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Caesarean scar defect: Risk factors and comparison of evaluation efficacy between transvaginal sonography and magnetic resonance imaging

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ABSTRACT

Objectives: To determine the risk factors for development of caesarean scar defect (CSD), compare the efficacy of transvaginal ultrasound (TVS) and magnetic resonance imaging (MRI) for CSD assessment, and investigate the association between CSD size and clinical symptoms.
Study design: One hundred and eighty-nine women with CSD and 378 women without CSD with a history of caesarean section (CS) at the Obsterics and Gynaecology Hospital of Fudan University between January 2008 and February 2016 were enrolled. The potential risk factors for CSD were investigated using multivariate logistic regression analysis. TVS and MRI were performed for CSD measurements, including residual myometrial thickness, and depth, length and width of CSD. Associations between CSD size by TVS/MRI and symptoms were evaluated.
Results: CS time ≥85 min, peripartum fever or infection, and retroflexed uterus were risk factors for CSD, and age at last CS < 30 years, intraoperative blood loss <150 ml and double-layer closure were protective factors for CSD. Prolonged menstruation, dysmenorrhoea, chronic pelvic pain and infertility were the main clinical manifestations. Women with a larger CSD presented with more prolonged menstruation. Compared with TVS, measurements by MRI showed better prediction of the clinical symptoms of CSD.
Conclusions: Various factors contribute to the development of CSD. Prevention of peripartum infection, reduction of CS time, reduction of blood loss and more careful uterine closure are needed to decrease the risk of developing CSD. MRI is a reliable method for the diagnosis and measurement of CSD, and can be utilized in clinical practice.

Introduction

In recent decades, the caesarean section (CS) rate has increased dramatically. It is estimated that almost one-third of women have delivered by CS worldwide [1], and the overall CS rate in China increased from 28.8% in 2008 to 34.9% in 2014 [2]. It is well known that an increasing CS rate is associated with potential short- and long-term complication of caesarean scars, such as uterine rupture and placental abnormalities in future pregnancies [3]. Interest in caesarean scar defect (CSD) is increasing accordingly.

A CSD, also called a 'niche', an 'isthmocele', a 'diverticulum' or 'caesarean scar dehiscence', is a defect of the anterior uterine isthmus located at the site of a prior CS [4]. Due to the increasing CS rate, the CSD rate is also increasing. The reported prevalence of CSD in women with a history of CS varied between 24% and 70% using transvaginal sonography (TVS), and was even higher (56–84%) using sonohysterography (SHG) [5]. Patients with CSD are usually asymptomatic, and the most common complaints related to CSD are prolonged menstrual bleeding and postmenstrual spotting [6], as well as pelvic pain, dysmenorrhoea and secondary infertility [7]. At present, it is generally believed that CSD is the result of

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incomplete healing of the isthmic myometrium after CS. While not all women with a history of CS develop CSD, there is a need to identify the risk factors that may predict its development.

Several methods have been described for CSD diagnosis, such as TVS [8], SHG [9,10], hysteroscopy [11] and hysterosalpingography [12]. However, studies on the use of magnetic resonance imaging (MRI) for the diagnosis of CSD are limited. Furthermore, there is still no consensus on a standardized approach for detection and measurement of CSD.

This study aimed to determine the risk factors for development of CSD in women with a history of CS, to compare the efficacy of TVS and MRI for the assessment of CSD, and to investigate correlation between CSD size and clinical symptoms.

Materials and methods

Patients and methods

Inclusion criteria in this case–control study were as follows: (1) history of CS and a diagnosis of CSD by TVS and/or MRI; (2) referral to the Obstetrics and Gynaecology Hospital of Fudan University between January 2008 and February 2016; (3) no uterine pathology that may have been responsible for abnormal uterine bleeding (e.g. endometrial hyperplasia, polyps or myoma); and (4) no previous uterine surgery except CS. Women who underwent CS at the Obstetrics and Gynaecology Hospital of Fudan University during the same period and did not develop CSD confirmed by TVS were included as a control group.

Demographic data and detailed obstetric characteristics were collected from the medical records for each patient. The clinical symptoms of the patients were reviewed, such as postmenstrual spotting, dysmenorrhoea, chronic pelvic pain and dyspareunia. Missing data were obtained by telephone follow-up.

