A practical guideline for examining a uterine niche using ultrasonography in non-pregnant women: a modified Delphi method amongst European experts

Short title: Delphi ultrasonographic niche evaluation

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Abstract

Objectives: To generate a uniform, internationally recognized guideline for detailed uterine niche evaluation by ultrasonography in non-pregnant women using a modified Delphi method amongst international experts.

Methods: Fifteen international gynecological experts were recruited by their membership of the European niche taskforce group. All experts were physicians with extensive experience in niche evaluation in clinical practice and/or authors of niche studies. Relevant items for niche measurement were determined based on the results of a literature search and recommendations of a focus group. Two online questionnaires were sent to the expert panel and one group meeting was organized. Consensus was predefined as a consensus rate of at least 70%.

Results: In total 15 experts participated in this study. Consensus was reached for a total of 42 items on niche evaluation, including definitions, relevance, method of measurement and tips for visualization of the niche. All experts agreed on the proposed guideline for niche evaluation in non-pregnant women as presented in this paper.

Conclusion: Consensus between niche experts was achieved on all items regarding ultrasonographic niche measurement.

Key words: Cesarean section, cicatrix, ultrasonography, Delphi technique

Introduction

Cesarean section (CS) rates are increasing worldwide with a corresponding increase in associated complications. The uterine scar or "niche" has been reported as an important feature that is associated with CS complications. Recently it has been demonstrated that niches may be the causative factor for abnormal uterine bleeding, dysmenorrhea, obstetric complications in subsequent pregnancies and possibly subfertility.[1-6] The relationship between various niche features and symptoms has not fully been elucidated, although an association has been reported between niche volume and the "healing ratio" (residual myometrium thickness (RMT) / adjacent myometrium thickness (AMT)) with abnormal uterine bleeding.[3, 4] Therefore, the accurate measurement and description of a niche is becoming increasingly important for both research, the clinical assessment of gynecological symptoms, and for the planning of possible surgical treatment.[6, 7]

Although many studies have evaluated the development and symptoms associated with niches, there is no standardized guideline for examining, measuring or describing a niche.[8] A niche can be examined by transvaginal ultrasonography, saline infusion sonography (SIS), gel infusion sonography (GIS), three-dimensional ultrasound, MRI (magnetic resonance imaging) and hysteroscopy.[4, 9-12] Naji et al. proposed a standardized approach for niche description by using ultrasonography, based on definitions and methods described in literature.[13] The authors proposed one approach to documenting the size of a niche, but this did not take into account variations that occur in scar morphology in case of non-pregnant patients. In addition to this proposal we identified the need for a more detailed practical guideline for clinicians. There is also a significant difference in measuring a niche in a pregnant or non-pregnant woman. To develop a practical guideline, we decided to initially focus on non-pregnant women. We considered a Delphi method to be very suitable to achieve consensus in a structured way amongst international experts. The Delphi technique has been used widely in healthcare research, in particular within the field of education and training, and in

developing clinical practice.[14, 15] The aim of this study was to determine a uniform, internationally recognized definition and guideline for detailed evaluation of a niche in non-pregnant women.

Methods

Design of a modified Delphi study

In this modified Delphi procedure repeated rounds of an anonymous questionnaire were used so that the experts are able to reflect on the results of the previous questionnaire round in a structured manner. After analyzing the collective opinion of the group, the results of the first questionnaire were used as the basis for formulating the second questionnaire. It was predetermined that the modified Delphi procedure would include at least three rounds; two questionnaire rounds and one face-to-face meeting and additional rounds until data saturation was achieved. We started with a systematic literature search and a focus group amongst Dutch experts to design a questionnaire for niche measurement and relevant items for niche assessment to form the basis of the proposal used during the Delphi method. This was followed by the modified Delphi procedure. The study design is presented in Figure 1, consisting of two online questionnaires and one face-to-face meeting. The data were collected between May and October 2016.

