

SONOGRAPHIC ASSESSMENT OF ENDOMETRIAL THICKNESS AND UTERUS SIZE IN INFERTILE WOMEN

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Abstract

Ultrasonography is widely used during female infertility evaluation because it enables non-invasive assessment of the endometrium, uterine morphology, uterine orientation, and associated pelvic abnormalities. To evaluate uterus size and endometrial thickness in infertile women using ultrasonography and to describe associations with age and menstrual-cycle phase. A cross-sectional study was conducted over six months among 178 infertile female patients at DHQ Teaching Hospital Swabi and Iqra Memorial Diagnostic Center, Attock. Convenience sampling was used. Grayscale transabdominal ultrasonography was performed using a Mindray system with a 3.5-MHz probe in longitudinal and transverse planes. Endometrial thickness, uterus size, uterus position, menstrual-cycle phase, and the presence of uterine pathologies were recorded. Data were analyzed in SPSS using descriptive statistics and chi-square tests. Among 178 participants, 92 (51.7%) were aged 26-35 years, 62 (34.8%) were aged 15-25 years, and 24 (13.5%) were above 35 years. Most had been married for 1-10 years (71.3%). Endometrial thickness ranged from 4 to 14 mm in the thesis tables; the highest single reported frequency was 29 participants at a reported 7-mm category. The most frequent uterine-size category was 7x4 cm (14.6%). The uterus was anteverted in 92.1%. No uterine pathology was recorded in 39.9%; PCOs were reported in 30.9%, fibroids in 9.0%, and nabothian cysts in 6.7%. The thesis reported significant associations of uterus size with age and menstrual cycle ($p=0.000$ for both), uterine pathologies with age ($p=0.007$) and menstrual cycle ($p=0.000$), and endometrial thickness with age and menstrual cycle ($p=0.000$ for both). Ultrasound was useful for characterizing endometrial thickness, uterine dimensions, uterine position, and associated pelvic findings in women undergoing infertility evaluation. The findings should be interpreted as descriptive associations because the study was cross-sectional, used convenience sampling, and did not include a fertile comparison group or an independent diagnostic reference standard.

1. Introduction

Infertility is a significant reproductive-health disorder where one is unable to conceive after a reasonable duration of unprotected intercourse. International Glossary on Infertility and Fertility Care standardized terminology of modern clinical and research practice whereby infertility

is not a diagnosis but is impairment of reproductive capacity [1]. Female infertility is multi-factorial and it can be ovulatory dysfunction, ovarian conditions, tubal disease, endometriosis, ovarian abnormalities, endometrial dysfunction, endocrine disturbances and combinations of these factors.

The central area of implantation is the endometrium which is then dynamically remodeled during the menstrual cycle. The overall sonographic endometrial thickness varies significantly between menstrual, follicular or proliferative, ovulation and luteal or secretory phases. De Geyter et al. in a prospective cohort of 1,186 infertile women showed that sonographic endometrial appearance has tight relationships with hormonal and cycle status, and supports the interpretation of thickness in terms of clinical and menstrual context [2]. Since the concept of endometrial receptivity cannot be decreased into one morphologic measure, the concept of thickness can be viewed as one component of an expanded fertility test.

Some of the original studies have assessed the relationship between the endometrial thickness and reproductive outcome. According to Kovacs et al., there were increasing levels of pregnancy rates with rising endometrial thickness during IVF/ICSI cycles, but the thickness did not guarantee specific outcome rates within an individual [3]. In 1,294 blastocyst-transfer cycles, Richter et al. also found that clinical pregnancy and persistent pregnancy or live-birth rates also increased with increasing endometrial thickness, with an adjustment of age and embryo quality [4]. Zhang et al. determined that there was better response to treatment as endometrial thickness increased in select IVF patients [5], and Weissman et al. also noticed decreased implantation and pregnancy rates in their group who had a significantly higher thickness of the endometriosi s [6]. Subsequent large datasets have not only solidified the idea that very thin endometrium is typically connected to worse assisted-reproduction outcomes but also that the concept is not a simple universal threshold [7,8]. Ultrasound is also significant in the measurement of uterine size, position, myometrium, endometrial cavity, ovaries and adnexa. Transvaginal ultrasonography gives superior images of the uterus when compared to regular transabdominal imaging and original diagnostic investigations have compared sonography to hysteroscopy and saline-infusion sonohysterography in identifying intrauterine lesions [9-13]. Loverro et al. contrasted the transvaginal sonography and the hysteroscopy of infertile women [9]. Alatas et al. proved sonohysterography beneficial in diagnosing

