0.09–1.38)</td>
</tr>
</tbody>
</table>

*Of the 263 women only the 197 women who underwent both TVU and GIS were included in this table.

**Niche depth was recorded as 0 when no niche was observed.
### Table 3  Uterine bleeding pattern and urological symptoms at 12 months after caesarean section.

<table>
<thead>
<tr>
<th></th>
<th>Niche (TVU)</th>
<th>No niche (TVU)</th>
<th>P value*</th>
<th>Niche (GIS)</th>
<th>No niche (GIS)</th>
<th>P value**</th>
<th>Odds (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of women with postmenstrual spotting ($n = 91/74$)**</td>
<td>13 (26)</td>
<td>5 (12)</td>
<td>0.10</td>
<td>13 (28.9)</td>
<td>2 (6.9)</td>
<td>0.02</td>
<td>5.48 (1.14–26.48)</td>
</tr>
<tr>
<td>Days of blood loss during menstruation, mean (±SD) ($n = 91/83$)**</td>
<td>5.9 (2.57)</td>
<td>6.1 (2.84)</td>
<td>0.75</td>
<td>5.5 (±2.1)</td>
<td>5.5 (±1.4)</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>No. of women with vaginal discharge ($n = 137/90$)**</td>
<td>11 (14)</td>
<td>11 (18)</td>
<td>0.84</td>
<td>7 (11)</td>
<td>8 (23)</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>No. of women taking oral contraceptives ($n = 137/109$)**</td>
<td>19 (25)</td>
<td>13 (21)</td>
<td>0.61</td>
<td>19 (28)</td>
<td>10 (24)</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>No. of women with LNG-IUD ($n = 137/109$)**</td>
<td>9 (12)</td>
<td>8 (13)</td>
<td>0.82</td>
<td>10 (15)</td>
<td>2 (5)</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>No. of women with amenorrhoea ($n = 137/109$)**</td>
<td>12 (16)</td>
<td>5 (8)</td>
<td>0.18</td>
<td>9 (13)</td>
<td>3 (7)</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>No. of women with incontinence ($n = 115/90$)**</td>
<td>20 (31)</td>
<td>17 (34)</td>
<td>0.71</td>
<td>19 (33)</td>
<td>10 (29)</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>No. of women with stress incontinence ($n = 115/90$)**</td>
<td>15 (23)</td>
<td>11 (22)</td>
<td>0.89</td>
<td>14 (25)</td>
<td>6 (17)</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>No. of women with urge incontinence ($n = 115/90$)**</td>
<td>4 (6)</td>
<td>3 (6)</td>
<td>0.97</td>
<td>2 (4)</td>
<td>2 (6)</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>No. of pregnant women ($n = 260/197$)**</td>
<td>17 (13)</td>
<td>28 (21)</td>
<td>0.08</td>
<td>21 (16.5)</td>
<td>15 (21)</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>No lost to follow up/ nonresponders ($n = 263/197$)</td>
<td>42 (33)</td>
<td>49 (37)</td>
<td>0.41</td>
<td>45 (35)</td>
<td>18 (26)</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Total ($n = 260/197$)**</td>
<td>129 (49.6)</td>
<td>131 (50.4)</td>
<td></td>
<td>127 (64.5)</td>
<td>70 (35.5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as number(%) unless indicated with mean (±SD). GIS, gel instillation sonohysterography; TVU, transvaginal ultrasound; LNG-IUD, levonorgestrel intrauterine device. Three women for whom the presence of a niche could not be determined are excluded. **Number of women who completed the questionnaire for a specific parameter and who underwent TVU/GIS, respectively. *P value between niche and no niche during TVU. **P value between niche and no niche during GIS.
Table 4  Niche characteristics in women with or without postmenstrual spotting (n = 91/74)*

<table>
<thead>
<tr>
<th></th>
<th>Post menstrual spotting (TVU) (n = 18)</th>
<th>No post menstrual spotting (TVU) (n = 73)</th>
<th>P value (OR, 95%CI) **</th>
<th>Post menstrual spotting (GIS) (n = 15)</th>
<th>No post menstrual spotting (GIS) (n = 59)</th>
<th>P value (OR, 95%CI) ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niche depth (mm), mean (±SD)</td>
<td>5.46 (±2.50)</td>
<td>5.15 (±2.77)</td>
<td>0.72</td>
<td>5.45 (±2.76)</td>
<td>4.86 (±2.50)</td>
<td>0.47</td>
</tr>
<tr>
<td>Residual thickness myometrium at the site of the caesarean scar (mm), mean (±SD)</td>
<td>8.92 (±4.76)</td>
<td>9.31 (±4.23)</td>
<td>0.73</td>
<td>8.19 (±5.06)</td>
<td>9.22 (±4.11)</td>
<td>0.40</td>
</tr>
<tr>
<td>No. of women with ratio RM/AM &lt;50%**** (TVU n = 69; GIS n = 73)</td>
<td>8 (61%)</td>
<td>10 (18%)</td>
<td>0.03 (OR 7.2 1.94–26.70)</td>
<td>8 (57%)</td>
<td>10 (18%)</td>
<td>0.005 (OR 6.13 1.74–21.83)</td>
</tr>
<tr>
<td>Mean ratio RM/AM****</td>
<td>0.50</td>
<td>0.72</td>
<td>0.008</td>
<td>0.53</td>
<td>0.70</td>
<td>0.03</td>
</tr>
</tbody>
</table>