Literature Search to collect relevant data to be used in the first Delphi round

A systematic search of the literature up to October 2015 was performed in PubMed and Embase databases with the assistance of a clinical librarian. Searches were carried out for methodological items described in delineating the uterine scar in non-pregnant women by ultrasonography (see Supplement 1 for search strategy). Duplicate articles were excluded. All English and Dutch articles that reported on niche measurement by ultrasound and reporting on one or more of our predetermined questions were included. The questions contained: 1. The optimal timing for measuring a niche following a CS; 2. The best infusion fluid – GIS or SIS; 3. Whether 2D or 3D ultrasonography should be used; 4. What features of the niche should be measured; 5. Best time in the menstrual cycle for measurement; 6. Relevance of pressure with transvaginal probe; 7. Relevance of Doppler ultrasound; 8. Relevance of measuring the distance between vesico-vaginal fold (VV fold)

and the internal os. From all reviewed papers we extracted all items that could possibly be relevant in a concept questionnaire for the Delphi and were presented to the focus group for final selection.

Focus group and development of the questionnaire used in the first round of the Delphi

The focus group contained six Dutch experts who previously participated in the Dutch HYSNICHE trial[16] and SCAR[4] or SECURE studies[3]. In a face-to-face meeting a proposal for the Delphi questionnaire that included potential relevant items for niche measurement (illustrated by ultrasonographic images) was discussed to determine internal validity. All comments and recommendations discussed in this meeting were recorded by the researchers and analyzed. A summary of the results was sent to the members of the focus group for feedback. Based on these results, an online questionnaire for the first round of the Delphi procedure was designed.

Expert panel recruitment

In order to obtain an expert panel comprising of members with sufficient experience in niche measurement, members of the taskforce on niches of the European niche taskforce group were invited to participate in the Delphi procedure. These experts could invite one colleague from the same institute, known to have sufficient experience in the field. The definition of being an expert in this Delphi procedure was predefined as a gynecologist or resident who performed >30 niche evaluations a year; or had published at least one article on niches in a peer reviewed journal or gave presentations on conferences concerning ultrasound and niches. After confirmation of participation, the experts received an email containing a unique link to the online questionnaire.

Description of the structural consensus method

Delphi rounds

The answers from all experts were analyzed for each question. If no consensus was reached, the question was transferred to the second round and the results of the first round were fed back

anonymously including the reasoning of the respondents. Additional questions seeking clarifications on the same subject were added as appropriate. Non-responders in the first round were not invited for the following rounds. Based on the results of the second round a draft guideline was designed. These results were presented in a face-to-face meeting at the ESGE world congress in Brussels, October 2016. The items without consensus were discussed again. The researchers recorded all comments and recommendations mentioned in this meeting. The experts could reflect on their reasoning and if necessary reconsider their opinion. The final results of the agreed items were sent to all experts participating in the first round for final approval.

Consensus rules

Consensus rules were predefined as a Rate of Agreement (RoA: (Agreement – Disagreement/Agreement + Disagreement + Indifferent) x 100%) above 70%; this is a commonly used cut-off value.[14, 17, 18]

Results

Identified papers

The literature search resulted in 1034 papers after removal of duplicates (see Supplement 1). All titles and abstracts were reviewed by I.J. and R.L. and 908 articles were excluded because their subject was not related to niche measurement. After assessing the full papers of the remaining 126 articles, we found eight papers that reported on our predefined research questions. The main results of the search are presented in Table 1. In total six papers reported higher detection rates after GIS or SIS than after TVU for niche measurement.[3-5, 10, 19, 20] Two papers proposed methodology for niche measurement.[5, 13] Fabres et al.[21] reported that the best time during the menstrual cycle to evaluate a niche is during menstruation. No literature was available for the other research questions. Based on the literature we formulated 11 main topics and 17 subtopics as being potentially relevant for niche measurements that were discussed in the focus group. The most relevant and illustrative results of our literature search were also presented to the experts in an evidence table scored according to the GRADE method[22], see Supplement 2.

Focus group participation and first round questionnaire

The focus group discussion took place on January 10th, 2016. It was recorded and transcribed, resulting in an analysis of 50 codes using Atlas.ti.software[23]. Analyzing these codes, 40 relevant items and 79 questions emerged. These questions could be categorized as: ultrasound machine settings, use of the transvaginal probe, type of ultrasound used (TVS, GIS or SIS, 3D, Doppler), definitions and method of measurements and their relevance and required items to be reported.

Number of Delphi rounds and response rates

Two (online) questionnaire rounds and one group meeting were required to meet the objectives of this study. Of the 15 experts that started in round 1, 12 also completed the second round (80%). Nine

experts were able to participate in the face-to-face meeting. Finally all participants (100%)of the first round agreed on the final results.

