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Two Dimension Versus Three Dimension Ultrasound Assessment of Caesarean Section Scars

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***Abstract*---**Background: Ultrasound (US) is now used as an imaging modality for the evaluation of lower uterine segment (LUS). A number of reports of sonographic evaluation of LUS have appeared in literature. It has been speculated that thickness of the LUS is related to the quality of wound healing. There is strong correlation between the anatomic status of scarred LUS as assessed by USG and its functional status which is tested during labour. Objective: The aim of this work was to investigate the accuracy of two-dimensional and three-dimensional ultrasound in measurement of Caesarean section scar thickness. Patients and methods: This study was cross sectional study, conducted in Aswan University Hospital. The ultrasound examinations were conducted in the Obstetrics and Gynecology department between June 2017 and September 2021. The study included 150 pregnant females with previous one or two cesarean sections (CS) (aged 20-41y; mean 32.5y), underwent TA 2D and 3D US for assessment of the LUS thickness at 37-39 gestational weeks, before planning. Results: By comparing the Area Under the Curve (AUC) for the Receiver operator characteristic curve (ROC), for the four different sonographic measuring modalities, it was found that transabdominal 3 D Full Thickness measurement of the LUS (0.782) was the best predictor for uterine scar dehiscence. The best cut –off

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value for prediction of scar dehiscence was ≤ 2.0 mm with area under the curve (AUC) of 0.782 with sensitivity of 53.8%, specificity of 88.7%. Conclusion: We concluded that, for the four different sonographic measuring modalities, it was found that transabdominal 3 D Full Thickness measurement of the LUS (0.782) was the best predictor for uterine scar dehiscence and the best cut –off value for prediction of scar dehiscence was ≤ 2.0 mm with high degree of sensitivity and specificity.

***Keywords*---**Two Dimension Ultrasound, Three Dimension Ultrasound, Caesarean Section Scars.

Introduction

Caesarean section (C.S) is the commonest operation performed by the gynaecologist and one of the commonest surgical procedures in general. The rates of Caesarean section are continuing to rise all over the world [1].

For women who have had previous Caesarean section, choices for mode of birth in their next pregnancy are either trial of vaginal birth after caesarean (VBAC) or an elective repeat caesarean (ERC). Caesarean section is associated with complications in subsequent pregnancies, such as placenta previa, placenta accreta, increta or percreta1 dehiscence or uterine rupture. Also the surgical maternal morbidity including risk of bowel and bladder injury is significantly increased [2].

According to the available evidence, VBAC is associated with increased risk of maternal haemorrhage, blood transfusion, peripartum hysterectomy and uterine rupture. Fetal risks of VBAC includes Hypoxic Ischemic Encephalopathy and stillbirth [2].

Uterine rupture due to dehiscence of the previous C.S scar is one of the most morbid and catastrophic complications that may happen with VBAC trial. The risk of uterine rupture during VBAC trial is estimated to be 74/10000 [3].

Many authors have tried to predict the possibility of scar dehiscence and uterine rupture in patients candidates for VBAC. Prediction of scar dehiscence will help in patient selection for VBAC. Trails have been made to visualize the lower uterine segment (LUS) and previous C.S scar. Many methods have been suggested, including Hysterography, sonohysterography, hysteroscopy, magnetic resonance imaging and ultrasonography [4].

The role of ultrasound in visualization of the lower uterine segment and detection of C.S scar defects has been investigated by many authors. Two dimensional (2-D) transvaginal ultrasound was found to be an accurate method for measurement of scar thickness. The addition of saline sonohysterography can improve the demarcation of the scar [5].

Many authors have tried to utilize transabdominal and transvaginal 2-D ultrasound to measure the scar thickness and detect the healing defects. Some authors measured the entire thickness of the lower uterine segment **[6],** while others measured the muscular layer thickness **[7].** The optimal cut-off value predicting scar dehiscence varied from 2.0 to 3.5 mm for full LUS thickness and from 1.4 to 2.0 for myometrial layer **[5].**

Three-dimensional (3-D) ultrasound gets more and more applications in the field of obstetrics and gynaecology. New horizons for the use of 3-D ultrasound imaging are explored every day, giving rise to new diagnostic modalities. Although 3-D ultrasound will not replace 2-D ultrasound, many additional benefits will be identified and its use will continue to grow in the field in obstetrics and gynaecology **[8].**

One of the main advantages of 3-D ultrasound is the ability to reconstruct and display any arbitrarily chosen section within the volume dataset. Many of these planes cannot be obtained on conventional two dimensional sonography, as a result of the restrictions on probe movements during examination imposed by pelvic anatomy**[9].**

The use of three - dimensional ultrasound in visualizing LUS and measuring cesarean scar thickness has started to be investigated. **Martins and co-workers [10]** have suggested that 3-D ultrasound decrease the interobserver variability in sonographic measurement of scar thickness, making the use of ultrasound for this goal more accurate.

However, **Cheung et al.[11],** have reached different conclusion as 3D in comparison to 2-D transabdominal approach did not seem to improve the reliability of LUS thickness measurement.

The aim of this work was to investigate the accuracy of two-dimensional and three-dimensional ultrasound in measurement of caesarean section scar thickness.

Patients and Methods

This study was cross sectional study, conducted in Aswan University Hospital. The ultrasound examinations were conducted in the Obstetrics and Gynecology department between June 2017 and September 2021. The study included 150 patients at term with history of one or two previous Cesarean sections were recruited. These patients were admitted to the hospital for elective Cesarean section.