The following measurements of CSD by TVS/MRI were recorded: uterine flexion, length (transverse distance of CSD at its base), width (length of CSD at its base along the cervicoisthmic canal), depth (vertical distance between the base and apex of CSD) and residual myometrial thickness (RMT) of CSD in accordance with Naji et al. [13]. CSD volume was defined as length × width × depth [14]. Participants underwent CSD evaluation by TVS or MRI at least 6 months after CS [15,16]. An anteflexed uterus and a retroflexed uterus were defined as when the long axis of the uterine body deviated anteriorly and posteriorly, respectively, in relation to the cervical axis. Single-layer closure was performed as one continuous, locked row of sutures. Double-layer closure was performed as two continuous rows of sutures, of which the first was locked and the second was a continuous, unlocked row of sutures. Peripartum fever or infection was defined as two measurements of body temperature >38 °C every 4 h pre and post CS, leukocytes $\geq 15 \times 10^9$/l, neutrophils ≥90%, C-reactive protein >8 mg/l and procalcitonin ≥0.5 ng/ml. The study protocol was approved by the Medical Ethics Committee of the Obstetrics and Gynaecology Hospital of Fudan University. All participants gave their written informed consent.

Statistical analysis

Data were analysed using SPSS 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were compared using a two-sample *t*-test, or the Mann–Whitney *U* test when they were non-normally distributed. All categorical variables were compared by Chi-squared test or Fisher's exact test. To identify risk factors that were associated with the development of CSD, multivariate logistic regression with stepwise regression analysis was undertaken. $P < 0.05$ was considered to indicate statistical significance.

Results

It has been reported previously that the odds ratio (OR) of CSD in women with a history of CS is approximately 2.0, and the CS rate of the general population is approximately 35% [2]. With a level of statistical significance of 0.05 and a power of 0.80, it was estimated that a sample size of 189 women with CSD was needed in the case group. The control group consisted of 378 women based on the ratio of cases to controls of 1:2. The baseline characteristics are shown in Table 1.

Significant differences in uterine position, age at last CS, duration of lochia, presence of active labour, suturing technique, peripartum infection or fever, intraoperative blood loss and CS time (all $P < 0.01$) were found between women with and without CSD. There were no significant differences between the two groups in terms of age, number of CSs and method of anaesthesia ($P > 0.05$).

In the analysis of clinical symptoms (Table 2), menstrual duration was significantly longer in women with CSD (12.90 ± 3.91 days vs 6.47 ± 2.44 days, $P < 0.001$). When the change in menstrual duration after CS was analysed, women with CSD had significantly prolonged menstruation compared with women in the control group (6.92±3.99 days vs 1.08±2.56 days, $P < 0.001$). Dysmenorrhoea and chronic pelvic pain, which are also described as CSD-related symptoms, were more common in women with CSD (all $P < 0.01$). Fifty-three of the 189 women with CSD and 95 of the 378 women without CSD presented with fertility desire, and 26 and 12 of them were diagnosed with secondary infertility, respectively [26/53 (49.1%) vs 12/95 (12.6%), $P < 0.001$]. No significant differences in the incidence of dyspareunia and menstrual volume were found ($P > 0.05$).

Table 1
Baseline characteristics.

Variable	CSD group (n = 189)	Control group (n = 378)	P-value
Age (years)			0.442[c]
	32.84 ± 3.74	32.25 ± 3.95	
Uterine position (n, %)			
Anteflexed	88 (46.6)	320 (84.7)	<0.001[b]
Straight and retroflexed	101 (53.4)	58 (15.3)	
Age at last CS (years)			<0.001[b]
<30	51 (27.0)	269 (71.2)	
≥30	138 (73.0)	109 (28.8)	
Number of CSs (n, %)			
1	139 (73.5)	299 (79.1)	0.297[a]
2	47 (24.9)	76 (20.1)	
3	3 (1.6)	3 (0.8)	
Duration of lochia (days)			<0.001[c]
	45.57 ± 13.90	39.73 ± 4.20	
Active labour (n, %)			<0.001[a]
Yes	65 (34.4)	4 (1.1)	
No	124 (65.6)	374 (98.9)	
Suturing technique (n, %)			<0.001[b]
Single-layer	96 (50.8)	12 (3.2)	
Double-layer	93 (49.2)	366 (96.8)	
Anaesthesia (n, %)			0.947[b]
Regional	138 (73.0)	277 (73.3)	
General	51 (27.0)	101 (26.7)	
Peripartum fever or infection (n, %)			<0.001[b]
Yes	29 (15.3)	7 (1.9)	
No	160 (84.7)	371 (98.1)	
Intraoperative blood loss (ml)			0.001[b]
≥150	101 (53.4)	87 (23.0)	
<150	88 (46.6)	291 (77.0)	
CS time (min)			<0.001[a]
<85	93 (49.2)	0 (0.0)	
≥85	96 (50.8)	378 (100.0)	

CSD, caesarean scar defect; CS, caesarean section.
[a] Fisher's exact test.
[b] Chi-squared test.
[c] Two-sample *t*-test.

