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# Standardized approach for imaging and measuring Cesarean section scars using ultrasonography

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**KEYWORDS:** Cesarean section; deficiency; lower uterine segment; saline contrast sonohysterography; scar defect; uterine scar; vaginal ultrasonography

## ABSTRACT

*Incomplete healing of the scar is a recognized sequel of Cesarean section (CS) and may be associated with complications in later pregnancies. These complications can include scar pregnancy, a morbidly adherent placenta, scar dehiscence or rupture. To date there is uncertainty relating to the factors that lead to poor scar healing and how to recognize it. In recent years, there has been an increase in studies using ultrasound that describe scars as deficient, or poorly, incompletely or inadequately healed with few data to associate the morphology of the scar with the functional integrity of the lower segment of the uterus. There have been multiple attempts to describe CS scars using ultrasonography. Different terminology, methods and results have been reported, yet there is still no consensus regarding the prevalence, clinical significance or most appropriate method to describe the appearances of these scars. Developing a test that can predict the likelihood of women having problems associated with a CS scar is becoming increasingly important. On the other hand, understanding whether the ultrasound appearances of the scar can tell us anything about its integrity is not well supported by the research evidence. In this article we present an overview of ultrasound-based definitions and methods used to describe CS scars. We also present information relating to the performance of alternative techniques used to evaluate CS scars. Having examined the current evidence we suggest a standardized approach to describe CS scars using ultrasound so that future studies can be meaningfully compared. Copyright © 2012 ISUOG. Published by John Wiley & Sons, Ltd.*

## INTRODUCTION

Cesarean section (CS) is one of the most frequent abdominal surgical operations carried out in the UK[1]. The CS rate increased from 12% to 29% in the UK[2] and from 21.2% to 30.1% in the USA[3] between 1990 and 2008. The increasing CS rate and its associated complications has stimulated an interest in the behavior of CS scars and their associated potential morbidity. There is evidence to suggest a reduction in maternal mortality and fetal morbidity in parallel with the rise in CS rates[4]. In addition, the incidence of uterine rupture in trials of vaginal birth after Cesarean section (VBAC) has remained static with a frequency estimated at 0.2–3.8%[5]. Attention has focused on the future performance of the uterus after CS. Of particular interest is the development of protocols to predict performance during trials of VBAC. The appearance of the CS scar using ultrasound may be relevant, but there is limited evidence to relate the scar appearances with function. There are also concerns about the incidence of implantation within the scar as well as the association between a scarred uterus and abnormal uterine bleeding and subfertility. In this article we have aimed to summarize the published literature on this condition. Furthermore, we have proposed an approach to evaluating CS scars and measuring them using transvaginal ultrasonography (TVS). In this way we hope to move towards agreement on standardizing nomenclature so that useful comparisons can be made between any future research studies in this area.

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## LITERATURE BACKGROUND

We searched the PubMed database using the following words 'Cesarean section', 'deficiency', 'lower uterine segment', 'saline contrast sonohysterography', 'scar defect', 'uterine scar' and 'vaginal ultrasonography' to obtain a list of articles on assessing CS scars by ultrasound. Additional articles were obtained from cross-references derived from the relevant publications. We studied the literature to assess the variation in nomenclature used, in definitions and in methods of niche/scar evaluation. We did not set out to perform a systematic literature review. Of the articles found, we retrieved only those relating to CS scars published in English language journals, as well as some of the English abstracts of original articles in other languages. We selected the original research studies that examined the uterine scar using TVS, we evaluated the methods used in delineating the scar in comparison with the other studies and we summarized the prevalence figures obtained in each. As a second step we proposed a standarized method of evaluating CS scars by ultrasound.