Consensus course

Based on the results of the literature search and first focus group meeting we identified 40 items to discuss resulting in 79 questions. During the rounds two items were added. Finally we achieved consensus on all 42 items (see Figure 2). Table 2 presents the mean consensus achieved per item in each round of the Delphi procedure.

Consented recommendations and statements

Definitions and relevance

Most experts (83%) agreed that a niche is defined as an indentation at the site of the caesarean scar with a depth of at least 2 mm. A niche can be subdivided according to the following classification: 1. Simple niche; 2. Simple niche with one branch; 3. Complex niche (with more than one branch).

A branch is agreed to be a thinner part of the main niche, directed towards the serosa, which has a smaller width than the main niche (86% agreement), and should always be registered and reported. The main niche is illustrated as the green and red area in Figure 3; the blue area illustrates a branch.

The vesico-vaginal fold (VV-fold) is the appearance of a triangular shaped fold between the bladder, the vagina and the cervix, created by placing the transvaginal probe in the anterior vaginal fornix (see Figure 3). The distances between the niche and the VV fold, and the niche and the external os were considered to provide additional value for planning future surgical strategies and for research but not for basic niche evaluation (75-92% agreement). Measurement of the adjacent myometrium was agreed to be relevant in clinical practice (92% agreement) . The internal os was defined as a slight narrowing in the lower uterine segment (LUS), between the uterine corpus and the cervix at the lower boundary of the urinary bladder (73% agreement), however it was considered to be irrelevant (75% agreement).[13]

Method of measurements

The best method to obtain the correct sagittal and transverse planes for niche measurement is described in Table 3. Measurements of the niche include: length, depth, RMT, width, AMT, distance between the niche and the VV fold, and distance between the niche and the external os. It was agreed that the length, depth and residual myometrial thickness (RMT) should be measured in the sagittal plane (100% agreement). The transverse plane was considered only relevant for the measurement of the width of a niche and to identify branches; it was not recommended to repeat depth and RMT measurements in this plane (100% agreement). The length, depth and width of the niche should be measured in the plane where it is the largest (92% agreement); RMT should be measured in the plane where the main niche has the smallest RMT (83% agreement). For simple niches this will be in the same plane, but for complex niches the plane to measure the depth of the main niche may be different from the plane with the thinnest RMT of the main niche or the thinnest RMT of the branch.

Figure 4 illustrates how to measure the various items, what should be measured and how the calipers should be positioned. According to all experts, there should be two different measurements performed if the length or the width of the main niche is wider higher up the niche base; both measurements at the base of the niche as well as the largest distance should be reported (see length Figure 4.1.1 and width Figure 4.2.1). If visible, branches should be measured and reported. In that situation, the depth of the niche and the RMT of the main niche and including a branch should be measured separately (see depth Figure 4.1.2 and RMT Figure 4.1.3). All experts agreed that documenting features of the endometrium was not relevant to niche measurement, thus the calipers should be placed at the border of the myometrium (see example, Figure 4.1.1).

Tips for the visualization of niches

During the Delphi procedure tips and tricks to improve visualization of the niche were proposed by individual experts and were added to the questions over the course of the process. It is important to have good visualization of the lower uterine segment (80% agreement). One of the tips from the experts was, that one should realize that transvaginal sonography is a dynamic process, in which variation of the position of the probe (anterior or posterior fornix) and using pressure with the probe can affect visualization of the niche (positively or negatively). Visualization of a niche that is located more proximal in the uterus in general requires more pressure, while for a good visualization of more distally located niches or for the visualization of the VV fold, less pressure is needed. Bladder filling is not obligatory for the visualisation of the VV fold. Doppler ultrasound was felt to be useful to differentiate between a niche and other uterine abnormalities (e.g. hematomas, myomas or adenomyosis), but was not considered mandatory for niche measurement.