Table 2
Comparison of clinical symptoms in women with vs without caesarean scar defect (CSD).

Variable	CSD group (n = 189)	Control group (n = 378)	P-value
Menstrual duration (days)			
	12.90 ± 3.91	6.47 ± 2.44	<0.001
Menstrual cycle (days)			
	30.48 ± 6.00	31.08 ± 8.87	0.120
Blood loss during menstruation (ml)			0.146
30–80	179 (94.6)	367 (97.1)	
<30 or >80	10 (5.4)	11 (2.9)	
Prolonged menstruation (days)			
	6.92 ± 3.99	1.08 ± 2.56	<0.001
Infertility			<0.001
Yes	26(49.06%)	12(12.63%)	
No	27(50.94%)	83(87.27%)	
Dysmenorrhoea			<0.001
Yes	53 (28.0)	40 (10.6)	
No	136 (72.0)	338 (89.4)	
Chronic pelvic pain			0.002
Yes	23 (12.2)	19 (5.0)	
No	166 (87.8)	359 (95.0)	
Dyspareunia			0.055
Yes	14 (7.4)	14 (3.7)	
No	175 (92.6)	364 (96.3)	

One hundred and fifty-six of the 189 women with CSD were evaluated by TVS and 147 women were evaluated by MRI. For women who underwent both TVS and MRI evaluation, a paired t-test was conducted to assess the consistency of the two methods. As shown in Table 3, the mean length and depth of CSD was significantly greater when measured by MRI than TVS ($P < 0.05$). Mean RMT was greater when measured by TVS than MRI, and no significant differences were found in the width and volume of CSD measured by TVS and MRI. The data showed that certain differences between the measurement results of CSD are inevitable using different methods.

In order to further identify the best measurement method for CSD, associations between CSD parameters (length, width, depth, volume and RMT) measured by TVS/MRI and clinical symptoms were analysed (Tables 4 and 5). The women with CSD were divided into two groups based on mean prolonged menstruation time: >6 days or ≤6 days. The results demonstrated that mean length, depth and volume of CSD measured by MRI were significantly greater in CSD patients with more prolonged menstruation (>6 days vs ≤6 days). However, no associations were found between all measured CSD parameters and the presence of other clinical symptoms. These results suggest an association between a larger CSD and a longer duration of menstrual bleeding. This association was not found by TVS.

Using multivariate logistic regression analyses, associations between all of the above factors and the development of CSD were analysed. After excluding the variables with collinear effects, the factors affecting the development of CSD were analysed by stepwise multivariate logistic regression (Table 6). CS time ≥85 min, peripartum fever or infection, and retroflexed uterus (all $P < 0.001$) were found to be risk factors for CSD, while age at last CS <30 years, intraoperative blood loss <150 ml and double-layer closure (all $P < 0.001$) were found to be protective factors for CSD.

Table 3
Measurement of caesarean scar defect (CSD) using transvaginal sonography (TVS) and magnetic resonance imaging (MRI).

Variable	n	TVS Mean ± SD	MRI Mean ± SD	P-value
Length of CSD (mm)	110	11.18 ± 8.21	14.63 ± 6.95	<0.001[a]
Width of CSD (mm)	115	8.83 ± 5.89	8.89 ± 5.57	0.906
Depth of CSD (mm)	115	6.81 ± 5.04	7.60 ± 4.49	0.034[a]
RMT of CSD (mm)	93	2.46 ± 1.73	3.61 ± 1.98	<0.001[a]
Volume of CSD (cm^3)	110	6.53 ± 0.62	4.37 ± 0.42	0.729

SD, standard deviation.
[a] Paired t-test.

Comment

To date, the precise pathophysiology underlying the genesis of CSD is unknown. Bij de Vaate et al. classified all potential risk factors into four main categories: factors related to closure technique, development of the lower uterine segment or location of the incision, wound healing and miscellaneous factors [5].