intrauterine abnormalities in infertility [10], whereas Grimbizis et al. detected saline-infusion sonohysterography particularly useful in intracavitary masses [11]. Niknejadi et al. documented clinically useful diagnostic performance of transvaginal sonography compared to hysteroscopy [12], and Apirakviriya et al. demonstrated that three-dimensional transvaginal ultrasound had good diagnostic performance based on identifying abnormalities in the uterine cavity [13].

The other common sonographic observation in infertility services is the presence of polycystic ovarian morphology. Haque et al. also elucidated the clinical, biochemical, and ultrasonographic features of infertile women with polycystic ovarian syndrome in a Pakistani population providing importance to the combination of the imaging with clinical and biochemical phenotype [14]. As usual practice, ultrasound could thus give a wide form of first-line image of uterine, endometrial and ovarian morphology and further procedures are chosen according to the question of the clinical concern.

Information on the joint distribution of endometrial thickness, uterine size, uterine position, menstrual-cycle phase, and uterine or adnexal abnormalities in infertile women are still lacking in most local areas. The current research was implemented to assess uterus size and endometrial thickness among infertile women with ultrasound and investigate the connection between these factors and age and phase of the menstrual cycle.

2. Materials and Methods

2.1 Study design and setting

The study was cross-sectional, and the sample was DHQ Teaching Hospital swabi and Iqra Memorial Diagnostic center, Attock. The number of months used was six months. The study involved the sonographic evaluation of endometrial thickness and uterus size among women who presented with infertility.

2.2 Sample size and sampling technique

A case of 178 infertile female cases was put in. The sample size in the thesis was determined based on $Z=1.96$ with 95 percent confidence, an expected proportion (P) of 0.35 and a margin of error (D) of 0.07 that gave a rule of $n=178$. A convenience sampling technique was used.

2.3 Eligibility criteria

The inclusion criteria provided in the thesis were female patients, patients that had been infertile, patients with thick endometrium, and infertile patients with variable sizes of uterus. The exclusion criteria included, male patients, pregnant patients, fertile patients having thick endometrium, fertile patients with unstable uterus size.

2.4 Ultrasound equipment and examination

An ultrasound machine (Mindray) was used. Ultrasonography of the pelvis with a transabdominal probe of 3.5 MHz transducer had been done. Examination of the patients was done in a supine position. The transabdominal longitudinal and transverse planes of the uterus were evaluated on grayscale images. Uterus size and endometrial thickness were measured.

2.5 Data collection

Clinical and demographic data were as described name, age, marital status, years of marriage and menstrual-cycle phase. Following sonographic analysis, the assessed variables included both endometrial thickness, uterus size, uterus position, and even the presence of uterine pathologies. Sonography results terminology in the results section remains that of the original thesis data.

2.6 Statistical analysis

Data analysis was done by SPSS. Descriptive statistics, frequencies, percentages and graphical presentations were used to summarize quantitative and qualitative data. Chi-square tests were used to assess associations in the thesis crosstabulations. The results in the tables also report the p values; these values are thus reported in the results tables instead of being recalculated.

2.7 Ethical considerations

The study complied with rules and regulations of the ethical committee of Department of Diagnostic Medical Sonography, Women University Swabi. All participants had informed written consent. All the information on participants and data gathered was held in confidence, the participants were not identified in the research reporting, and the participants were aware that they could pull out at any time. The records were kept in safe places and passwords were used to safeguard electronic data.

3. Results

A total of 178 infertile women were included in the study and were evaluated using grayscale ultrasonography. All result tables and all seven frequency figures below reproduce the finalized results presented in the thesis.

3.1 Age distribution

The largest age group was 26-35 years (51.7%), followed by 15-25 years (34.8%); 13.5% of participants were above 35 years.

