Sonographic Lower Uterine Segment Thickness and Risk of Uterine Scar Defect: A Systematic Review

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Abstract

Objective: To study the diagnostic accuracy of sonographic measurements of the lower uterine segment (LUS) thickness near term in predicting uterine scar defects in women with prior Caesarean section (CS).

Data Sources: PubMed, Embase, and Cochrane Library (1965–2009).

Methods of Study Selection: Studies of populations of women with previous low transverse CS who underwent third-trimester evaluation of LUS thickness were selected. We retrieved articles in which number of patients, sensitivity, and specificity to predict a uterine scar defect were available.

Data Synthesis: Twelve eligible studies including 1834 women were identified. Uterine scar defect was reported in a total of 121 cases (6.6%). Seven studies examined the full LUS thickness only, four examined the myometrial layer specifically, and one examined both measurements. Weighted mean differences in LUS thickness and associated 95% confidence intervals between women with and without uterine scar defect were calculated. Summary receiver operating characteristic (SROC) analysis and summary diagnostic odds ratios (DOR) were used to evaluate and compare the area under the curve (AUC) and the association between LUS thickness and uterine scar defect. Women with a uterine scar defect had thinner full LUS and thinner myometrial layer (weighted mean difference of 0.98 mm; 95% CI 0.37 to 1.59, $P = 0.002$; and 1.13 mm; 95% CI 0.32 to 1.94 mm, $P = 0.006$, respectively). SROC analysis showed a stronger association between full LUS thickness and uterine scar defect (AUC: 0.84 ± 0.03, $P < 0.001$) than between myometrial layer and scar defect (AUC: 0.75 ± 0.05, $P < 0.01$). The optimal cut-off value varied from 2.0 to 3.5 mm for full LUS thickness and from 1.4 to 2.0 for myometrial layer.

Conclusion: Sonographic LUS thickness is a strong predictor for uterine scar defect in women with prior Caesarean section. However, because of the heterogeneity of the studies we analyzed, no ideal cut-off value can yet be recommended, which underlines the need for more standardized measurement techniques in future studies.

Key Words: Pregnancy, Caesarean section, uterine rupture, ultrasound

Competing Interests: None declared.

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Résumé

Objectif : Étudier la précision diagnostique des mesures échographiques de l'épaisseur du segment inférieur utérin (SIU) à l'approche du terme pour ce qui est de prédire les anomalies de la cicatrice utérine chez les femmes ayant déjà subi une césarienne (CS).

Sources de données : PubMed, Embase et Cochrane Library (1965–2009).

Méthodes de sélection des études : Les études portant sur des populations de femmes ayant déjà subi une CS transversale basse qui ont été soumises à une évaluation de l'épaisseur du SIU au cours du troisième trimestre ont été sélectionnées. Nous avons extrait les articles dans lesquels la sensibilité et la spécificité de la mesure visant à prédire une anomalie de la cicatrice utérine et le nombre de patientes étaient disponibles.

Synthèse des données : Douze études admissibles portant sur 1 834 femmes ont été identifiées. Une anomalie de la cicatrice utérine a été signalée dans 121 cas en tout (6,6 %). Sept études ont examiné l'épaisseur du SIU dans sa totalité; quatre études ont étudié la mesure du myomètre uniquement; et une étude a examiné ces deux mesures. Les différences moyennes pondérées en matière d'épaisseur du SIU et les intervalles de confiance à 95 % connexes entre les femmes avec et sans anomalie de la cicatrice utérine ont été calculés. L'analyse des courbes *summary receiver operating characteristic* (SROC) et *summary diagnostic odds ratios* (DOR) a été utilisée pour évaluer et comparer l'aire sous la courbe (ASC) et l'association entre l'épaisseur du SIU et l'anomalie de la cicatrice utérine. Chez les femmes présentant une anomalie de la cicatrice utérine, le SIU dans sa totalité et la couche myométriale étaient plus minces (différence moyenne pondérée de 0,98 mm; IC à 95 %, 0,37 – 1,59, P = 0,002; et de 1,13 mm; IC à 95 %, 0,32 – 1,94 mm, P = 0,006, respectivement). L'analyse SROC a indiqué une plus forte association entre totale épaisseur du SIU et l'anomalie de la cicatrice utérine (ASC : 0,84 ± 0,03, P < 0,001) qu'entre la couche myométriale et l'anomalie de la cicatrice utérine (ASC : 0,75 ± 0,05, P < 0,01). La valeur seuil optimale variait entre 2,0 et 3,5 mm, pour ce qui est de totale épaisseur du SIU, et entre 1,4 et 2,0, pour ce qui est de la couche myométriale.