The present study demonstrated that longer CS time, peripartum fever or infection, and retroflexed uterus were risk factors for CSD, whereas age at last CS < 30 years, intraoperative blood loss <150 ml and double-layer closure were protective factors for CSD. A number of studies have noted an association between a retroflexed uterus and the development of CSD. It has been suggested that the high degree of mechanical tension of the lower uterine segment in a retroflexed uterus might reduce blood perfusion and oxygenation, and this could have a negative effect on healing of the caesarean scar [17]. In agreement with previous studies, this study found that a retroflexed uterus increased the risk for CSD development [OR 6.315, 95% confidence interval (CI) 3.212–12.414].

Closing the uterine wall in either single or double layers, using locked or unlocked suture techniques, the inclusion or exclusion of decidua, and the type of suture material may affect the development of CSD [18]. Although several studies have investigated the association between closure technique and CSD, the results remain contradictory. Vikhareva Osser et al. found that a larger CSD was more common in women with single-layer uterine closure (90.9%) in comparison with women with double-layer closure (9.1%), but the difference was not significant [19]. This is consistent with the present finding that double-layer closure was a protective factor for CSD. However, a review by Tulandi et al. found that single-layer closure reduced the risk of CSD [20]. Recently, Shashikant concluded that double-layer closure may be associated with better apposition of the thick uterine muscle edges, while single-layer closure has the potential advantage of less ischaemia of the myometrial edges, which will influence the thickness of muscle-to-muscle healing. As such, it is crucial to achieve good apposition of myometrial edges without ischaemia, rather than the simple concept of single-layer closure vs double-layer closure [21]. Further well-designed research is needed to confirm this hypothesis.

The multivariate logistic analysis showed that CSD was more common after a longer CS (OR 1.253, 95% CI 1.128–1.391) and peripartum fever or infection (OR 29.848, 95% CI 7.897–112.811). However, a definite mechanism for the relationship between CS time and CSD is unclear. Shortening the CS time seems to reduce the CSD rate, but more careful uterine closure and bleeding control may be more important. Less intraoperative blood loss has a protective effect on the development of CSD (OR 1.253, 95% CI 1.128–1.391); this can be explained by the importance of perfusion for wound healing. Peripartum fever or infection may impair wound healing, which may contribute to the development of CSD; as such, prevention of peripartum infection is vital. This study also found that women who underwent their last CS at <30 years of age reported less CSD (OR 0.098, 95% CI 0.039–0.247); this is in agreement with the study by Vikhareva Osser et al. but the underlying mechanism is uncertain.

The most common complaints related to CSD are prolonged menstrual bleeding and postmenstrual spotting (in up to three-quarters of women with CSD), followed by pelvic pain (39.6%), dysmenorrhoea (53.1%), dyspareunia (18.3%) and secondary

Table 4
Association between clinical symptoms and caesarean scar defect (CSD) dimensions measured by transvaginal sonography.

Symptoms	Length of CSD (mm)		Width of CSD (mm)		Depth of CSD (mm)		RMT (mm)		Volume of CSD (cm^3)	
	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	*P*-value
Prolonged menstruation		0.140		0.595		0.077		0.899		0.287
>6 days	12.97 ± 9.25		9.09 ± 6.46		7.43 ± 5.80		2.81 ± 2.66		2.33 ± 7.71	
≤6 days	10.28 ± 5.92		9.98 ± 6.44		6.76 ± 4.61		2.63 ± 1.57		1.58 ± 6.66	
Dysmenorrhoea		0.519		0.139		0.171		0.308		0.436
Yes	12.19 ± 7.33		10.65 ± 6.86		7.25 ± 5.92		2.54 ± 1.56		2.51 ± 8.46	
No	11.39 ± 8.12		9.03 ± 6.21		7.21 ± 4.93		2.36 ± 1.65		1.71 ± 6.58	
Chronic pelvic pain		0.370		0.050		0.415		0.824		0.244
Yes	10.57 ± 4.96		8.01 ± 4.28		6.05 ± 3.73		2.91 ± 1.60		0.88 ± 1.68	
No	11.81 ± 8.23		9.76 ± 6.70		7.26 ± 5.43		2.34 ± 1.62		2.12 ± 7.70	
Dyspareunia		0.243		0.884		0.678		0.265		0.482
Yes	13.67 ± 4.03		9.77 ± 6.38		9.83 ± 4.90		2.22 ± 1.27		1.64 ± 1.43	
No	11.47 ± 8.09		9.51 ± 6.47		6.87 ± 5.22		2.42 ± 1.65		1.98 ± 7.48	
Infertility		0.850		0.872		0.710		0.132		0.206
Yes	14.17 ± 6.28		10.08 ± 5.60		9.86 ± 4.10		2.00 ± 2.26		2.08 ± 2.18	
No	11.10 ± 9.21		9.77 ± 8.65		7.24 ± 6.89		2.29 ± 1.58		3.55 ± 11.99	

RMT, residual myometrial thickness; SD, standard deviation.