The study approved by the Ethical Review Committee of Aswan University Hospital. All steps explained in details for every patient and informed about the expected value and outcome. Informed consent was obtained from all patients participating in the study.

Inclusion criteria: Gestational age: 37-40 weeks of gestation, singletone pregnancy, cephalic presentation, not in labour, intact membranes, and all patients must had previous one or two cesarean sections.

Exclusion criteria: Gestational age of less than 37 weeks or more than 40 weeks, non-vertex presentation, disorders of amniotic fluid, either oligohydramnios or polyhydramnios, placenta previa, patients in labour, patients with ruptured fetal membranes, multiple pregnancy, history of more than two cesarean sections, and history of other uterine surgery, e.g, myomectomy.

All patients were subjected to:
a) History taking, including: age, gravidity, parity, number of deliveries, time interval between previous CS.
B) Clinical examination including: General examination, vital signs, systemic examination, and abdominal obstetric examination
C) Ultrasonographic examination: The ultrasound examinations were performed with an ultrasound machine (Voluson 730 Pro; GE Medical Systems, Milwakee, WI, USA) equipped with a 4–8-MHz transducer for 2D and 3D volume scanning.
Transabdominal ultrasound examination:

The first step was to obtain full obstetric ultrasound report including estimated gestational age, fetal lie, presentation, amniotic fluid volume, placental location with special focus on relation to the uterine scar.
The second step was to measure the thickness of the lower uterine segment using two-dimensional ultrasound. View of the LUS was obtained in the **mid-sagittal** plane and the view was magnified looking for the thinnest area of the LUS.
Also, the lower uterine segment was examined in a **lateral view** to detect any apparent rupture, ballooning or funneling of the LUS. The measurement was taken with the cursors at the urine-Urinary bladder interface and the amniotic fluid –decidua interface after sufficient magnification and measurement was taken to the nearest tenth of millimeter.

Three layers can be identified ultrasonographically in a well-developed lower uterine segment in a midline section of sagittal view, in a partially filled bladder. They are as follows from inside outwards: (a) Chorioamniotic membrane with decidualized endometrium. (b) A middle layer of myometrium. (c) Utero-vesical peritoneal reflection and urinary bladder wall.

The 2D TA LUS thickness was measured using a previously described technique to identify any areas of obvious dehiscence or rupture. At least 3 measurements were made for each thickness, with the lowest value taken as the LUS measurement. After the entire thickness was measured by 2-D ultrasound,

3-D volume dataset was obtained of the LUS. The acquired volume was manipulated on the multiplanar display mode, searching for the thinnest part of the lower uterine segment avoiding obliquity. The thinnest part of the lower uterine segment was measured to the nearest tenth of millimeter and recorded. The same operator has performed the 2D and 3D transabdominal sonographic examination.

D) During Cesarean section:
Intra operatively; as a gold standard uterine scar thickness was measured during caesarean section before delivery of the fetus. The ultrasound examination to Cesarean delivery ,time interval varied from one to forty-eight hours. During Cesarean delivery the lower uterine segment was defined as the part of the uterus below the utero-vesical peritoneal reflection. After opening the visceral peritoneum and performing the bladder dissection, the LUS was assessed for integrity of the Cesarean section scar by the operating surgeon to avoid bias by the sonographic findings. ***Uterine scar dehiscence*** was ***defined*** as an incomplete and clinically occult uterine scar separation with intact serosa.
The lower uterine segment was assessed intraoperatively during the cesarean delivery and graded according to the system developed by Qureshi et al. Figure (1)**:**
Grade I: Well-developed lower uterine segment.
Grade II: Thin lower segment, content not visible.
Grade III: Translucent lower segment, content visible.
Grade IV: Well-circumscribed defect, either dehiscence or rupture **[12]**.

LUS was identified as the part of the uterus below the loose reflection of the vesico-uterine serosa. Before the delivery of fetus, the thinnest portion of the lower uterine segment (myometrium and decidua only) was measured by **ophthalmic calipers** Figure **(2)** just after incising the uterus and before membrane rupture,. A sterile calliper was placed on the lower flap of the incision at a right angle to the surface and the measurement was taken at three different places one centimetre apart each & lowest value was taken as the thickness of the LUS. Figures (3-5).

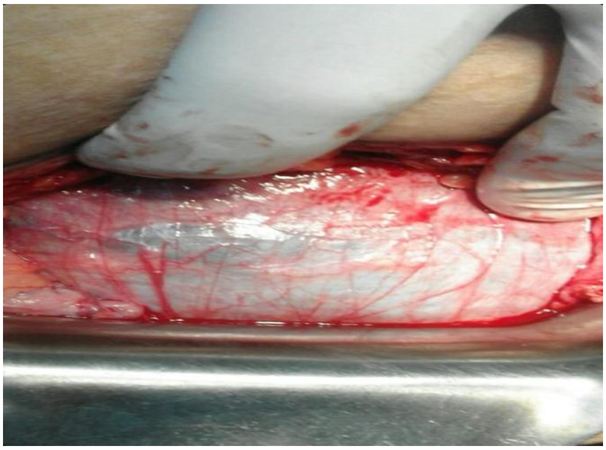


Figure (1): The intraoperative cesarean scar morphology: grade 3 thin LUS with visible content

Figure (2): The intraoperative cesarean scar morphology: grade 3 thin LUS with visible content

Figure (3): The Castroviejo ophthalmic calipers.

Figure (4): The intraoperative incision-site uterine wall thickness measurement using the Castroviejo ophthalmic calipers.