## IMAGING THE UTERINE SCAR

Improvements in imaging have facilitated the evaluation of CS scars both before and during pregnancy. A wedge-shaped cystic or hypoechoic distortion in the scar in the non-pregnant state is a well-described feature and has been reported in the literature using various imaging modalities[1]. It was first described using hysterosalpingography in 1961[6], transabdominal sonography (TAS) in 1982[7] and TVS in 1990[8]. Poidevin performed hysterographic examination on 43 women 6 months after CS[6]. He described a typical small wedge-shaped morphological 'defect' in 27 patients, which he believed was an indication of healing and considered this safe for vaginal delivery in the future. He further proposed that a 6-month wait was necessary before hysterography, as an earlier examination may reveal no deformity owing to wound edema[6]. Interestingly, this fact was confirmed 35 years later. Dicle *et al.* examined the healing period of the myometrium after CS using magnetic resonance imaging (MRI)[9]. They concluded that myometrial scar tissue takes at least 3 months to form and that complete involution and recovery of the zonal anatomy is not achieved until 6 months later[9]. Burger *et al.* performed TAS on 48 women who had undergone CS[7]. They described a sonolucent area, with varied degrees of echogenicity, at the wound site between the anterior wall and the cavity of the uterus. This pattern was found in 15 out of the 48 patients involved in the study, and was classified as an incompletely healed uterine scar[7]. Once again the data to link the appearance of the scar to functional integrity was missing.

TVS has since offered a further tool for observing the uterine scar after CS. Chen *et al.* described a wedge-shaped hypoechoic area at the CS wound site that was easily distinguishable from the neighboring part of the lower uterine segment (LUS)[8]. They used Doppler to show that the scar is relatively avascular, and found that the longer the time elapsed since surgery the smaller the wedge-shaped 'defect' became[8]. At a later stage the word 'niche' was introduced by Monteagudo *et al.* They described the 'niche' using ultrasound as a triangular anechoic area at the presumed site of CS incision[10].

There are now many studies describing the morphological features of CS scars, and the methods used in reporting the ultrasound findings are, in most cases, clear. However, important questions remain to be answered. Principal among these is whether a scar classified as deficient using ultrasound leads to an increased risk of failed VBAC or uterine rupture in labor, and if it is associated with other complications such as menstrual problems, subfertility and scar pregnancy. A recent publication has suggested a possible relationship between the non-pregnant appearance of a CS scar and scar performance in a subsequent pregnancy. However, the number of cases included in the study was too small to draw definitive conclusions[11].

## ULTRASOUND AS A RELIABLE AND REPRODUCIBLE METHOD TO ASSESS SCAR MORPHOLOGY

Ultrasound has been used to evaluate CS scars in late pregnancy[12]. Numerous authors have attempted to describe the LUS using both two-dimensional (2D) and three-dimensional (3D) ultrasound and compared the two methods in terms of reliability, reproducibility and cost-effectiveness. Jastrow *et al.* conducted a study to assess the reliability of 2D and 3D TAS and TVS in measuring the LUS and the CS scar in late pregnancy[13]. They included 30 women with at least one previous CS who had singleton pregnancies, a cephalic presentation and were between 36 and 39 weeks' gestation. The authors concluded that TVS was more reliable for measuring the thickness of the LUS than was TAS, with a difference of less than 1 mm in the intraobserver and interobserver variability[13]. These findings were confirmed by Martins *et al.*[14].

The use of 3D ultrasound has been reported to improve the interobserver reliability of CS scar measurements in pregnant women[14]. However, its use requires specific training, a longer examination time and ultrasound machines with facility for 3D applications. Contrary to what is often stated, 3D ultrasound is not without limitations[15]. One of the problems when assessing CS scars by 3D ultrasound is the lack of good tissue contrast, which is helpful for optimal 3D examination of the scar. However, some scar indentations contain blood or fluid, which may act as a contrast agent. In the non-pregnant uterus, the instillation of saline or gel may achieve a similar effect[16]. An important advantage of 3D ultrasound over conventional 2D imaging is its ability to reconstruct and display chosen sections within the volume dataset. In particular, examination of the scar in the coronal plane provides additional information, which cannot be obtained using 2D ultrasound. In addition, Virtual Organ

Computer-aided AnaLysis (VOCAL™) and XI VOCAL™ technology enable volume measurements[15,17].