Table 5
Association between clinical symptoms and caesarean scar defect (CSD) dimensions measured by magnetic resonance imaging.

Symptoms	Length of CSD (mm)		Width of CSD (mm)		Depth of CSD (mm)		RMT (mm)		Volume of CSD (cm^3)	
	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	*P*-value	Mean ± SD	P-value
Prolonged menstruation		0.035[a]		0.407		0.008[a]		0.952		0.025[a]
>6 days	14.56 ± 7.53		8.66 ± 5.73		8.26 ± 5.28		3.63 ± 1.85		1.77 ± 5.05	
≤6 days	13.88 ± 5.08		8.40 ± 4.95		6.49 ± 2.83		3.60 ± 2.07		0.85 ± 0.94	
Dysmenorrhoea		0.954		0.739		0.323		0.523		0.915
Yes	14.40 ± 6.86		9.41 ± 5.10		7.46 ± 4.01		3.77 ± 2.22		1.42 ± 3.49	
No	14.22 ± 6.49		8.21 ± 5.50		7.52 ± 4.66		3.56 ± 1.83		1.35 ± 4.02	
Chronic pelvic pain		0.108		0.339		0.136		0.410		0.085
Yes	15.29 ± 9.18		8.64 ± 6.92		9.03 ± 5.68		3.86 ± 1.79		2.21 ± 5.37	
No	14.13 ± 6.17		8.54 ± 5.17		7.27 ± 4.25		3.58 ± 1.97		1.26 ± 3.63	
Dyspareunia		0.460		0.665		0.931		0.057		0.971
Yes	17.33 ± 5.22		10.89 ± 4.23		10.67 ± 0.36		4.63 ± 1.69		2.23 ± 1.80	
No	14.06 ± 6.62		8.34 ± 5.44		7.30 ± 4.46		3.56 ± 1.95		1.31 ± 3.96	
Infertility		0.757		0.924		0.336		0.548		0.318
Yes	11.56 ± 6.88		10.30 ± 5.93		9.50 ± 2.99		3.00 ± 2.62		1.09 ± 0.92	
No	15.92 ± 7.52		9.27 ± 6.12		8.21 ± 6.07		3.64 ± 2.40		2.43 ± 7.13	

RMT, residual myometrial thickness; SD, standard deviation.

Table 6
Multivariate logistic analysis for risk factors for development of caesarean scar defect.

Variable	β	SE	Wald χ^2	*P*-value	OR	95% CI
Age (<30 = 0, ≥30 = 1)	0.081	0.052	2.389	0.122	1.084	0.979–1.202
Age at last CS (years, ≥30 = 0, <30 = 1)	−2.323	0.472	24.272	<0.001	0.098	0.039–0.247
Intraoperative blood loss (ml, ≥150 = 0, <150 = 1)	−1.335	0.330	16.349	<0.001	0.263	0.138–0.503
CS time (min, <85 = 0, ≥85 = 1)	0.226	0.053	17.842	<0.001	1.253	1.128–1.391
Suturing technique (single layer = 0, double layer = 1)	−4.088	0.511	64.057	<0.001	0.017	0.006–0.046
Peripartum fever or infection (no = 0, yes = 1)	3.396	0.678	25.061	<0.001	29.848	7.897–112.811
Uterine position (anteflexed = 0, straight and retroflexed = 1)	1.843	0.345	28.553	<0.001	6.315	3.212–12.414

CS, caesarean section; SE, standard error; OR, odds ratio; CI, confidence interval.

infertility [20,22,23]. In the present study, menstrual duration was significantly longer in women with CSD than in women without CSD. Dysmenorrhoea and chronic pelvic pain were more common in women with CSD (all $P < 0.01$). More women with CSD were diagnosed with secondary infertility compared with women without CSD. However, there was no significant difference in the incidence of dyspareunia and menstrual volume.