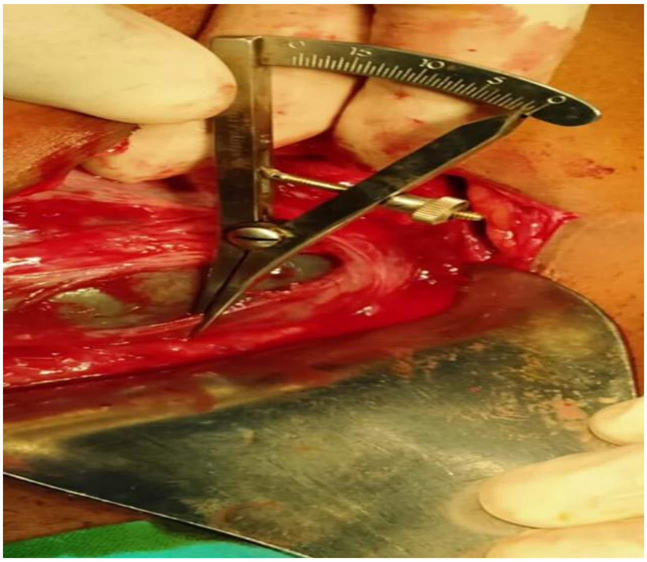


Figure (5): The intraoperative incision-site uterine wall thickness measurement using the Castroviejo ophthalmic calipers.

Statistical analysis

Statistical analysis was done using MedCalc© version 12.5 (MedCalc© Software, Ostend, Belgium) and IBM © SPSS © Statistics version 24 (IBM© Corp., Armonk, NY). Data were collected, verified and revised. Qualitative data was described in terms of frequencies and percentages. Quantitative data was described in terms of mean and standard deviations if normally distributed and median and interquartile range. Kolmogorov Semornov test was used to test the normality of distribution of numerical variables. Pearson correlation coefficient was used to determine significant correlations among different parameters and Spearman one was used if non parametric. The strength of the κ coefficient was judged according to the criteria proposed by Cohen: less than 0.41 was considered poor; 0.41–0.60 was moderate; 0.61–0.80 was good; and 0.81–1.0 was excellent. Receiver operating characteristic (ROC) curve was used to determine the sensitivity and specificity of the four different ultrasound measurement techniques, And to assign a cut off value of a test quantitative variable for prediction of a state of a nominal one with estimation of area under the curve (AUC) .The data were considered significant if p values was ≤ 0.05, highly significant if p < 0.01.

Results

Table (1): General characteristics of the included patients

Variable	Mean	Std. Deviation
AGE (Year)	**32.533**	**5.5523**
Parity	**1.34**	**.664**
Previous C.S	**1.39**	**.490**
Gestational Age (WK)	**37.97**	**.878**
Body Mass Index (BMI) kg/m^2	**29.167**	**2.7913**

One hundred and fifty pregnant females were examined. Their mean age was 32.53 ± 5.55 years old. Their mean BMI was 29.17 ± 2.79 kg/m^2 . On analyzing their gestational age, we found that their mean gestational age was 37.97 ± 0.88 weeks. with a mean parity of 1.34 ± 0.66. mean previous CS was 1.39 ± 0.49 .

Table (2): Intra-Operative Grading of LUS In the studied group. according to Qureshi et al.[12]

Grading	No.	Percent
G1	**93**	**62.0**
G2	**31**	**20.7**
G3	**18**	**12.0**
G4	**8**	**5.3**
Total	**150**	**100.0**

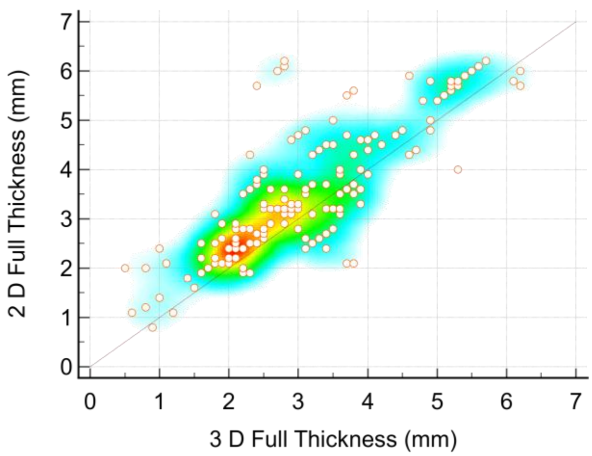
G1 Grade I: Well-developed lower uterine segment. G2 Grade II: Thin lower segment, content not visible. G3 Grade III: Translucent lower segment, content visible. G4 Grade IV: Well-circumscribed defect, either dehiscence or rupture.

We also measured the full thickness of LUS intraoperatively and found that the mean level of the LUS thickness was 2.68 ± 1.15 mm and found that most patients (62%, 93 participants) were in the first grade (well developed) while 20.7% of patients (31 participants) were in the second grade (thin not visible), 18 patients (12.0%) were found with the grade 3 only 5.3% of them (8 patients) were in the fourth grade (well circumscribed).

Table (3): Correlation between transabdominal 2D full Thickness and 3D full Thickness

Correlations						
	Spearman's rho					
	2 D Full Thickness (mm)			3 D Full Thickness (mm)		
	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N
2 D Full Thickness (mm)	1.000	.	150	.792**	.000	150
3 D Full Thickness (mm)	.792**	.000	150	1.000	.	150
**. Correlation is significant at the 0.01 level (2-tailed).						