Conclusion : La mesure échographique de l'épaisseur du SIU est un fort facteur prédictif de l'anomalie de la cicatrice utérine chez les femmes ayant déjà subi une césarienne. Cependant, en raison de l'hétérogénéité des études que nous avons analysées, aucune valeur seuil idéale ne peut encore être recommandée, ce qui souligne la nécessité d'adopter des techniques de mesure mieux standardisées dans le cadre des études à venir.

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INTRODUCTION

Uterine rupture is an uncommon but potentially catastrophic complication of a trial of VBAC.[1,2] Several studies have reported the perinatal risks of failed trial of labour and uterine rupture in women attempting VBAC.[1–6] Partly because of concerns about this complication, the rate of VBAC deliveries continues to fall in developed countries, with an inverse increase in CSs. However, multiple CSs are associated with a greater risk of complications during surgery and abnormal placentation (previa, accreta).[7] Because in the last two decades the choice between elective repeat CS and TOL has been largely left to the patients' preferences, few tools have been made available to help in decision making.

To better assess the risk of uterine rupture, some authors have proposed sonographic measurement of lower uterine segment thickness near term, assuming that there is an inverse correlation between LUS thickness and the risk of uterine scar defect.[8,9] Therefore, this assessment for the management of women with prior CS may increase safety during labour by selecting women with the lowest risk of uterine rupture. However, while a large prospective study demonstrated that a full LUS thickness of under 3.5 mm had a strong negative predictive value, the best cut-off values and the best measuring technique remain controversial.[10,11]

The main objective of the current study was to assess the strength of the association between sonographic measurement of the LUS in women with prior CS and uterine scar defect at delivery. Second, we aimed to ascertain the best cut-off values for predicting uterine rupture.

ABBREVIATIONS

AUC	area under the curve
CS	Caesarean section
DOR	diagnostic odds ratios
LUS	lower uterine segment
SROC	summary receiver operating characteristic
TOL	trial of labour
VBAC	vaginal birth after Caesarean section

METHODS

Sources

We searched PubMed, Embase, and the Cochrane Library for articles published between 1965 and 2009 in any language with various combinations of the following terms: lower uterine segment, uterine rupture, uterine scar, thickness, and ultrasound.

Study Selection

Populations of pregnant women with prior low transverse CS who underwent third-trimester evaluation of LUS thickness were selected. We retrieved articles for which sensitivity and specificity to predict uterine scar defect, as well as the number of patients, were available. The number of patients and mean LUS thickness for women with and without uterine scar defect were collected. The outcome of interest was uterine rupture during TOL (defined as complete separation of the uterine scar, resulting in communication between the uterine and peritoneal cavities) or uterine scar defect (defined as either uterine rupture or uterine scar dehiscence, which was also called "window"). LUS thickness data were collected considering the different layers included (full thickness, myometrial layer alone, or both). Full LUS thickness was defined as the smallest measurement between the amniotic fluid and urine in the maternal bladder.[9] The myometrial layer was defined as the smallest hypoechoic portion of the LUS.[12] Analyses were stratified according to specific measurements (full thickness or myometrial layer) and according to available cut-off values. The quality of our study was assessed according to (STAndards for Reporting of Diagnostic accuracy).[13]