TVU, transvaginal ultrasound; GIS, gel instillation sonohysterography; RM, residual myometrium; AM, adjacent myometrium; OR, odds ratio; 95% CI, 95% confidence interval. *Number of women who completed the postmenstrual spotting questionnaire and who underwent TVU/GIS, respectively. All patients who completed the questionnaire on postmenstrual spotting were included. **P value between patients with and without postmenstrual spotting who underwent TVU. ***P value between patients with and without postmenstrual spotting who received a GIS. ****Ratio RM/AM = residual myometrial thickness at the site of the caesarean scar/myometrial thickness of the adjacent myometrium, presented in numbers (percentage).
**Strengths and limitations of the study**

To the best of our knowledge this is the first study that has recruited participants at a very early stage after their CS (within 3 days) followed by early examination (within 3 months) by both TVS and GIS and sequential completion of menstrual questionnaires up to 1 year after the CS. Only two prospective studies have evaluated niches in an unselected population.\textsuperscript{11,19} Both these studies recruited patients 6–12 months after CS. The Bij de Vaate et al.\textsuperscript{11} study was carried out by our study group but in a different population and with the examinations done by a different examiner. In the present study early scanning (3 months after the CS) meant that the vast majority of the women were still amenorrhoic, so the influence of abnormal uterine bleeding on the willingness of women to participate (selection bias) is expected to be limited. An additional advantage of early sonographic evaluation is that, due to amenorrhoea in most patients, the potential confounding effect of variations in timing of the measurements during the menstrual cycle and related endometrial thickness is limited. In addition, women were consecutively asked to participate by research midwives and the registration of the results was independent of clinical considerations. Women and their doctors were not informed whether or not a niche was observed to prevent possible bias in reporting their bleeding pattern. Although complete post-CS scar healing may take up to 6 months,\textsuperscript{6} we do not know the exact time needed to develop a niche. We defined a niche as an anechoic space (with or without fluid) with a depth of at least 2 mm at the presumed site of the CS scar. This should not be confused with the CS scar itself. As demonstrated in this study, a scar is almost always visible and is reflected as a hypoechoic indentation of the myometrium at the location of the CS. We expect the uterine scar to continue to heal beyond 6–12 weeks and it might differ in performance with time. However, we consider it very unlikely that niches (i.e. discontinuations and fluid-stained spaces in the myometrium) will heal after this period. However, changes in a niche over time are not unlikely. Sustained accumulation of fluid may, in theory, increase niche size over time but no data are currently available to confirm this theory.

A possible limitation of our study is that not all women who were delivered by CS during the study period were asked to participate. Women were asked consecutively by trained midwives during their day and night shifts, but these midwives were not always present. Because the absence of the midwives was randomly distributed over the week, we consider this potential effect on selection bias to be minor. This is underlined by the lack of differences in baseline characteristics between women who were asked to participate and those who were not concerning elective or emergency CS, age and parity. In addition, we did not observe any differences in these parameters between included and excluded women or those who were not willing to undergo a GIS or who did not complete the questionnaire.

Patients with a previous twin pregnancy or a known uterine anomaly were excluded in order to assemble a homogeneous group and to prevent undesired effects of unknown confounders. However, whether these factors would in fact introduce significant confounding effects is a topic for further discussion. We also decided not to perform a GIS
Niche prevalence and abnormal uterine bleeding

in patients with a placental remnant, haematoma or fluid in the uterine cavity detected by TVU. The consequence of all this is that a relatively small proportion of all patients who provided informed consent were analysed. Whether it is correct to exclude women with intrauterine fluid collection from examination by GIS should be further discussed. This was decided before the start of the study and included in the study protocol. However, it can be postulated that this group might have been particularly symptomatic and prone to postmenstrual spotting. We could not observe any relation between niches and urinary incontinence, but we did not report other urinary symptoms, such as urgency. An additional shortcoming of the study is that we did not measure the niche width in the sagittal plane or the niche length in the transverse plane as recently proposed by Naji et al.5 (our study had already begun before that publication). Therefore we could not analyse the relation between these parameters and niche symptomatology. We also did not determine the reproducibility of our measurements.