There is still lack of agreement about the definition and diagnostic methodology for CSD. Ultrasonography, as a non-invasive and low-cost method, has been considered as the initial choice for screening and diagnosis of CSD [24]. Three-dimensional sonography may offer some advantages over conventional sonography [25]. Saline infusion sonohysterography has been reported to be effective in assessing scar integrity [26]. However, this method has limited application because of its poor cost-effectiveness [17]. CSD can also be diagnosed by direct visualization with hysteroscopy; however, this is usually used for repair rather than diagnosis of CSD because of its invasiveness [27]. MRI can easily define CSD and can also be reviewed retrospectively. However, MRI is not commonly used as an investigative imaging tool due to its relatively high cost [28]. A few studies have compared the different methods for CSD evaluation (Table 7).

This study compared TVS and MRI for the measurement of CSD. The mean length and depth of CSD were significantly greater when measured by MRI than by TVS, while there were no differences in width, volume and RMT of CSD. To further compare the efficacy of

Table 7
Comparison of different methods for caesarean scar defect (CSD) diagnosis and measurement.

Author	Study type	Number of patients	Evaluation method	Outcome
Bij de Vaate [6]	Prospective cohort	225	TVS and GIS	The prevalence of a niche on evaluation with TVS and GIS was 24.0% and 56.0%, respectively
Giral [29]	Prospective cohort	16	3D-TVS and SHG	The detection rate of CSD was 50%, 86% and 100% by 3D-TVS, SHG and hysteroscopy, respectively. In 29% of patients, the size and depth of CSD was more important with SHG and hysteroscopy than expected by 3D-TVS
Ganovska [30]	Retrospective cohort	25	2D-TVS and hysteroscopy	In women with postmenstrual bleeding, the detection rate of CSD was 60% by TVS and 40% by diagnostic hysteroscopy. There was no significant difference between the two methods in terms of accuracy of diagnosis, although there was a statistically higher one for hysteroscopy
Baranov [31]	Prospective cohort	56	TVS and SCSH	SCSH showed a higher detection rate (69.1% vs 46.4%) and more reliable interobserver intraclass correlation coefficients
Yao [32]	Retrospective cohort	282	TVS, general MRI and contrast-enhanced MRI	Contrast-enhanced MRI yielded greater length or width, or thinner residual myometrial thickness of CSD compared with MRI and TVS
Antila-Långsjö [33]	Prospective cohort	371	TVS and SHG	The prevalence of CSD was 22.4% and 45.6% based on TVS and SHG, respectively. Sensitivity and specificity for TVS was 49.1% and 100% compared with SHG

3D, three-dimensional; 2D, two-dimensional; GIS, gel instillation sonohysterography; MRI, magnetic resonance imaging; SCSH, saline infusion sonohysterography; SHG, sonohysterography; TVS, transvaginal sonography.

different methods, associations between clinical symptoms and CSD size measured by MRI and TVS were evaluated. Some studies have reported an association between CSD size and postmenstrual bleeding. Bij de Vaate et al. reported a larger CSD volume in women with postmenstrual spotting [6]. Wang et al. found that CSD were significantly wider in women with postmenstrual spotting, dysmenorrhoea or chronic pelvic pain, and the incidence of postmenstrual spotting was higher in women with a CSD of larger diameter [22]. The present study found that depth and volume of CSD measured by MRI were greater in women with more prolonged menstruation. However, there was no correlation between other symptoms and CSD size. The results may suggest that MRI is more reflective of the severity of clinical manifestations and a better modality for the measurement of CSD. To the best of the authors' knowledge, this is the first study to compare correlation between TVS and MRI findings and clinical symptoms of CSD.

There are some limitations to this study. Due to the lack of information on some medical records, collection of information about exposure factors is not sufficiently complete for comprehensive evaluation of the risk factors of CSD. Also, the efficacy of measurements of CSD by TVS and MRI were compared without the real objective indicators as a reference.

In conclusion, this study found that longer CS time, peripartum fever or infection, and retroflexed uterus are risk factors for CSD, and age at last CS < 30 years, intraoperative blood loss <150 ml and double-layer closure are protective factors for CSD. Women with a larger CSD presented with more prolonged menstruation. Compared with TVS, measurements by MRI showed better prediction of the clinical symptoms of CSD, which may help to improve the therapeutic strategy for CSD.

Declaration of Competing Interest

None declared.

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