Weighted mean differences of full LUS and myometrial thicknesses and their associated 95% confidence intervals between women with and without uterine scar defect were calculated using Cochrane Review Manager software (version 4.2.8). Individual and pooled odds ratio, as well as associated 95% confidence interval were computed. Summary receiver operating characteristic curve analysis was undertaken to evaluate the association between full LUS thickness or myometrial layer and uterine scar defect.[14] Because the number, training, and expertise of the persons executing and reading the tests can vary across studies, a Dersimonian and Laird (random effects) model was adopted. Summary sensitivity and specificity, summary estimates of diagnostic odds ratios, and SROC analyses for full LUS thickness and myometrial layer were generated by Meta-DiSc software (version 1.4). Summary DOR value was used to represent the test's accuracy against the reference standard.[15] To handle studies with no false negatives or false positives, 0.5 was added to all their cells with zero. Heterogeneity was assessed for each summary estimate according to the Cochran-Q test.[16]

Figure 1a. Differences in mean full LUS thickness between women who experienced a uterine scar defect and those who did not. The results are reported as mean weighted differences with 95% CI.

Study or Subgroup	Scar defects Mean	SD	Total	No scar defects Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Bujold	2.22	0.89	9	2.97	1.12	227	64.2%	-0.75 [-1.35, -0.15]
Montanari	2.8	1.1	17	4.2	2.5	44	35.8%	-1.40 [-2.31, -0.49]
Total (95% CI)			**26**			**271**	**100.0%**	**-0.98 [-1.59, -0.37]**

Heterogeneity: Tau² = 0.06; Chi² = 1.38, df = 1 (P = 0.24); I² = 27%
Test for overall effect: Z = 3.15 (P = 0.002)

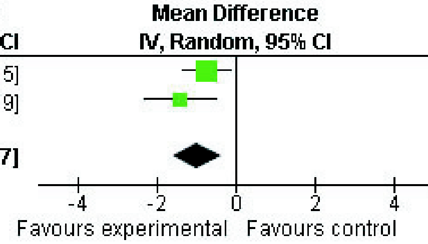
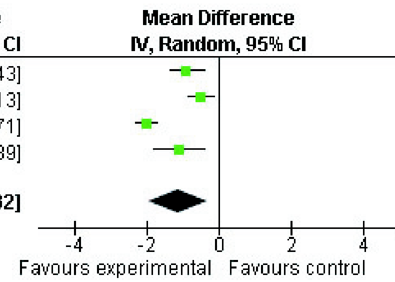


Figure 1b. Differences in mean myometrial layer thickness between women who experienced a uterine scar defect and those who did not. The results are reported as mean weighted differences with 95% CI.

Study or Subgroup	Uterine scar defects Mean	SD	Total	No uterine scar defects Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Asakura et al. 2000	1.7	0.7	9	2.6	0.8	177	25.0%	-0.90 [-1.37, -0.43]
Bujold et al.	1.07	0.51	9	1.56	0.94	214	26.0%	-0.49 [-0.85, -0.13]
Cheung et al. 2004	0	0.1	1	2	0.8	52	26.4%	-2.00 [-2.29, -1.71]
Cheung et al. 2005	0.9	0.5	2	2	0.8	100	22.6%	-1.10 [-1.81, -0.39]
Total (95% CI)			**21**			**543**	**100.0%**	**-1.13 [-1.94, -0.32]**

Heterogeneity: Tau² = 0.62; Chi² = 44.87, df = 3 (P < 0.00001); I² = 93%
Test for overall effect: Z = 2.73 (P = 0.006)



For both full LUS thickness and myometrial layer, the area under the SROC curves and 95% confidence interval were calculated by the trapezoidal method with MedCalc software (version 11.0.1, MedCalc Software, Mariakerke, Belgium), to compare test efficacy (Z test with *P* value).[17,18] Tests with a maximal effect have an AUC value of 1, and tests with no effect have an AUC value of 0.5.[19] The AUC of both the full LUS thickness and the myometrial layer SROC curves was compared to the standard 0.5 AUC. Then, the AUC of the full LUS SROC curve was compared to that of the myometrial layer, to determine their relative efficacy. *P* values less than 0.05 were considered significant.