## PREVALENCE

The prevalence of CS scar morphological 'abnormalities' has been studied in non-pregnant women using TVS in seven publications in English language journals over the last 10 years[5,16,18–22]. The incidence of CS scars with an apparent 'defect' ranged from 6.9% to 69% (Table 1). Different methods of classifying CS scars have been applied, based on the dimensions of the scar and its relation to the internal cervical os and the uterine fundus. In all the studies cited, a scar 'defect' or 'niche' was defined by the presence of a hypoechogenic area within the myometrium of the LUS, at the site of a previous CS[7]. Despite similar imaging protocols, there was no agreement between the seven studies regarding the definition of scar-apparent 'defects', and so the real prevalence of the different morphological subgroups of CS scars is unknown.

In the non-pregnant uterus, apparent scar 'defects' are seen more often, appear to be larger and have clearer margins when saline contrast sonohysterography (SCSH)[23] or gel instillation sonography (GIS) is used[16]. We agree that the apparent prevalence of any scar 'defects' increases if SCSH or GIS is used compared with 2D ultrasound. However, the increased uterine pressure associated with this procedure may exaggerate the size of any scar present. There is disagreement about the value of SCSH in this context. Monteagudo *et al.* concluded that ultrasound examination of CS scars is not possible without saline infusion enhancement[10], whilst Ofili-Yebovi *et al.* suggested that saline infusion may be associated with unnecessary risks (i.e. infection), is not cost-effective and is of limited value[5], although the risks of SCSH seem to be rather low in reality[19]. More recently, no complications were encountered using SCSH or GIS to examine CS scars[16,23]. Whatever method is used, it is clear that there must be consistency if data are to be comparable because different results are likely to be obtained with and without SCSH.

## MEASURING THE LOWER UTERINE SEGMENT OR RESIDUAL MYOMETRIAL THICKNESS

Uterine rupture is defined as a full-thickness separation of the uterine wall and the overlying serosa[24]. A previous CS is the most frequent risk factor[25]. The most commonly quoted incidence for scar rupture is 0.5%, or one in every 200 women who undergo a trial of vaginal delivery after previous lower-segment CS[26]. In general, the normal LUS can be seen, using ultrasound, as a two-layer structure that consists of a hyperechoic layer representing the bladder wall and a less echogenic layer representing the myometrium[27] (Figure 1).

In pregnancy, various methods have been developed to correlate measurement of the LUS with the risk of uterine rupture or dehiscence[28–32]. In some studies, the investigators measured the entire LUS using TAS, while in others, only the muscular layer was measured using a transvaginal approach. Further efforts have been made to find a way to predict scar rupture at the time of VBAC[24]; however, no reliable model has been developed to date. Bujold *et al.* conducted a study to establish the validity of sonographic evaluation of LUS thickness to predict complete uterine rupture[27]. Full thickness and myometrial thickness only were measured by TAS and TVS in 263 pregnant women between 35 and 38 weeks' gestation. They concluded that a LUS thickness of $< 2.5$ mm was associated with a uterine rupture rate of more than 10% with an approximate specificity of 90%[27]. Martins and co-workers concluded, in their two-observer reliability study, that sonographic measurement of LUS muscular thickness transvaginally in the pregnant state appears more reliable than the evaluation of the entire LUS thickness transabdominally[14]. Jastrow and colleagues also confirmed, in their systematic review on sonographic LUS thickness, that there is a strong association between LUS measurement in pregnancy and the risk of uterine scar complications. They have proposed that this may serve as a predictor of uterine rupture. However, no cut-off values have been developed and tested, underlining the need for more standarized measurement techniques[12].