Most (75%) experts agreed that niche evaluation with GIS or SIS is of additional value compared to standard 2D ultrasonography, but no preference was expressed for GIS or SIS. The expert panel also concluded that there is no preference for the type of catheter to be used for contrast sonography, apart from one catheter that was considered unsuitable (GIS catheter) since it impairs visualization of the niche because of its thicker intracervical component. It was also considered that if fluid is present in the uterine cavity there is no need for additional gel or saline instillation (100% agreement). Since intra-uterine fluid is most frequently seen during the mid-follicular phase, possibly under influence of higher estradiol levels[24], niche evaluation between cycle day 7 and 14 may prevent the need for an additional infusion of gel or saline. In addition, it allows the evaluation of the existence of intra-uterine fluid during this phase that may be relevant in women who want to conceive, since this may affect implantation.[25, 26]

Discussion

Main findings

The modified Delphi procedure as used in this study, including two questionnaire rounds and one group meeting, resulted in consensus amongst experts for all items concerning definition and evaluation of a uterine niche with ultrasonography. Based on the consensus findings, we formulated a definition for a niche and produced guidance on the measurements, as simple and consistent as possible to facilitate use in daily clinical practice. Only basic measurements including the length and depth of a niche, RMT and AMT in the sagittal plane, and width of a niche in the transverse plane were considered to be essential. The existence of branches should be reported and if so additional measurements are recommended. GIS or SIS was preferred over standard transvaginal sonography but is not mandatory if intra-uterine fluid is present. Variation in pressure generated with the transvaginal probe can optimize imaging and Doppler ultrasound can be used to differentiate between a niche and other uterine abnormalities but is not mandatory.

The current consensus focused on the basic module, additional items that may be relevant for pre-surgical assessment or research purposes were not included.

Comparison with other studies

Although the number of published niche-studies has increased over the last few years, a uniform, internationally recognized definition and guideline for niche evaluation does not yet exist. Naji et al. proposed a standardized method how to identify a niche with ultrasonography based on a literature search.[13] They suggested to classify the appearance of the niche based on its clinical value (mild, moderate or severe scar defect) and to perform measurements in three dimensions (length, width, depth and RMT). The measurements are not further defined or specified for different niche shapes, in case of a branch or fibrotic tissue at the site of the uterine scar. Tower et al. proposed a classification of niches based on RMT and the ratio RMT/AMT as the only ultrasonographic features.[5]

Our literature search confirmed the lack of detailed guidelines for niche measurement. In most previous niche-studies measurements were not clearly described neither were motivations given for type of measurements that were used. Given the lack of studies evaluating the accuracy and validity of various measurements we decided to use the structured consensus method to define the current guidelines. The usefulness and accuracy of our recommendations need to be confirmed in future studies.

Strengths and limitations

The use of a modified Delphi method allows experts to maintain anonymity during the questionnaire rounds, which prevents domination by any individual, and to revise their opinion during the next round. Furthermore, we composed a focus group prior to the start of the Delphi procedure in order to optimize validity of the questionnaire to be used in the first round. The items selected by the focus group were additionally confirmed by the expert panel. An additional strength is that members of the expert panel were gynecologists from all over Europe with possibly different viewpoints due to different education and experience.

This study also includes some limitations. The response rate in the second round decreased to 80% and only 9 experts (60%) were present during the group meeting. The response rate of the final round was 100%. All items for which consensus was achieved on three rounds were finally approved by all experts of the first round. In this study consensus was achieved on the content of the items concerning niche measurements. Validity of the construction and accuracy of the used item list should be determined in future studies.

Future perspectives

The recommendations on basic niche evaluation are meant to be a practical guideline for gynecologists, ultrasound examiners and researchers aiming to standardize niche measurements and facilitate future research. In order to facilitate its use we designed an e-learning module including the

agreed recommendations. The value of this e-learning program is under evaluation (the eNiche study) and its results will be published later. During our Delphi procedure we identified several knowledge gaps concerning niche measurement that require future research, such as the optimal cut-off level for the depth of a niche to be used in the definition of a (large) niche; the cut-off value of RMT and the ratio of RMT/AMT or depth/RMT to define its clinical relevance; and the relevance of certain measurements including a branch, the distance between niche and external os and two measurements of width and length if the niche base is smaller than higher up. The relevance of these parameters in terms of related symptoms, subfertility or problems during fertility treatment, prediction of obstetric complications in subsequent pregnancies or prediction of treatment risks and success need to be elucidated. To determine the optimal timing for niche measurement after a CS future studies are needed as data is limited. Currently one ongoing trial with this aim has been registered in the trial register (NTR6921). One previous study reported a change in niche measurements using SIS between 6-12 weeks and 12 months follow-up.[27] Based on the expected duration of scar healing process and until future data becomes available, we advise to evaluate a niche at 3 months or later after a cesarean section. This is in line with a large ongoing study (2CLOSE study; NTR5480) in which niches are measured at 3 months follow-up after double or single layer closure of the uterine caesarean scar in 2290 patients. Also, the best timing for niche measurement during a menstrual cycle needs to be elucidated. For pragmatic reasons one could consider to measure the niche in the mid-follicular phase since this allows the evaluation of intrauterine fluid that might be relevant for eventual future fertility. Additionally, it may reduce the need for saline or gel insertion in the presence of intra-uterine fluid.