Clinical implications of the findings and relation to published data

We were able to identify the CS scar with GIS in 100% of the women. This is in line with another study examining women within 3 months of a CS.18 The observed niche prevalence rate of 49.6% using TVU is comparable to the reported prevalence (42%) in a prospective cohort study of an unselected population.9 Different prevalence rates (28 and 61%) were reported in prospective studies in populations evaluated 6 months and 6–12 months after a CS.11,13 Different definitions of a niche and different timing after the CS may both affect the niche detection rate. Vikhareva Osser et al.13 used the definition ‘any visible defect’ and Bij de Vaate et al.11 used ‘any indentation of at least 1 mm’. We used a cut-off level of 2 mm. However, consensus on the exact cut-off levels is lacking. Early scanning may facilitate recognition of the location of the CS scar in the uterine wall due to incomplete scar healing, and this may increase the detection of small niches. In addition, the related thin endometrium due to breastfeeding in the majority of the women may also improve niche recognition and measurement.

We used the same terminology as suggested by Naji et al.5 and measured the depth and residual myometrial thickness in the sagittal plane as described. Niche prevalence using GIS was 64.5% in our study, which is comparable to the reported prevalence using GIS or SIS in random, unselected populations (56%,10 59.5%,11 59%14 and 78%19). Niche prevalence was higher using GIS than with TVU only. These findings are in line with the reported findings of three studies comparing GIS or SIS with TVU.10,11,19 These studies showed a higher niche prevalence with sonohysterography than with TVU without contrast, thus GIS may be more accurate at detecting niches. Although the niches that were detected using GIS but were missed using TVU were smaller than those detected by both TVU and GIS, they can be clinically relevant. This is underlined by the strong relationship we found between postmenstrual spotting and niches on GIS.11 An additional argument for using GIS rather than TVU is that the residual myometrium measured using GIS was significantly thinner. The residual myometrium is considered to be the main limiting factor for eventual hysteroscopic niche resections to treat related bleeding symptoms. Most publications
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report a required residual myometrium of 2 to 3 mm for hysteroscopic niche resection given the risk of perforation and/or bladder injury. In order to prevent undesired complications during hysteroscopic niche resections we propose that a GIS or SIS be used rather than TVU for preoperative evaluation of the residual myometrium. Several previous studies indicated a relation between large niches and postmenstrual spotting. Bij de Vaate et al. reported the niche volume to be related to postmenstrual spotting. We were not able to calculate niche volume due to the lack of stored three-dimensional volumes. In order to assess the relation between large niches and postmenstrual spotting, we decided not to take an absolute measurement of residual myometrium but to relate it to the adjacent myometrium. We defined large niches as those with a residual myometrium having a thickness of less than 50% of that of the adjacent myometrium. This parameter was significantly related to postmenstrual spotting. This parameter and cut-off level were also used by Ofilli-Yebovi et al., who reported a high prevalence of women with a ratio of less than 50% in a population with gynaecological symptoms. A potential relationship between niche size and postmenstrual spotting is in line with the hypothesis that spotting is induced by the accumulation of blood inside the niche. A depth of more than half the myometrial thickness makes the anterior part of the niche possibly large enough to obstruct the direct outflow of menstrual blood. This, in combination with lower contractility due to fibrosis, may induce the accumulation of blood in a niche.

One out of three women with a niche observed by GIS reported postmenstrual spotting. This is in line with the previous reported prevalence of postmenstrual spotting in patients with a niche. Given the high prevalence of postmenstrual spotting after CS, this should be part of routine counselling before elective CS.

Future perspectives

Future research should focus on the relationship of niches to subsequent fertility, obstetric complications such as uterine rupture and on the impact of a niche on a woman’s well-being. There is a lack of information on the impact of niche-related bleeding disorders on women’s quality of life, their sexual function and their willingness to undergo treatment for the related symptoms.

Conclusion

In conclusion, the CS scar was visible in all women at 6–12 weeks after CS using GIS. The prevalence of niches detected by GIS is high after CS (64.5%) and more niches are detected using GIS than using TVU, with a larger observed niche size and reduced residual myometrial thickness. The presence of a niche is related to postmenstrual spotting. Postmenstrual spotting is more frequent in patients with large niches (defined as a residual myometrium having a thickness less than 50% of that of the adjacent myometrium) than in patients with smaller niches.
Disclosure of interest
None of the authors have any relevant financial, personal, political or religious interest linked to the subject of this article.

Contribution to authorship
The study was conceived by L.V., J.H., H.B. and S.V. and L.V. and S.V. performed the ultrasounds and collected the data. Analysis of the data was performed by L.V. and J.H. The first draft was written by L.V. and J.H. S.V., H.B. and A.B. helped to supervise the article up to the final draft.

Details of ethics approval
The study received ethics approval from the United Committee on research involving human subjects (VCMO), Nieuwegein, The Netherlands on 27 September 2007; ref. no. NL18722.100.07 R-07.14A/SCAR.

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