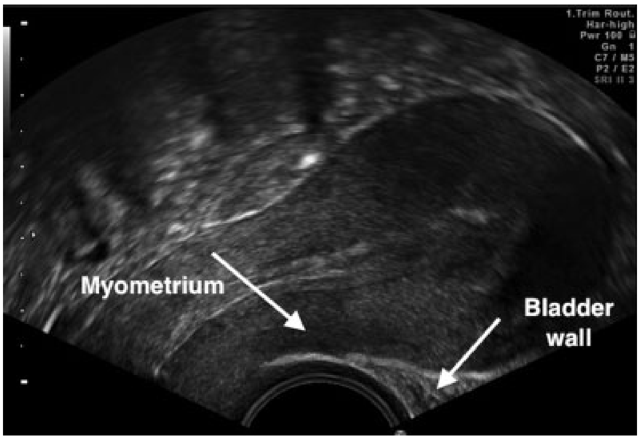


**Figure 1** Normal anteverted uterus showing the hyperechoic bladder wall and hypoechoic myometrial muscle.

## EVALUATING CS SCARS USING 2D-TVS: TERMS OF AGREEMENT

### Identification in pregnancy

In general, there are three layers that can be identified in the LUS in pregnancy using B-mode 2D-TVS[14]: the chorioamniotic membrane with the decidualized endometrium; the middle muscular layer; and the uterovesical fold (peritoneal reflection seen as a hyperechoic line juxtaposed with the muscularis and musosa of the bladder). Anatomically, an incision is made in the LUS, 2–3 cm below the upper edge of the uterovesical fold of the peritoneum. This is especially important when

 

**Table 1** Transvaginal ultrasound assessment of the prevalence of apparent Cesarean section (CS) scar 'defects'

| *Reference* | n | *Definition* | *Methods* | *Percentage of apparent scar 'defects'* | *Percentage of large scars* | *Type of study* |
|---|---|---|---|---|---|---|
| Bij de Vaate *et al.*[16] (2010) | 225 | Anechoic area at the site of the Cesarean scar 'niche' with a depth of at least 1 mm | Scar depth; residual myometrium; scar volume on XI VOCAL™; with and without gel instillation | 24% on TV ultrasound, 56% with gel instillation | NA | Observational prospective cohort |
| Vikhareva Osser *et al.*[18] (2009) | 162 | Any indentation at the scar area, however small | Subjective evaluation; thickness of remaining myometrium above scar; thickness of the myometrium next to and cranial to the defect | 69% | 42% | Prospective cohort |
| Wang *et al.*[19] (2009) | 4250 | Filling defect within the myometrium of the lower uterine segment, at the presumed site of previous CS | Scar width; scar depth; thickness of the residual myometrium | 6.9% | 6.3% | Cross-sectional |
| Ofili-Yebovi *et al.*[5] (2008) | 324 | Any detectable myometrial thinning at the CS site | Distance between uterine fundus and internal os; myometrial thickness at the depth of the scar; myometrial thickness at the adjacent unaffected myometrium | 19% | 10% | Prospective cohort |
| Menada Valenzano *et al.*[20] (2006) | 116 | Triangular anechoic area at the presumed site of incision (niche) | Presence or absence of the scar | 59.5% | NA | Observational retrospective case–control |
| Regnard *et al.*[21] (2004) | 33 | Triangular anechoic area at the presumed site of incision (niche) | Scar depth; thickness of residual myometrium; thickness of cranial myometrium; with saline contrast enhancement | 60% | NA | Prospective cohort |
| Armstrong *et al.*[22] (2003) | 32 | Any detectable fluid within the scar | Presence or absence of the scar | 42% | NA | Prospective cohort |

NA, not assessed; TV transvaginal; VOCAL, Virtual Organ Computer-aided AnaLysis.