Conclusion

We have developed and described a uniform definition and guideline for evaluating a uterine niche in non-pregnant women. Consensus was achieved using a modified Delphi method amongst international experts for all 42 items regarded as relevant for ultrasonographic niche evaluation. The

relationship between the morphological characteristics and measurements of a niche with clinical outcomes is yet to be described.

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Conflict of interest

Judith A.F. Huirne, Inge P.M. Jordans and Sanne I. Stegwee declare to have potential conflict of interest due to their involvement in the Dutch 2Close study; “The cost effectiveness of double layer closure of the caesarean (uterine) scar in the prevention of gynecological symptoms in relation to niche development”. This is a randomized controlled trial funded by ZonMw, an organization for health research and development in the Netherlands. Judith Huirne is project leader of the study; Inge Jordans and Sanne Stegwee are executive researchers.

All other authors have no conflict of interest.

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Figure Legends

Figure 1. Study design

The stepwise modified Delphi consensus method used in this study to reach a consensus on niche definition and evaluation.

Figure 2. Flow diagram of agreement with or rejection of various items during the Delphi procedure

Items were accepted if an agreement of at least 70% was reached on the same answer.

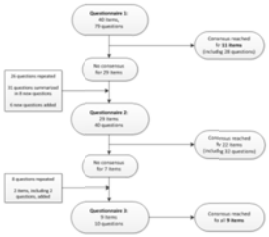


Figure 3. Main niche and VV fold

Figure 3A: The red and green area represent the main niche. The blue area illustrates a branch. Figure 3B: The green marked line is called the plica vesico-uterina or uterovesical fold (UV fold). The red marked line is called the vesico-vaginal fold (VV fold).

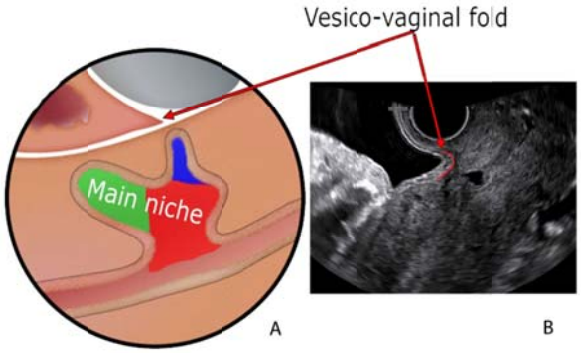


Figure 4. Position of calipers in niche measurement

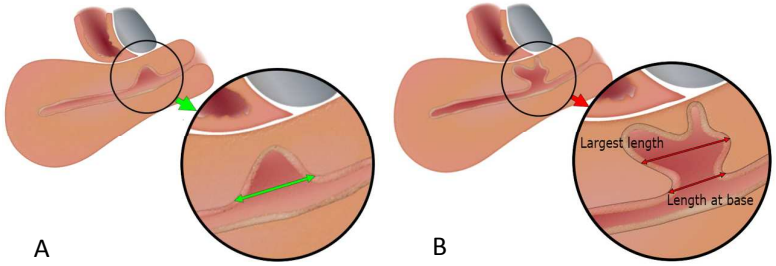
These images illustrate the position of the calipers for the different measurements of a niche.

Figure 4 Position of calipers in niche measurement

These images illustrate the position of the calipers for the different measurements of a niche.