The interclass correlation between transabdominal 2D full Thickness and 3D full Thickness ultrasonography measurement LUS was 0.792, suggesting a good index of correlation between the two modalities in the evaluation of lower uterine segment thickness.



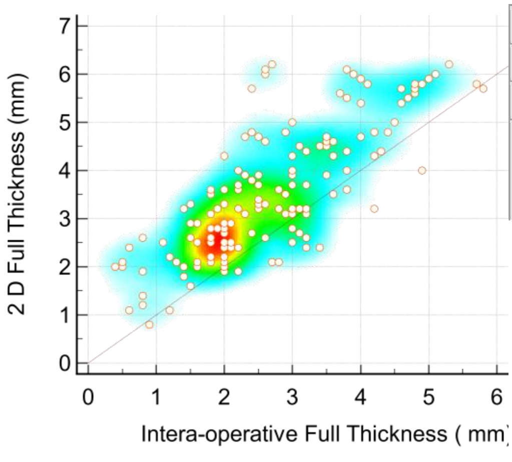
Sample size	150
Correlation coefficient r	0.8044
Significance level	P<0.0001
95% Confidence interval for r	0.7394 to 0.8545

Fig. (6): Correlation between transabdominal 2D full Thickness and 3D full Thickness.

Table (3): Correlation between transabdominal 2D full Thickness and Intra-operative full Thickness

Correlations						
	Spearman's rho					
	2 D Full Thickness (mm)			Intra-operative Full Thickness (mm)		
	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N
2 D Full Thickness (mm)	1.000	.	150	.762**	.000	150
Intra-operative Full Thickness (mm)	.762**	.000	150	1.000	.	150
**. Correlation is significant at the 0.01 level (2-tailed).						

The interclass correlation between transabdominal 2D full Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS was 0.762, suggesting a good index of correlation between the two modalities in the evaluation of lower uterine segment thickness.



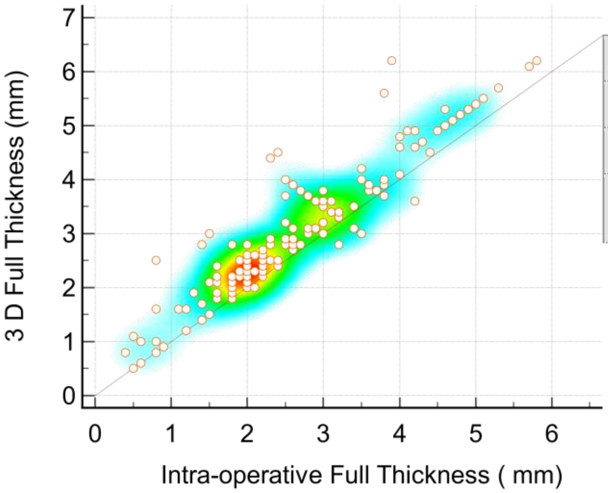
Sample size	150
Correlation coefficient r	0.7740
Significance level	P<0.0001
95% Confidence interval for r	0.7007 to 0.8312

Fig. (7): Correlation between transabdominal 2D full Thickness and Intra-operative full Thickness.

Table (5): Correlation between transabdominal 3D full Thickness and Intra-operative full Thickness

Correlations						
	Spearman's rho					
	3 D Full Thickness (mm)			**Intra-operative Full Thickness (mm)**		
	Correlation Coefficient	**Sig. (2-tailed)**	**N**	**Correlation Coefficient**	**Sig. (2-tailed)**	**N**
3 D Full Thickness (mm)	**1.000**	**.**	**150**	**.922****	**.000**	**150**
Intra-operative Full Thickness (mm)	**.922****	**.000**	**150**	**1.000**	**.**	**150**
**. Correlation is significant at the 0.01 level (2-tailed).						

The interclass correlation between transabdominal 3D full Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.922, suggesting a excellent index of correlation between the two modalities in the evaluation of lower uterine segment thickness.



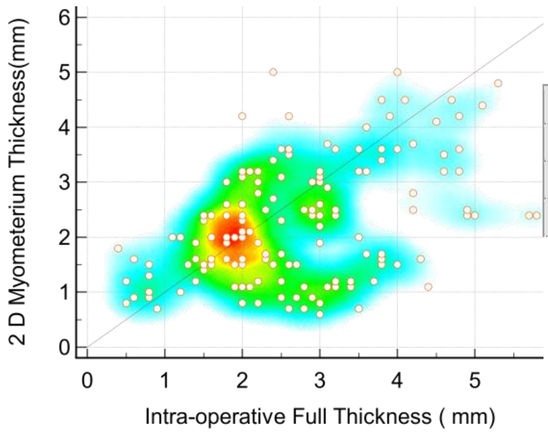
Sample size	150
Correlation coefficient r	0.9295
Significance level	P<0.0001
95% Confidence interval for r	0.9039 to 0.9485

Fig. (8): Correlation between transabdominal 3D full Thickness and Intra-operative full Thickness.

Table (6): Correlation between transabdominal 2D Myometrium Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS

Correlations						
	Spearman's rho					
	2 D Myometerium Thickness(mm)			Intra-operative Full Thickness (mm)		
	Correlation Coefficient	Sig. (2-tailed)	N	Correlation Coefficient	Sig. (2-tailed)	N
2 D Myometrium Thickness(mm)	1.000	.	150	.394**	.000	150
Intra-operative Full Thickness (mm)	.394**	.000	150	1.000	.	150
**. Correlation is significant at the 0.01 level (2-tailed).						