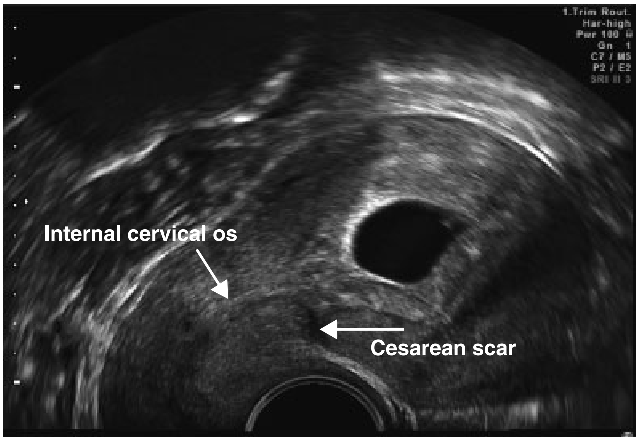


**Figure 2** Cesarean section scar above the internal os.

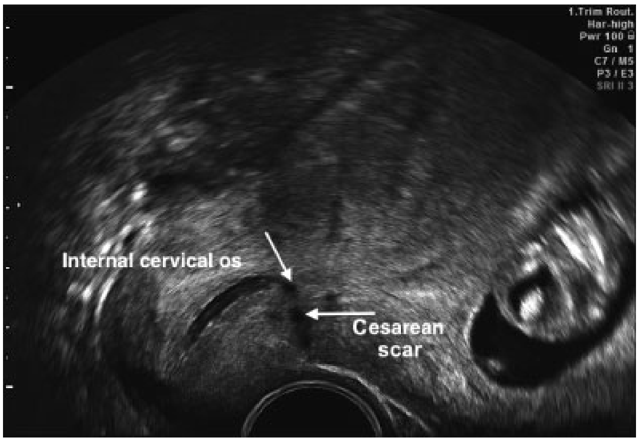


**Figure 3** Cesarean section scar at the level of the internal os.

the CS is performed at or near full dilatation, when the tendency is to enter the uterus too low because of the stretched and ballooned-out lower segment[33].

Essentially, the uterine scar should be easily identified with TVS by applying the following approach (Figures 2 and 3).

- Settings: first-trimester routine setting or any gynecology settings preferred by the operator.
- Depth should be set where a panoramic view of the lower segment can be obtained, including the cervical canal up to the external os where possible. After identifying the scar, the picture then can be magnified so the scar occupies at least 75% of the image to ensure consistent and accurate measurements.
- The sector width is set to full range, where the axis of the cervical canal can be demonstrated in relation to the lower segment and the uterine fundus.
- The endocervical canal should be clearly visible as a hyperechoic thin line; care must be taken not to exert undue pressure on the cervix with the probe because this will elongate the cervix.
- The internal os (Figures 1–3) can be identified at the level of the slight narrowing in the LUS, between the uterine corpus and the cervix at the lower boundary of the urinary bladder[18]. The endocervical mucosa can be used to define the cervical canal and the internal os appears as a V-shaped notch at the top of the canal, before reaching the thickened LUS[34]. The uterovesical fold should be clearly visible as a hyperechoic line between the bladder interface and the endocervical canal. The internal os is generally at the level of the uterine arteries.

## Definition

The CS scar should be well delineated as a hypoechoic indentation at the anterior wall of the LUS, measurable in three dimensions and lying between the uterovesical fold and the internal cervical os. In cases of previous elective CS the scar will appear halfway between the uterovesical fold and the internal cervical os (Figure 2), whilst, following emergency CS, the scar could well be below, or at the level of, the os (Figure 3).

The above approach has been tested prospectively and associated with scar-detection rates of approximately 92% in anteverted uteri and 66% in retroverted uteri, where anecdotally, poor scar visibility seems to be an issue[35].