RESULTS

Among 44 articles retrieved, 12 met the inclusion criteria and were used for statistical analysis.[8–12,20–26] All LUS measurements were performed between 35 and 40 weeks' gestation. Uterine rupture and uterine scar dehiscence were diagnosed during CS for all cases, except in one study where transvaginal manual revision of the LUS was performed after delivery to diagnose uterine scar dehiscence.[9] Uterine ruptures were reported in only three studies (Tables 1 and 2), but only one author specifically evaluated the association between LUS thickness and uterine rupture.[26] In that study, Bujold et al.[26] demonstrated an association between a thin full LUS measurement and uterine rupture (AUC: 0.88, 95% CI: 0.79 to 0.98) but not between a thin myometrial layer and uterine rupture. Because of a paucity of data on uterine rupture alone, our analysis was extended to uterine scar defect overall. Of 1834 women in the 12 included studies, 121 (6.6%) cases of uterine scar defect were reported. Each study demonstrated a significant association between the degree of LUS thinning and uterine scar defect. Seven studies examined full LUS thickness only,[8–10,20,22,24,25] four specifically assessed the myometrial layer of the LUS,[11,12,21,23] and one evaluated both measurements.[26] The characteristics of the 12 studies appear in Tables 1 and 2. Mean sonographic LUS thickness data were available in two studies for full LUS thickness[24,26] and in four studies for the myometrial layer.[11,12,21,26] From studies with available data, the mean weighted difference in sonographic full LUS thickness is shown in Figure 1a and in myometrial layer thickness in Figure 1b. Both mean full LUS and myometrial layer measurements were approximately 1 mm thinner in patients with a uterine scar defect than in patients without a defect.

SROC curve revealed a significant association between full LUS thickness and uterine scar defect (Figure 2a). However, the optimal cut-off value varied between 2.0 and 3.5 mm, depending on the study, and description of the

Figure 2a. SROC curve analyses of the association between full LUS thickness and the risk of uterine scar

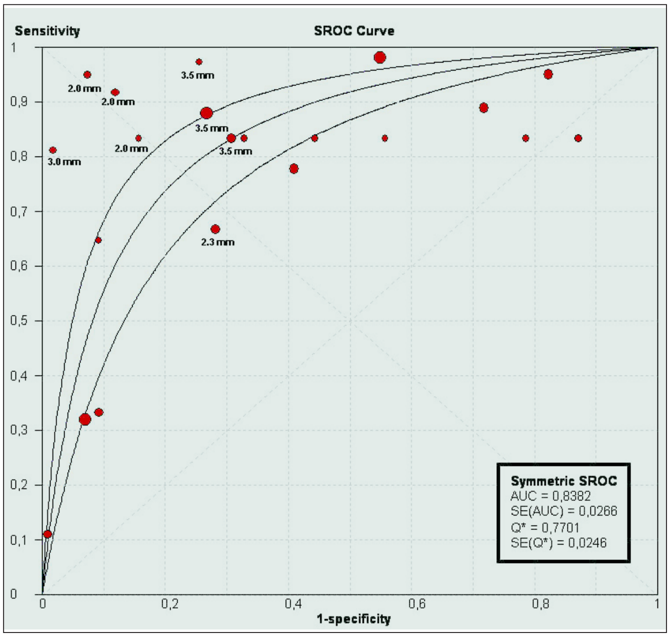
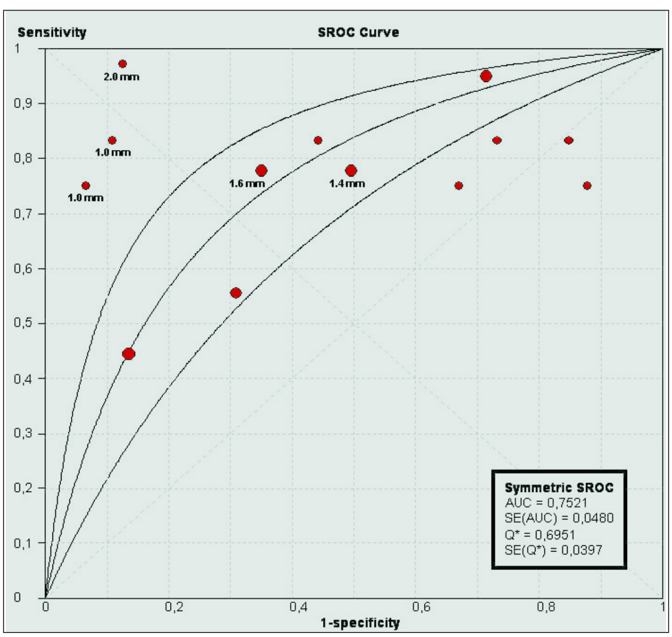