The interclass correlation between transabdominal 2D Myometrium Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.394, suggesting a poor index of correlation between the two modalities in the evaluation of lower uterine segment thickness.



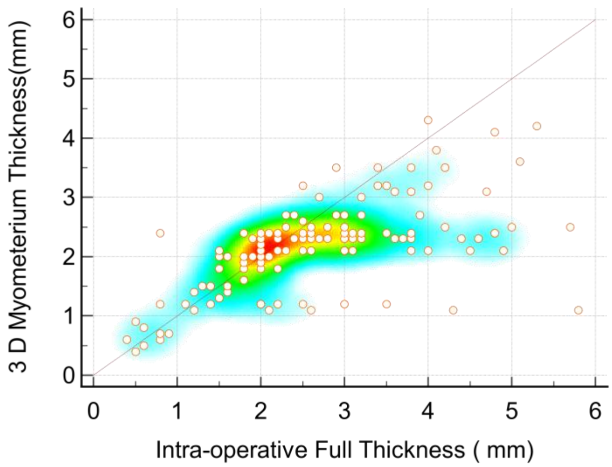
Sample size	150
Correlation coefficient r	0.4383
Significance level	P<0.0001
95% Confidence interval for r	0.2991 to 0.5593

Fig. (9): Correlation between transabdominal 2D Myometrium Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS

Table (7): Correlation between transabdominal 3D Myometrium Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS

Correlations						
	Spearman's rho					
	3 D Myometerium Thickness(mm)			**Intera-operative Full Thickness (mm)**		
	Correlation Coefficient	**Sig. (2-tailed)**	**N**	**Correlation Coefficient**	**Sig. (2-tailed)**	**N**
3 D Myometrium Thickness(mm)	**1.000**	**.**	**150**	**.634****	**.000**	**150**
Intera-operative Full Thickness (mm)	**.634****	**.000**	**150**	**1.000**	**.**	**150**
**. Correlation is significant at the 0.01 level (2-tailed).						

The interclass correlation between transabdominal 3D Myometrium Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.634, suggesting a moderate index of correlation between the two modalities in the evaluation of lower uterine segment thickness.



Sample size	150
Correlation coefficient r	0.6081
Significance level	P<0.0001
95% Confidence interval for r	0.4962 to 0.7001

Fig. (10): Correlation between transabdominal 3D Myometrium Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS

Table (8): ROC curve for 2-D transabdominal LUS full thickness measurement

Area Under the Curve				
Test Result Variable(s): 2 D Full Thickness (mm)				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
.769	**.048**	**.000**	**.675**	**.862**
The test result variable(s): 2 D Full Thickness (mm) has at least one tie between the positive actual state group and the negative actual state group.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Receiver operating characteristic (ROC) curve of the 2 D full thickness (mm) has shown that the best cut –off value for prediction of scar dehiscence was ≤ 2.5 mm with area under the curve (AUC) of 0.769 with sensitivity of 61.5%, specificity of 79.8%.

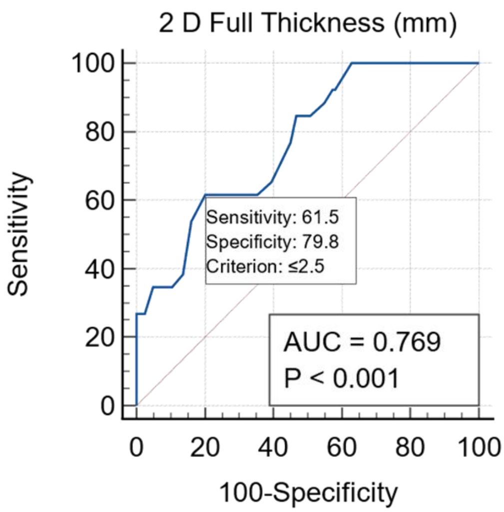


Fig. (11): ROC curve for 2-D transabdominal LUS full thickness measurement

Table (9): ROC curve for 3-D transabdominal LUS full thickness measurement

Area Under the Curve				
Test Result Variable(s): 3 D Full Thickness (mm)				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
.782	**.052**	**.000**	**.681**	**.883**
The test result variable(s): 3 D Full Thickness (mm) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Receiver operating characteristic (ROC) curve of the 3 D full thicknesses (mm) has shown that the best cut –off value for prediction of scar dehiscence was ≤ 2.0 mm with area under the curve (AUC) of 0.782 with sensitivity of 53.8%, specificity of 88.7%.

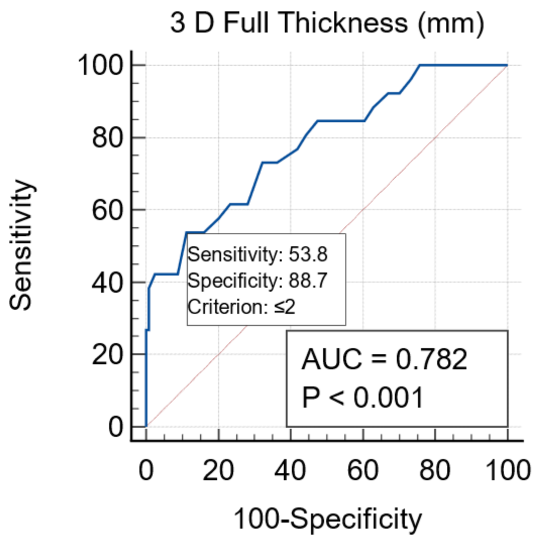


Fig. (12): ROC curve for 3-D transabdominal LUS full thickness measurement

Table (10): ROC curve for 2-D transabdominal Myometrium thickness measurement

Area Under the Curve				
Test Result Variable(s): 2 D Myometrium Thickness(mm)				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
.745	**.050**	**.000**	**.647**	**.843**
The test result variable(s): 2 D Myometerium Thickness(mm) has at least one tie between the positive actual state group and the negative actual state group.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Receiver operating characteristic (ROC) curve of the 2 D Myometrium Thickness (mm) has shown that the best cut –off value for prediction of scar dehiscence was ≤ 2.1 mm with area under the curve (AUC) of 0.745 with sensitivity of 80.8%, specificity of 55.6%.