Table 1. Frequency and percentage for age group

Age group (years)	Frequency	Percent
15-25	62	34.8
26-35	92	51.7
Above 35	24	13.5
Total	178	100.0

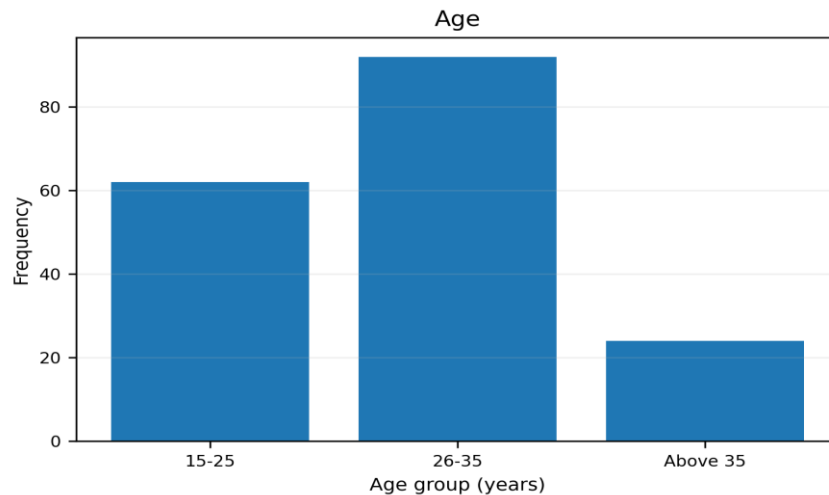


Figure 1. Frequency of age

3.2 Years of marriage

Most participants had been married for 1-10 years (71.3%), while 28.1% had been married for 11-20 years and 0.6% for more than 20 years.

Table 2. Frequency and percentage for years of marriage

Years of marriage	Frequency	Percent
1-10	127	71.3
11-20	50	28.1
Above 20	1	0.6
Total	178	100.0

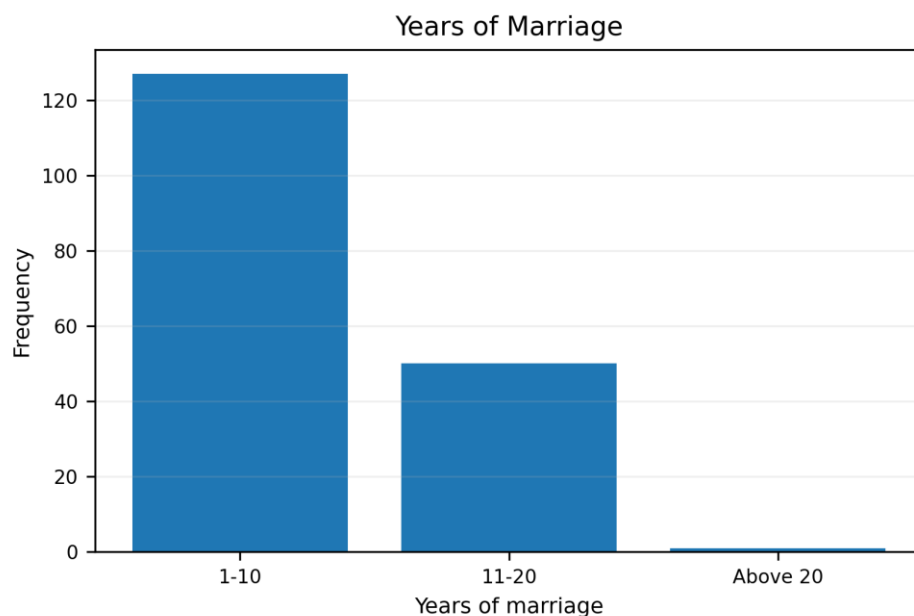


Figure 2. Frequency of years of marriage

3.3 Endometrial thickness

Endometrial thickness entries in the thesis ranged from 4 to 14 mm. The highest single

reported frequency was 29 patients in a 7-mm category, whereas the lowest was one patient in

the 11-mm category. Repeated integer labels are retained exactly as presented in the thesis table.