## Scar dimensions

Scar morphology and dimensions have been described in different studies, and different grades of apparent deficiency have been reported according to the subjective impression by the operator of the filling defect occupied by the scar. Bij de Vaate *et al.* demonstrated scar length and depth in the sagittal plane using TVS with gel enhancement[16]. Similar methods were applied by Vikhareva Osser *et al.*, who also found delineating the scar in the oblique transverse plane to be technically difficult[23]. Both studies relied on a subjective evaluation of the scar and the residual myometrial thickness to classify them as small or large. Subjective impression by an expert operator is a legitimate approach to classification using ultrasound, an example being the characterization of ovarian pathology[36]. However, the experience required to do this is not easy to gain, and so a more objective quantification is needed if the assessment of CS scars is to become generally reproducible. We propose that the CS scar should be measured in three dimensions (length, width and depth) in both sagittal and transverse planes, and that the morphological appearances of the scar should be classified as mild, moderate and severe based on the value of mean scar 'defect' (Figures 4 and 5). The hypoechoic shadow of the scar seen on the sagittal plane should be followed slowly while switching into the transverse plane of the uterus, it should appear between the hyperechoic uterovesical fold and the myometrial mantle; the caliber of the new shadow obtained represents the length of the scar.

 

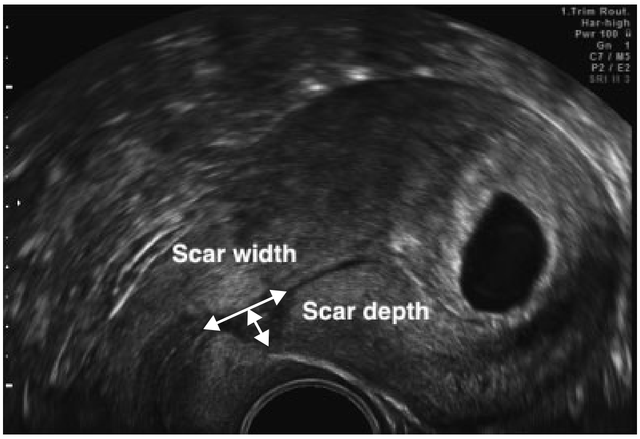


**Figure 4** Dimensions of apparent scar 'defect' in the sagittal plane.

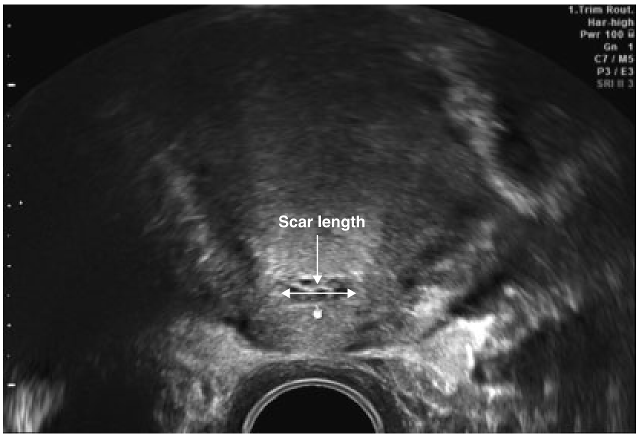


**Figure 5** Length of apparent scar 'defect' in the transverse plane.

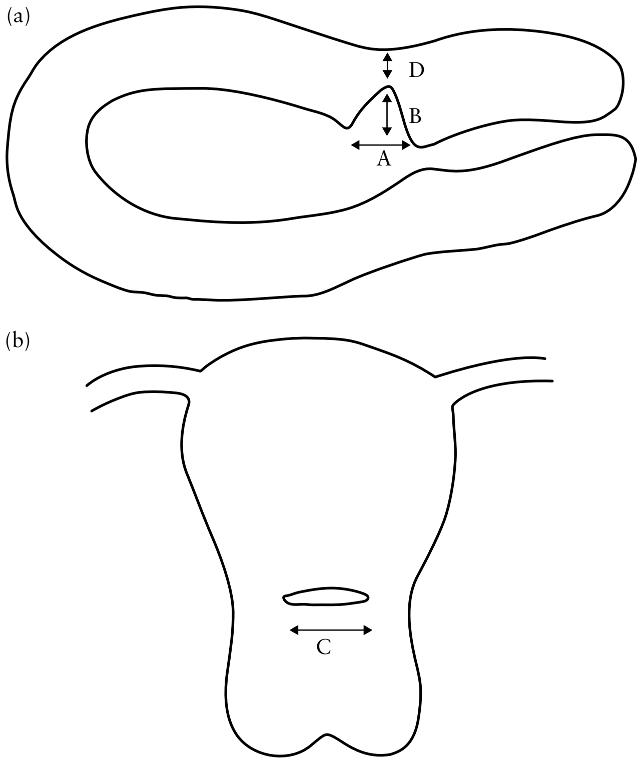


**Figure 6** Schematic diagram showing Cesarean scar dimensions in the sagittal (a) and transverse (b) planes. A, width of hypoechoic part of scar (apparent 'defect') on the sagittal plane; B, depth of hypoechoic part of scar (apparent 'defect') on the sagittal plane; C, length of hypoechoic part of scar (apparent 'defect') on the transverse plane; D, residual myometrial thickness on sagittal plane.

## CLINICAL APPLICATION

Suboptimal healing of a CS scar has become one of the recognized complications associated with this type of operation. The exact cause and mechanism of this condition is not well understood. As more women undergo TVS, the morphology of section scars has come under increasing scrutiny. Currently, it is not known if the appearances of CS scars using ultrasound relate to the functional integrity of the uterus, the risk of scar ectopic pregnancy, pathological placentation, uterine rupture or performance in labor. There is an urgent need to explore this relationship so that we can understand how to interpret images of the uterus following CS and the implications of various types of scar