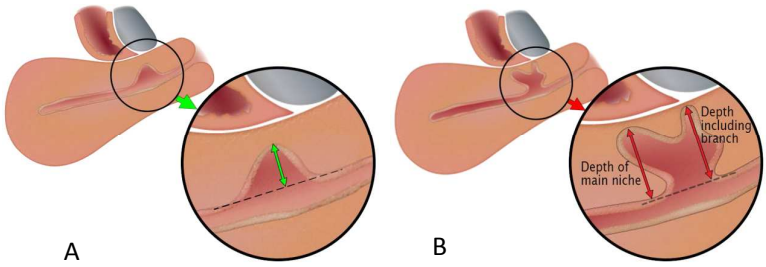
Figure 4.1 Sagittal plane

4.1.1 Length



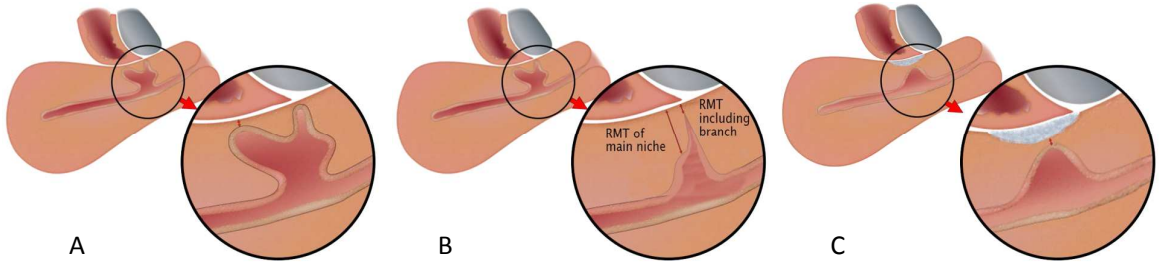
- Length is measured in the sagittal plane
- Length should be measured at its biggest
- Both the longest length as the length at niche base should be measured

4.1.2 Depth



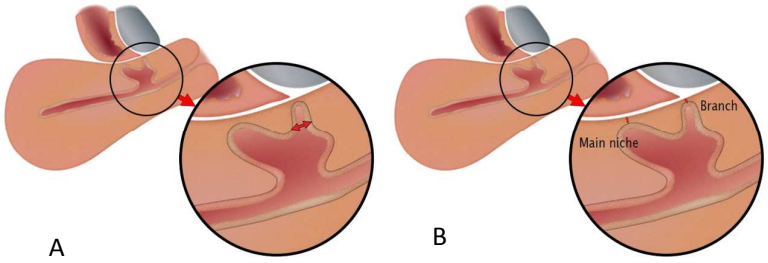
- Depth should be measured at its biggest
- Both depth of the main niche as well as depth of the branch should be measured and registered

4.1.3 RMT (residual myometrium thickness)



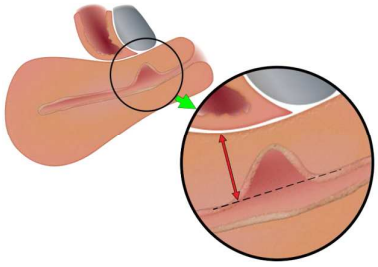
- The RMT of the main niche should be measured in the sagittal plane where the main niche has the smallest RMT
- The residual myometrial thickness should be measured at its thinnest, no matter what the direction (perpendicular to the serosa but not necessarily perpendicular to the uterine cavity)
- Both the thinnest RMT of the main niche as well as thinnest RMT including the branch should be measured and registered
- Fibrosis is not included in RMT measurement

4.1.4 Branch



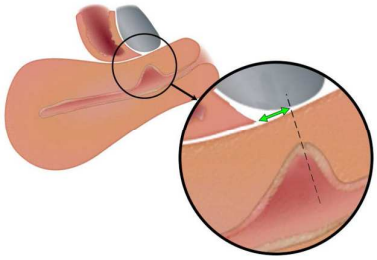
- The width of a branch should be measured and registered (in mm)
- The RMT of a branch should be measured in the sagittal plane where the main niche has the smallest RMT

4.1.5 AMT (adjacent myometrium thickness)



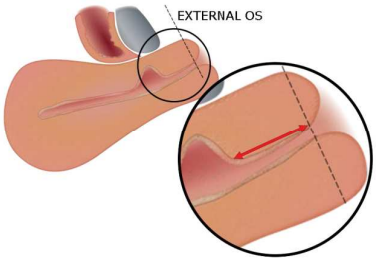
- Adjacent myometrium should be measured as close to the myometrium, where the myometrium is at its thickest

4.1.6 Distance niche – VV fold



- The distance between niche and VV fold should be measured on top of the main niche (where the RMT is the thinnest) to the VV fold