Figure 2b. SROC curve analyses of the association between myometrial thickness and the risk of uterine scar defect.



techniques that were used did not always permit their replication. A similar association was observed for the myometrial layer (Figure 2b), with optimal cut-off values ranging from 1.4 to 2.0 mm. The summary estimate of DOR was 11.2 (95% CI 6.5 to 19.4) for the association between full LUS thickness and uterine scar defect, and 5.2 (95% CI 2.5 to 10.8) for the association between myometrial layer and uterine scar defect (Figures 3a and 3b).

DISCUSSION

Our findings indicate that there is a strong association between the degree of LUS thinning measured near term and the risk of uterine scar defect at birth. However, most likely because of significant differences in study populations and measurement techniques, the optimal cut-off values for predicting uterine scar defects varied from 2.0 to 3.5 mm for full LUS thickness and from 1.4 to 2.0 mm for the myometrial layer. Therefore, there is actually no ideal cut-off value that can be recommended for clinical purposes, even if the association of LUS thickness and uterine scar defect is strong.

Until recently, the 3.5 mm cut-off value for full LUS thickness was the best validated, with 937 cases analyzed in the literature. However, although this cut-off demonstrated a high sensitivity and a strong negative predictive value for uterine scar defect, it had weak specificity. To improve the positive predictive value, a thinner cut-off value was proposed by several authors.[8,23,25] Bujold et al. recently suggested that 2.3 mm could be a better cut-off value for the prediction of complete uterine rupture during a TOL.[26] On the other hand, measurement of the myometrial layer was expected to be more representative of LUS thickness, as the outer bladder wall is unlikely to contribute to the functional integrity of the LUS.[12] This hypothesis was corroborated by a recent case report where uterine rupture occurred in the presence of a thick full LUS but a thin myometrial layer.[27] However, only a few studies have evaluated this possibility, and these studies were limited by a small number of subjects.[11,12,21,23,26] In the largest study, the association between myometrial layer thickness and uterine rupture or uterine scar defect was not confirmed.[26] Moreover, no study evaluated the reproducibility of myometrial layer measurement.

Several limitations should be considered when interpreting our findings. First, we retrieved articles for which sensitivity and specificity were available for at least one LUS thickness cut-off value. It would have been ideal to determine the impact of LUS thickness at the same cut-off values for all studies. More specifically, we found considerable heterogeneity between studies with regard to both the outcome of interest and the measuring technique. One of the main sources of variation in the original studies pertained to the definition of uterine scar defect. While uterine rupture is rare, most of these studies considered uterine dehiscence the primary outcome, rather than rupture, and the predictive value of this technique for symptomatic uterine rupture is doubtful, even if uterine dehiscence usually precedes uterine rupture. Thus, the incidence of defective scars was high and heterogeneous in the different studies (from 1% to 46%). Another source of variation was the fact that in some studies, the care providers were aware of the

Figure 3a. Summary estimates of DOR for the association between full LUS thickness and the risk of uterine scar defect, using a random effect model. (Pooled DOR: 11.2, 95% CI 6.5 to 19.4. Cochran-Q = 29.4; *df* = 21; *P* = 0.10)