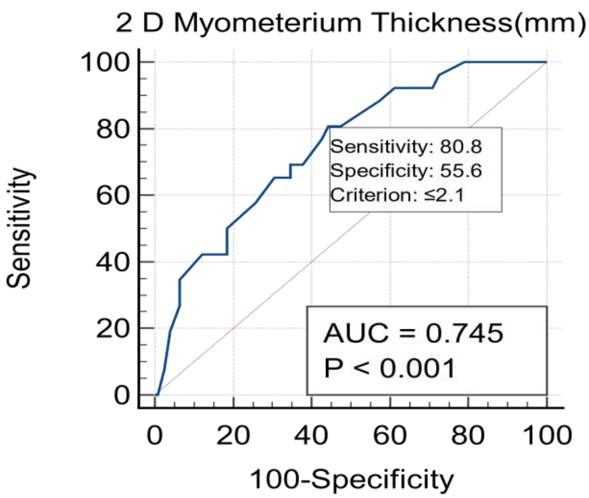


Fig. (13): ROC curve for 2-D transabdominal Myometrium thickness measurement

Table (11): ROC curve for 3-D transabdominal Myometrium thickness measurement

Area Under the Curve				
Test Result Variable(s): 3 D Myometerium Thickness(mm)				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
.708	**.063**	**.001**	**.585**	**.831**
The test result variable(s): 3 D Myometerium Thickness(mm) has at least one tie between the positive actual state group and the negative actual state group.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Receiver operating characteristic (ROC) curve of the 3 D Myometrium Thickness (mm) has shown that the best cut –off value for prediction of scar dehiscence was ≤ 1.3 mm with area under the curve (AUC) of 0.708 with sensitivity of 46.2%, specificity of 90.3%.

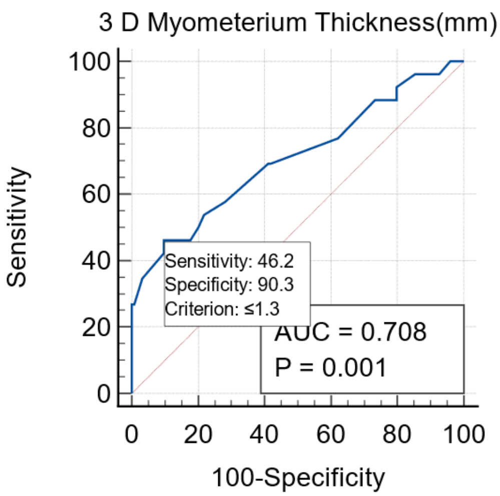


Fig. (14): ROC curve for 3-D transabdominal Myometrium thickness measurement

Table (12): Area under curve (AUC), Standard Error (SE) and 95% Confidence Interval for the four different measuring modalities

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
2 D Full Thickness (mm)	**.769**	.048	.000	.675	.862
2 D Myometrium Thickness(mm)	**.745**	.050	.000	.647	.843
3 D Full Thickness (mm)	**.782**	.052	.000	.681	.883
3 D Myometrium Thickness(mm)	**.708**	.063	.001	.585	.831
The test result variable(s): 2 D Full Thickness (mm), 2 D Myometrium Thickness(mm) , 3 D Full Thickness (mm), 3 D Myometrium Thickness(mm) has at least one tie between the positive actual state group and the negative actual state group.					
a. Under the nonparametric assumption					
b. Null hypothesis: true area = 0.5					

By comparing the Area Under the Curve (AUC) for the Receiver operator characteristic curve (ROC), for the four different sonographic measuring modalities, it was found that transabdominal 3 D Full Thickness measurement of the LUS (0.782) was the best predictor for uterine scar dehiscence.

Discussion

In this study our results showed that, mean age was 32.53 ± 5.55 years old. With mean BMI 29.17 ± 2.79 kg/m^2 , the mean fetal weight was 2819 ± 226.7 gm. and mean gestational age was 37.97 ± 0.88 weeks.

In the study of **Sarwar et al. [13]**, A total of 117 women were enrolled. Their ages ranged from 19–39 years, with mode at 30 years (33.3%) and mean age of 28.9±4.0 years. The parity ranged from 1–5 with mode at 1 (69.2%) and mean of 1.56. Gestational age ranged from 37–42 weeks, with mode at 38 (12.0%) and mean of 38.4±1.3 weeks. Duration since last caesarean section ranged from 1 to 9 years, with mode at 2 (61.5%) and mean of 2.12±1.1 years.

In a study by **Sen et al.[14]** 71 pregnant women with previous CS were included as study group. In the study group, mean ± S.D. age was 25 ± 3 years, mean parity was 1.3 ± 0.5, mean pregnancy duration was 39.5±0.9 weeks. In a prospective study by **Cheung et al.[15]**, the caesarean group mean maternal age was 30.5 ± 4.2 years& mean maternal weight was 66.5 ± 5.2 kg.