Table 3. Frequency and percentage for endometrial thickness (mm)

Endometrial thickness (mm)	Frequency	Percent
4	7	3.9
5	14	7.9
5	6	3.4
5	28	15.7
6	8	4.5
6	12	6.7
7	6	3.4
7	29	16.3
8	14	7.9
9	13	7.3
10	7	3.9
10	20	11.2
11	1	0.6
12	5	2.8
13	4	2.2
14	4	2.2
Total	178	100.0

Source-note: Repeated endometrial-thickness labels (5, 6, 7, and 10 mm) are reproduced exactly from the finalized thesis table.

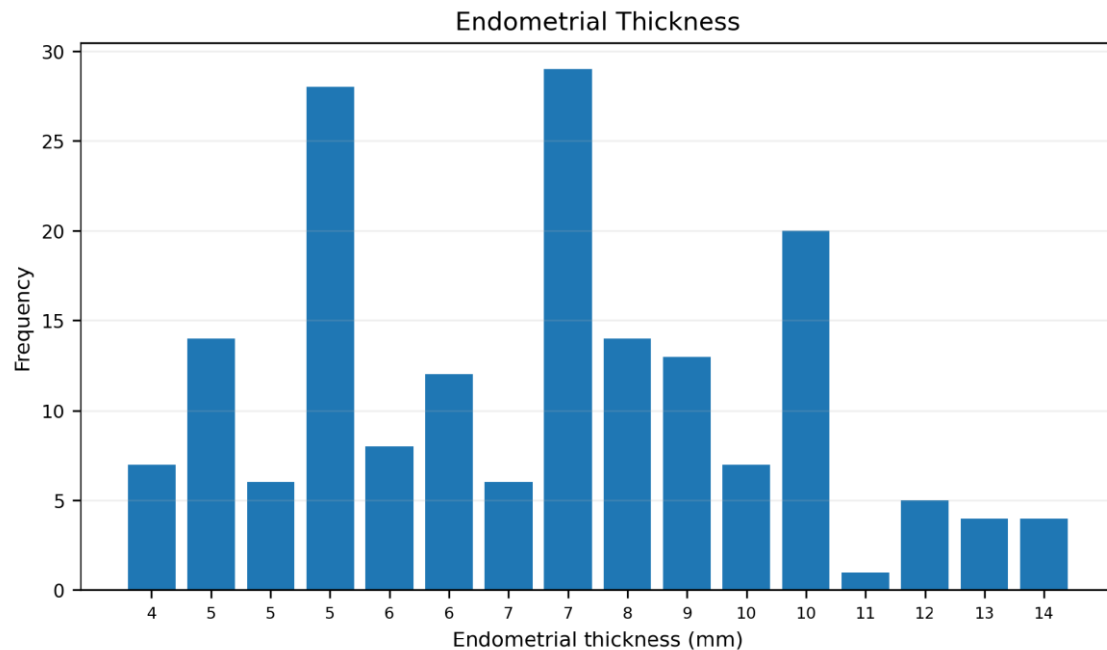


Figure 3. Frequency of endometrial thickness

3.4 Uterus size

The most frequent uterus-size category was 7x4 cm (26 patients; 14.6%). The 5x2, 6x3, and 7x3

cm categories each occurred in 21 patients (11.8%). The least frequent category was 9x6 cm (one patient; 0.6%).

Table 4. Frequency and percentage for uterus size (cm)

Uterus size (cm)	Frequency	Percent
3x4	4	2.2
4x4	6	3.4
5x2	21	11.8
5x3	6	3.4
5x4	6	3.4
5x5	5	2.8
6x1	5	2.8
6x2	9	5.1
6x3	21	11.8
7x2	8	4.5
7x3	21	11.8
7x4	26	14.6
7x5	14	7.9
8x2	5	2.8
8x3	4	2.2
8x4	16	9.0