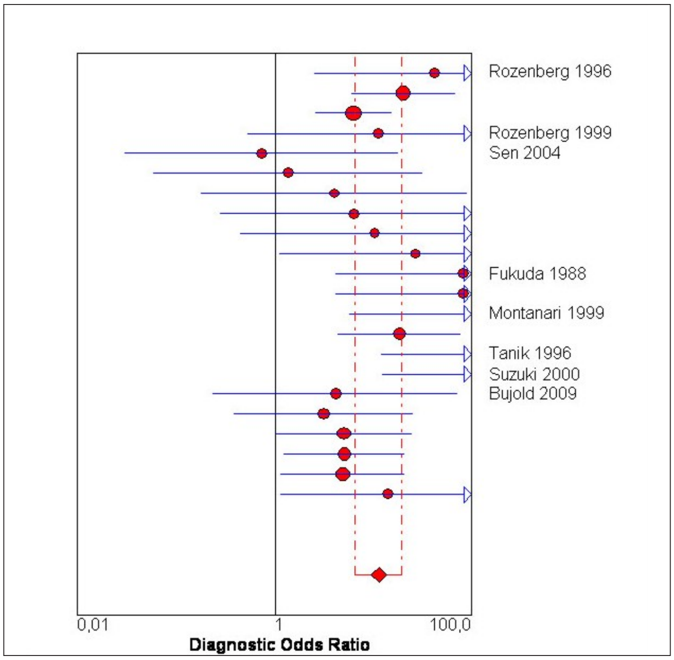
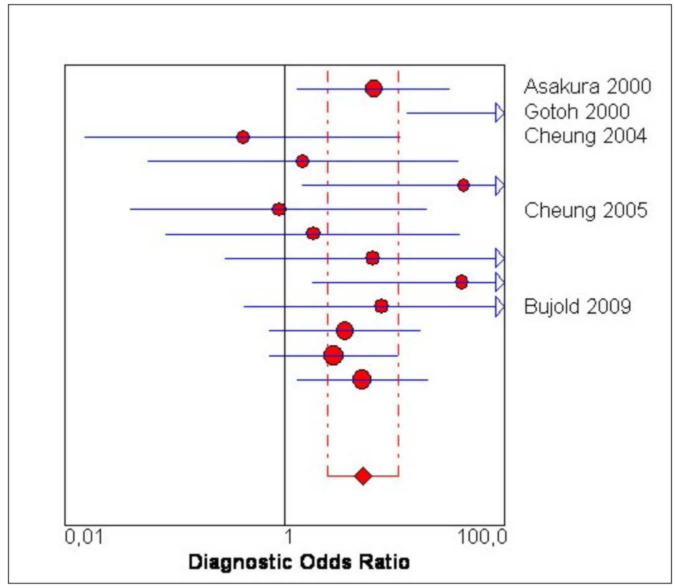


Figure 3b. Summary estimates of DOR for the association between myometrial thickness and the risk of uterine scar defect, using a random effect model. (Pooled DOR: 5.2, 95% CI 2.5 to 10.8. Cochran-Q = 16.0; *df* = 12; *P* = 0.19)



sonographic results and allowed patients to attempt a TOL,[8,10–12,22,23,25,26] whereas in other studies, the sonographic findings were not conveyed to the care providers.[9,20,21,24] Avoiding a TOL when the LUS was expected to be very thin could have led to a change in the frequency of the outcome variable. On the other hand, asymptomatic dehiscence would have not been identified in successful VBAC.