Some studies showed an association between maternal age, inter-pregnancy interval, single layer closure and infection after previous caesarean section and scar rupture/dehiscence [16, 17]. While others showed that was no significant difference between normal & abnormal CS scars as regard maternal age, maternal weight, gestational age & duration of last previous CS (P>0.05) [18].

Intraoperatively, We also measured the full thickness of LUS and found that the mean level of the LUS thickness was 2.68 ± 1.15 mm and most patients 62%, (93 participants) were in the Grades I (well developed) while 20.7% of patients (31 participants) were in the Grades II (thin not visible), 18 patients (12.0%) were found with the Grades III only 5.3% of them (8 patients) were in the Grades IV (well circumscribed). according to the system developed by **Qureshi et al.**[12]**.** Grades IV and III were considered abnormal lower uterine segment (bad scar), and Grades I and II were considered normal (good scar).

Our results are comparable to the study by **Sen et al.** [14]**,** reported that 85% had grade I LUS, 11% had grade II, and 2% had grade III & 2% had grade IV. And **Sarwar et al.** [13]**,** found that 30% of scars of cases were of grade 1, 36% of grade 2, 31% of grade 3 and only 3% of grade 4**.**

As regard correlations, in our study we found correlation between transabdominal 2D full Thickness and 3D full Thickness ultrasonography measurement which was 0.792, suggesting a strong index of correlation between the two modalities in the evaluation of lower uterine segment thickness. Significance level P<0.0001.

The interclass correlation between transabdominal 2D full Thickness ultrasonography and Intra-operative Full Thickness measurement of LUS was 0.762, suggesting a strong index of correlation between the two modalities in the evaluation of lower uterine segment thickness. Significance level P<0.0001.

The interclass correlation between transabdominal 3D full Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.922, suggesting a very strong index of correlation between the two modalities in the evaluation of lower uterine segment thickness. Significance level P<0.0001.

The interclass correlation between transabdominal 2D Myometrium Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.394, suggesting a low index of correlation between the two modalities in the evaluation of lower uterine segment thickness. Significance level P<0.0001.

The interclass correlation between transabdominal 3D Myometrium Thickness ultrasonography and Inter-operative Full Thickness measurement of LUS was 0.634, suggesting a moderate index of correlation between the two modalities in the evaluation of lower uterine segment thickness. Significance level P<0.0001.

Consistent with our study **Fukuda et al.**[19] concluded that there is a significant correlation between the overall sonographic LUS thickness and the intraoperative uterine wall thickness, and as regard Full 2D and Full 3D: There was a strong significant positive correlation between the two methods for measurement as R was 0.95 and p-value was 0.0001 , as regard full 2D and intraoperative method: There was a strong significant positive correlation between the two methods for measurement as R was 0.92 and p-value was 0.0001, as regard Full 3D and intraoperative method: There was a strong significant positive correlation between the two methods for measurement as R was 0.97 and p-value was 0.0001 , as regard Inner 2D and intraoperative method: There was a strong significant positive correlation between the two methods for measurement as R was 0.82 and p-value was 0.0001, as regard Inner 3D and intraoperative method: There was a strong significant positive correlation between the two methods for measurement as R was 0.822 and p-value was 0.0001.

Also, **Cheung et al. [11]** found that, with regard to inter method reliability, both the MT and the FT measurements obtained via 3D sonography were comparable to those obtained with the 2D approach The κ coefficients were generally good 0.77–0.91. **ROC curves** used to determine the sensitivity and specificity of different ultrasound modalities in prediction of scar dehiscence. In our study we found that:

The best cut-off value for transabdominal 2D full thickness ultrasound was ≤ 2.5 mm with area under the curve (AUC) of 0.769 with sensitivity of 61.5%, specificity of 79.8%. The best cut-off value for transabdominal 3D full thickness (mm) has shown that ≤ 2.0 mm with area under the curve (AUC) of 0.782 with sensitivity of 53.8%, specificity of 88.7%.

The best cut-off value for transabdominal 2D myometrium thickness (mm) has shown that ≤ 2.1 mm with area under the curve (AUC) of 0.745 with sensitivity of 80.8%, specificity of 55.6%. The best cut-off value for transabdominal 3D myometrium thickness (mm) has shown that ≤ 1.3 mm with area under the curve (AUC) of 0.708 with sensitivity of 46.2%, specificity of 90.3%.

By comparing the Area Under the Curve (AUC) for the Receiver operator characteristic curve (ROC), for the four different sonographic measuring modalities, it was found that transabdominal 3D Full Thickness measurement of the LUS (0.782) was the best predictor for uterine scar dehiscence. **Consistent with our findings**, others stated that the cut off value of LUS thickness above which the intrapartum rupture is less likely has varied from 2 to 3.5 mm

In study by **Uharček et al.[20]** using transabdominal ultrasound on 336 women, 2.5 mm was considered the critical cut-off value of the LUS thickness. This critical cut-off value was derived from the ROC curve with sensitivity, specificity, PPV, and NPV of 90.9, 84, 71.4, and 95.5 %, respectively and concluded that Full LUS thickness of ≤ 2.5 mm is associated with a higher risk of uterine dehiscence.

Sen et al. [14] which used both vaginal and abdominal ultrasound measurement. They reported a 96 % correlation between transabdominal ultrasonography with magnification and transvaginal ultrasonography. The critical cut-off value for safe lower segment thickness, derived from the receiver operator characteristic curve, was 2.5 mm.