Uterus size (cm)	Frequency	Percent
9x6	1	0.6
Total	178	100.0

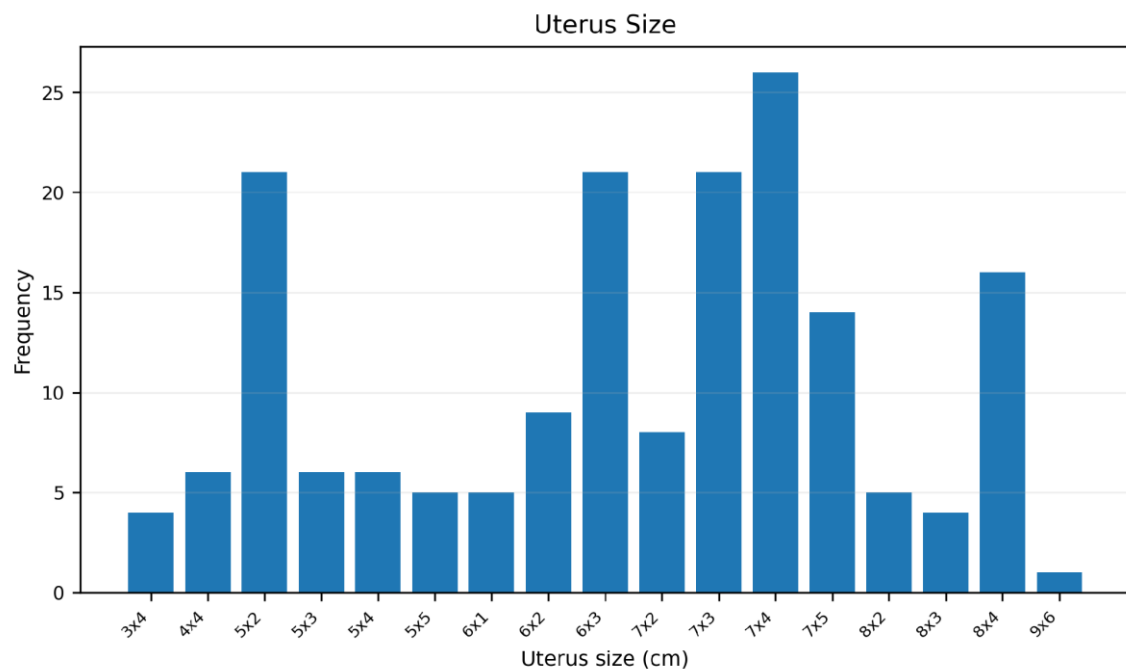


Figure 4. Frequency of uterus size

3.5 Uterine pathologies

No pathology was recorded in 71 participants (39.9%). PCOs were recorded in 55 participants (30.9%), fibroids in 16 (9.0%), nabothian cysts

in 12 (6.7%), complex adnexal cysts in eight (4.5%), and no dominant follicles on both sides in seven (3.9%).

Table 5. Frequency and percentage for uterine pathologies

Uterine pathologies	Frequency	Percent
None	71	39.9
No dominant follicles on both sides	7	3.9
PCOs	55	30.9
Small echogenic lesion	4	2.2
Complex adnexal cyst	8	4.5
Hormonal problem	1	0.6
Simple cyst	4	2.2
Nabothian cyst	12	6.7
Fibroids	16	9.0
Total	178	100.0