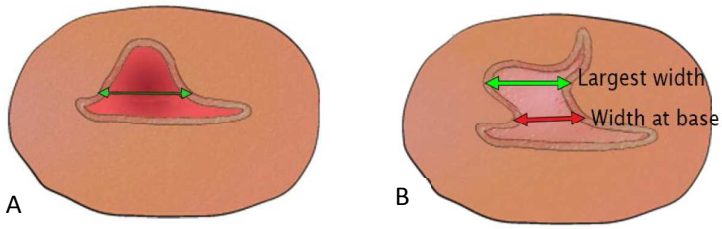
4.1.7 Distance niche – external os



- The distance between niche and external os should be measured parallel to the top of the main niche; from the most distal niche point to external os

Figure 4.2 Transverse plane

4.2.1 Width



- Width is measured in the transverse plane
- Width should be measured at its biggest
- Both the longest width as the width at niche base should be measured

Table 1. Results of literature search

Subject	Publication	Study type	Results
Best timing after CS to measure a niche	None		
Best method (TVU or GIS/SIS) to use for measurement	Allison 2010(19)	Overview of literature	SIS is a useful adjunct to TVU, especially for evaluation of the endometrium and adjacent lesions.
	Baranov 2016(10)	Cohort study	Scar defects in 46,4% seen by both observers by TVU. Scar defects in 69,1% seen by both observers by SIS.
	Vikhareva Osser 2009(20)	Cohort study	53 scar defects seen on SIS; 42 scar defects seen on TVS
	Tower 2013(5)	Overview of literature	SIS has a higher sensitivity and specificity for detection of CS scars than TVU. Recommendation based on literature: if a caesarean section defect is suspected, evaluation using SIS is recommended unless this is unacceptable or contraindicated in the patient. In that case TVU can be used.
	bij de Vaate 2011(3)	Observational prospective cohort study	Prevalence of niche on TVU was 24%, prevalence of niche on GIS was 56%
	van der Voet 2014(4)	Prospective cohort study	Prevalence of niche on TVU was 49,6%, prevalence of niche on GIS was 64,5%
Best method (3D or 2D TVU) to use for measurement	BijdeVaate 2015(28)	Prospective cohort study	3D is a reproducible tool for niche measurement (size and RMT) in the sagittal plane
	Giral 2015(29)	Retrospective study	Prevalence of niche on 3D was 50%, prevalence of niche on 2D SIS was 86%.
Niche measurements	Naji 2012(13)	Overview of literature	Length, width, depth of the niche in both sagittal and transverse plane and RMT, illustration is shown in their paper.
	Tower 2013(5)	Overview of literature	RMT is measured from the apex of the defect to the outer edge of the myometrium.
Best timing in the menstrual cycle to measure a niche	Fabres 2003(21)	Retrospective review	The best time during the cycle to identify the CS defect with sonography was during the bleeding episode, usually a few days after the menses.
Relevance of pressure with the transvaginal probe	None		
Relevance of Doppler ultrasound	None		
Relevance of measurement between VV fold and internal os	None		

Table 2. Course of consensus for niche measurement - presented per item

Category	Item	No. of questions	Round 1 consensus (%)	Round 2 consensus (%)	Round 3 consensus (%)
Definitions	Niche*	2	53	67-83	c
	Main niche	1	60	100	c
	Branch	2	86	c	c
	Utero-vesical fold (UV fold)	1	100	c	c
	Vesico-vaginal fold (VV fold)	1	86	c	c
	Internal os	1	73	c	c
	Distance internal os - niche	2	73-73	c	c
	Length and width of a niche†	2	53	67-92	100
	Niche classification	1	53	92	c
Method of measurements	In- or exclusion of endometrium‡	6	53-100	100	c
	Length and width of a niche; two measurements	4	47-60	67	100
	Depth of a niche	2	53-60	92-100	c
	Residual myometrium thickness (RMT)‡	3	60-93	83-92	c
	RMT and fibrotic tissue	2	87-93	c	c
	Depth and RMT; measurement of main niche and branch	1	73	c	c
	Measurement of a branch	1	40	100	c
	Anterior myometrium	1	67	100	c
	1. Distance VV fold - niche 2. Distance internal os - niche 3. Distance external os - niche‡	10	40-80	50-58	100