Rosenberg et al.[21] performed the largest ever study on the scar thickness by sonography measuring full thickness and using cut-off point of 3.5 mm, the sensitivity was 88 % and the specificity was 73.2 %. Suggested that measurement of only the myometrial layer is more representative of the LUS thickness[15].

Our findings are supported by those of **Asakura et al.**[22] who measured only the myometrial layer as the LUS thickness instead of the full thickness and suggested a cut-off point of 1.6 mm, the sensitivity was 77.8 % and the specificity was 88.6 %. And concluded that myometrium thickness more than 1.5 mm to 2 mm as potentially safe to take trial of labor.

Kok et al. [23] in his meta-Analysis has shown full LUS cut off value of 3.1–5.1mm as a strong negative predictive value for the occurrence of a defect scar during trial of labor. A study conducted in **Tazion et al.** [24] showed significant association (p-value <0.001) between scar thickness (1–3 mm) and intraoperative findings of scar dehiscence and rupture.

Sharma et al. [25] from India in their study also observed that lower uterine segment thickness less than 3.65 mm has 91% sensitivity, 93% specificity, and 91% negative predictive value for prediction of scar rupture. **Bujold et al.** [26] study for the full LUS thickness, also concluded that lower uterine segment thickness of <2.5 mm is associated with uterine rupture rate of 10% with specificity of 90%.

In a similar study done by **Ramteke and Wankhede**[27] those with LUS thickness 3mm had successful VBAC in 40 - 60% patients. However, the association of scar thickness and probability of successful VBAC is not statistically significant. Sensitivity and specificity of ultrasonography in detecting abnormal LUS according to present study was 84.79% and 100% respectively. The PPV and NPV was 100% and 91% respectively.

Other study also, showed that scar thickness of 2.55 mm and above measured by transabdominal method in the third trimester can be safely given trial of VBAC [28]. **Cheung et al.**[11] in his study reported that a cut off sonographic LUS thickness of 1.5 mm had a sensitivity of 88.9%, a specificity of 59.5%, a PPV of 32.0%, and a NPV of 96.2% in predicting a paper-thin or dehiscence LUS.

Pahirah et al.[29] found that abdominal sonographic myometrial LUS cut-off value of 1.5 mm could predict CSD and a thin incision-site uterine wall thickness with sensitivity, specificity, PPV, NPV of 50.0%, 90.8%, 9.1%, 99.0%, and 37.5%, 94.6%, 54.5%, 90.0%, respectively. A receiver operating characteristic curve was generated to determine the optimum cut-off value at 2.5 mm with a sensitivity of 76.5% and a specificity of 73.3%. The area under the curve was 0.8 (a 95% confidence interval, 0.718-0.885).

Sharma et al.[25] shows the ROC curves of TAS LUS and TVS LUS and TAS myometrium (TAS MYO) and TVS myometrium (TVS MYO), respectively. As shown in Table 5, the cutoff value of LUS as measured by TAS was 3.65 mm (sensitivity 91 %, specificity 93 %, PPV 14 %, NPV 91.2 %), TVS LUS was 4.05 mm (sensitivity

71 %, specificity 93 %, PPV 64 %, NPV 95 %), TAS myometrium was 2.15 mm (sensitivity 57 %, specificity 93 %, PPV 59 %, NPV 92 %), and TVS myometrium (sensitivity 65 %, specificity 73 %, PPV 30 %, NPV 92 %). **Unlike the studies mentioned,** THE following studies failed to show strong association between scar thickness measured on ultrasound and scar dehiscence/rupture.

Sarwar et al. [13] on a study of 117 patients. using transabdominal ultrasound FT of LUS Out of these 33% had thin or dehiscence/rupture scar. At the cut-off value of ≤5 mm the sensitivity was 76.9%, specificity 48.7% and accuracy was 58.12%. and concluded that No definite US cut-off limit could be established to provide guidance regarding the clinical decision of opting for VBAC or repeat caesarean/section; scar thicknesses ≤5.0 mm should be judged cautiously.

The variation in the figures worldwide could reflect many contributing factors. The difference in cesarean section techniques especially in the closure of the uterus and peritoneal closure may be a contributing factor. Also, the healing process which is not yet fully understood may share a part in this dilemma. The type of the ultrasound machine and its resolution and the inter observer error also exist. Lastly, but most importantly is that there is yet, no universal method to measure the scar thickness[29].

Conclusion

- Observations of present study conclude that Sonographic evaluation of LUS scar (both with TA 2D and TA 3D) is a safe, reliable, and non-invasive method for predicting the risk of scar dehiscence/rupture in women with previous CS.
- The lower uterine segment thickness is related to the grade of the scar.
- The best timing to perform the scan is at late third trimester.
- By comparing the Area Under the Curve (AUC) for the Receiver operator characteristic curve (ROC), for the four different sonographic measuring modalities, it was found that transabdominal 3 D Full Thickness measurement of the LUS (0.782) was the best predictor for uterine scar dehiscence. and the best cut –off value for prediction of scar dehiscence was ≤ 2.0 mm with high degree of sensitivity and specificity.

Recommendations

- US measurements of lower uterine segment thickness by ultrasound is useful clinical tool. It may be performed routinely in women who had a previous cesarean before labour
- Measurement of lower uterine segment thickness by ultrasound cannot be used alone as a predictor of uterine scar defects and should be used in conjunction with other clinical evidence and risks to foeto-maternal health as final arbiters of mode of delivery.
- A definite technique for use of ultrasound for measurement of LUS and myometrium needs to be standardized
- Training module for obstetricians and sonologists should be offered for assessment of LUS and myometrium.

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