Concerning the measuring technique, we gathered the results of the abdominal and vaginal approaches used in different studies. While the largest prospective study involved abdominal measurement,[9] several smaller studies adopted a vaginal approach[20,21,23,24] and it is possible that the conclusions of this study may not apply when transvaginal sonography is performed.[28] Two studies evaluated the correlation between transabdominal and transvaginal scanning,[11,20] and showed a strong correlation between these techniques. However, in the first study,[20] the transabdominal results were unavailable because contradictory data in the manuscript did not allow an ROC analysis. In the second study,[11] which evaluated only the effect of the myometrial layer on the risk of scar defect, the number of measurements was too small to reach a valid conclusion. Interestingly, a recent study using a cut-off value of 3.5 mm, but within the same range of measurements, showed a poor correlation between these two techniques.[29] As stated in a previous publication, the transvaginal approach can give good visualization of the LUS and seems to be preferred to the transabdominal approach for obtaining the most precise measurement of the LUS.[28] Moreover, two studies demonstrated higher reproducibility with transvaginal measurements.[29,30] Although sonographic LUS measurement could be a tool to determine the risk of uterine rupture and uterine scar defect, other factors such as interdelivery interval,[31–33] type of uterine closure,[34] a history of prior vaginal delivery,[35] and labour dystocia[36] may influence its accuracy. This is illustrated in two case reports in which uterine rupture occurred despite LUS thickness judged as normal.[27,37] While recent studies concluded that uterine rupture could not easily be predicted by either individual or combined clinical factors,[38,39] they did not evaluate LUS sonography, hysterotomy closure type, or interdelivery interval as variables.[40,41]

CONCLUSION

Our findings suggest a strong association between the degree of LUS thinning and the risk of uterine scar defect. LUS thickness may thus serve as an excellent predictor of uterine scar defect in women contemplating VBAC. However, at present an ideal cut-off value cannot be recommended, underlining the need for more standardized measurement techniques. Combined with careful intrapartum management, we believe that well-investigated parameters for measurement of LUS thickness could lead to novel guidelines for the management of women contemplating a VBAC, with a very low rate of uterine rupture.

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Table 1. Characteristics of studies that examined full LUS thickness

First author, year	Sample size, n	Sonographic approach	Blinded sonographic results	TOL, n	VBAC, n	CS, n	Scar defect n (%)	Cut-off value, mm	Sensitivity	Specificity
Rozenberg, 1996	642	Transabdominal	Yes	517	386	256	25 (3.9)	2.5	32	93
								3.5	88	73
								4.5	100	45
Rozenberg, 1999	198	Transabdominal	No	170	131	62	2 (1.0)	3.5	100	69
Sen, 2004	71*	Transvaginal	Yes	52	33	38	2 (2.8)	2.0	100	85
								2.5	100	68
								3.0	100	56
								3.5	100	44
Fukuda, 1988	84	Transabdominal	No	NA	24	60	5 (6.0)	2.0	100	89
								3.0	100	89
Montanari, 1999	61	Transvaginal	Yes	NA	8	53	17 (27.9)	3.0	65	91
								3.5	100	75
Tanik, 1996	50	Transabdominal	No	0	0	50	23 (46)	3.0	83	100
Suzuki, 2000	83†	Transabdominal	No	44	27	56	9 (10.7)	2.0	100	93
Bujold, 2009	236	Transabdominal and transvaginal	No	125	90	146	9 (3.8)	2.0	44	86
								2.5	67	64
								3.0	78	47
								3.5	89	26

NA: not available
*Sonographic results available for only 33 patients (successful VBAC)
†LUS appearance described only for elective Caesarean sections (n = 39)

Table 2. Characteristics of studies that examined the myometrial layer of the LUS

First author, year	Sample size, n	Sonographic approach	Blinded sonographic results	TOL, n	VBAC, n	CS, n	Scar defect n, %	Cut-off value, mm	Sensitivity	Specificity
Asakura, 2000	186	Transvaginal	Yes	132	63	123	9 (4.8)	1.6	78	65
Gotoh, 2000	68	Transvaginal	No	0	0	68	17 (25)	2.0	100	88
Cheung, 2004	53	Transabdominal	No	28	18	35	1 (1.9)	1.0	100	94
								2.0	100	33
Cheung, 2005	102*	Transabdominal	No	50	32	70	2 (2.0)	1.0	100	90
								1.5	100	56
								2.0	100	26
Bujold, 2009	223	Transabdominal and transvaginal	No	125	90	146	9 (3.8)	1.0	44	77
								1.5	78	45
								2.0	100	23

*LUS appearance described only for Caesarean sections

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