on patient management. A recent study suggests that CS scars are likely to be associated with postmenstrual spotting[16]. However, there is a lack of evidence regarding the impact of different CS scars in pregnancy. Studying the natural history of CS scars in pregnancy is important as certain scar features, and how they change over the course of pregnancy, may provide important information when considering either a trial of vaginal delivery or a repeat CS. Furthermore, the incorporation of such ultrasound features into scoring systems or models to predict successful VBAC may refine decision making further. Uterine scar rupture is a rare event, yet its consequences can be dramatic. On the other hand, scar dehiscence, poor performance in labor, menstrual problems or scar pregnancy are also important secondary outcome measures to consider[37].

## CONCLUSION

The CS rate varies from about 20% to 50%, depending on the country and clinical environment. This variation is attributable to a combination of factors, including the increased safety of the procedure, medical training, patient choice and the risk of litigation. The result is that more women are becoming pregnant with a scar on the uterus. As a result, any problems associated with the presence of a CS scar are potentially significant both for individual patients as well as at a societal level. Ultrasound offers a non-invasive approach to visualize the uterus and any scar present. We know that ultrasound can be used both to measure and to describe the morphology of CS scars when present. However, to date, there is only one study that translates these observations into associated potential complications[11]. There is a need to characterize scars accurately and to explore their clinical relevance in subsequent pregnancy and future conception. In order to achieve this, different investigators must agree on the terms and definitions used to document the appearances of CS scars to enable studies to be compared and long-term outcomes to be known. Until we have these data, commenting on the appearance of CS scars using ultrasound in current clinical practice is difficult to justify. Furthermore, the tendency to describe the ultrasound features of scars as 'deficient' inevitably leads the reader to conclude that 'deficient' relates to function and not just appearance. A CS scar may appear hyperechoic and cystic using ultrasonography, but how can it be called 'deficient'? Our view is that an alternative terminology should be developed, and that the morphology of a CS scar should be described on the basis of objective measurements rather than descriptive ultrasound terms alone. We suggest that the dimensions shown in Figure 6 would be a logical approach. Once we have a standardized approach for describing the morphology of CS scars, we should be able to engage in studies that are large enough to give us information on the complications associated with them.

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