Relevance	Niche measurement in midsagittal plane[§]	2	53-67	100	c
	Correct plane for length and depth[§]	2	53-67	92	c
	Correct plane for width[¶]	1			100
	Correct plane for RMT[□]	2	53-80	75	100
	Correct plane for RMT including a branch	1	73	c	c
	Additional value of transverse plane for niche measurement (length, width, branches)	3	72-90	c	c
	Depth and RMT in transverse plane[§]	2	60-64	67	100
	Additional value of anterior myometrium	1	60	92	c
	Additional value of distance VV fold - niche	1	60	92	c
	Additional value of distance external os - niche	1	53	75	c
	Additional value of distance internal os - niche	2	60	75-75	c
	Relevance of branches	3	67-80	c	c
General ultrasound methods to be used	Achieving the correct sagittal plane for niche measurement	1	67	92	c
	Achieving the correct transverse plane for niche measurement	1	67	92	c
	Magnification for niche measurement	6	60-100	c	c
	Position of the transvaginal probe	1	53	83	c
Value of additional tools	Pressure with transvaginal probe	1	60	83	c
	Doppler ultrasound[‡]	4	60-80	92	c

GIS/SIS	Additional value GIS/SIS	1	40	75	c
	Superior method; GIS or SIS*	2	40	42-92	100
	Catheter preference for GIS/SIS*	3	27-27	33-92	c
	Catheter location	1	47	92	c
	Remove/ leave catheter during GIS/SIS◊	2	47	42-92	100
	Intra-uterine fluid accumulation¶	1			100

This table presents the mean consensus per item in niche measurement per Delphi round. When consensus was reached (green marking), the item was excluded from the next Delphi round. In the table this is presented as 'c' (consensus achieved).

** One question about this item was added in round 2; † In round 2 consensus was reached for an added question, but not yet for the definition of this item; ‡ Consensus was reached for part of the clustered questions in round 1; it was decided to repeat the item in round 2; § The two questions about this item in round 1 were summarized in one question in round 2; ¶ This item was added in round 3; □ The answers on the two questions about this item in round 1 were contradictory, as well as the answer of the summarized question in the second round compared with answers in the first round; although consensus was achieved in both rounds, it was decide to repeat the item in round 3; ◊ One question about this item was added in round 2. In round 2 consensus was not reached for both questions; it was decided to repeat the item in round 3.*

Table 3. Agreed statements according to method of niche measurements

Methods of measurements
Endometrium is to be ignored; niche measurements are only based on the myometrium
The correct sagittal plane to perform niche measurement depends on the measurement itself in case of complex niches with branches (length, depth or RMT)
Transverse plane is only used for the third dimension of the niche (width), not for depth and RMT
General ultrasound methods to be used
The best method to obtain the correct sagittal plane for niche measurement is by starting in midsagittal plane with good visualization of the cervical canal, then by moving the transvaginal probe to both lateral sides to determine the correct plane
In transverse plane the best method to visualize the niche is by using the sagittal plane; by keeping a good visualization of the niche while rotating the transvaginal probe from the sagittal to the transverse plane
In transverse plane the best method to detect possible branches is by screening the entire LUS in transverse plane from cervix to corpus
To measure a niche there should be good visualization of the lower uterus segment only; this applies to all positions of the uterus (anteversion, retroversion or stretched)
The position of the transvaginal probe (in the anterior or posterior fornix) affects the correct plane for niche measurement
Value of additional tools
It is useful to vary pressure with the transvaginal probe in order to achieve the best plane for niche measurement
The use of Doppler ultrasound is not mandatory in standard niche measurement, but can be useful to differentiate between hematomas, adenomyomas, adenomyosis, fibrotic tissue etc.
GIS/SIS
GIS/SIS have added value in patients with a niche
There is no preference for either GIS or SIS
There is no preference for the catheter used in GIS/SIS
The best location of the catheter used in GIS/SIS is just in front of the niche or if possible cranial of the niche by the start, then pulling the catheter slowly backwards until the base of the niche
While performing the ultrasound in SIS, the catheter can be left in front of the niche
While performing the ultrasound in GIS, there is no preference whether to remove the catheter or to leave it in front of the niche
In case of intra-uterine fluid accumulation, GIS or SIS are not of additional value

This table presents the results of all agreed statements after 3 Delphi rounds.