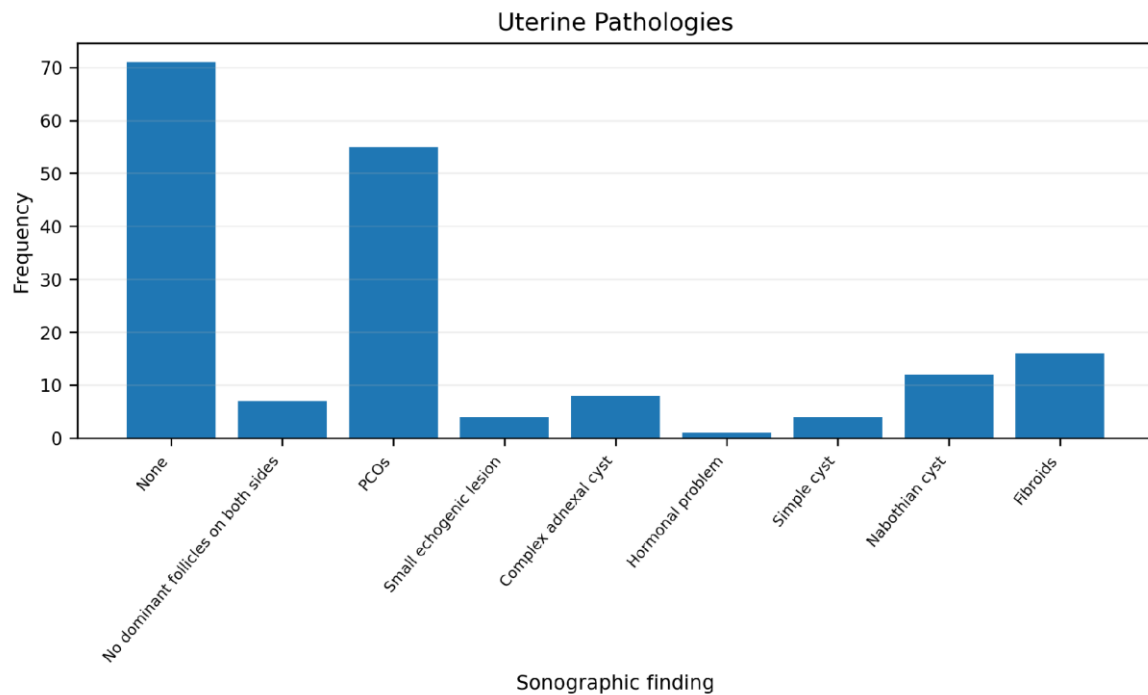


Figure 5. Frequency of uterine pathologies

3.6 Uterus position

An anteverted uterus was recorded in 164 participants (92.1%), while 14 (7.9%) had a retroverted uterus.

Table 6. Frequency and percentage for uterus position

Uterus position	Frequency	Percent
Anteverted	164	92.1
Retroverted	14	7.9
Total	178	100.0

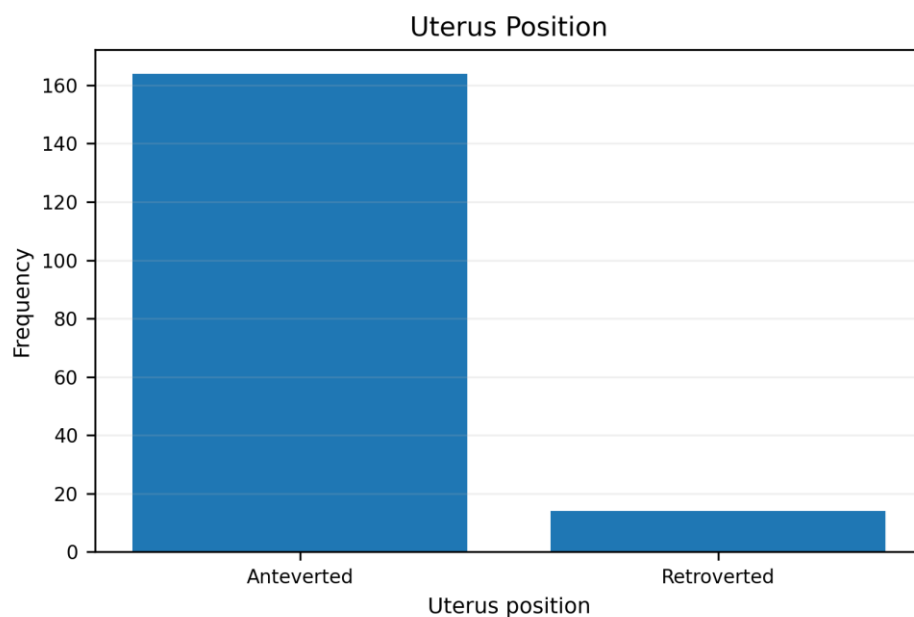


Figure 6. Frequency of uterus position

3.7 Menstrual-cycle phase

The follicular phase was the most frequent menstrual-cycle phase (95; 53.4%), followed by

menstruation (35; 19.7%), luteal phase (34; 19.1%), and ovulation (14; 7.9%).

Table 7. Frequency and percentage for menstrual cycle

Menstrual cycle	Frequency	Percent
Menstruation	35	19.7
Follicular	95	53.4
Ovulation	14	7.9
Luteal	34	19.1
Total	178	100.0

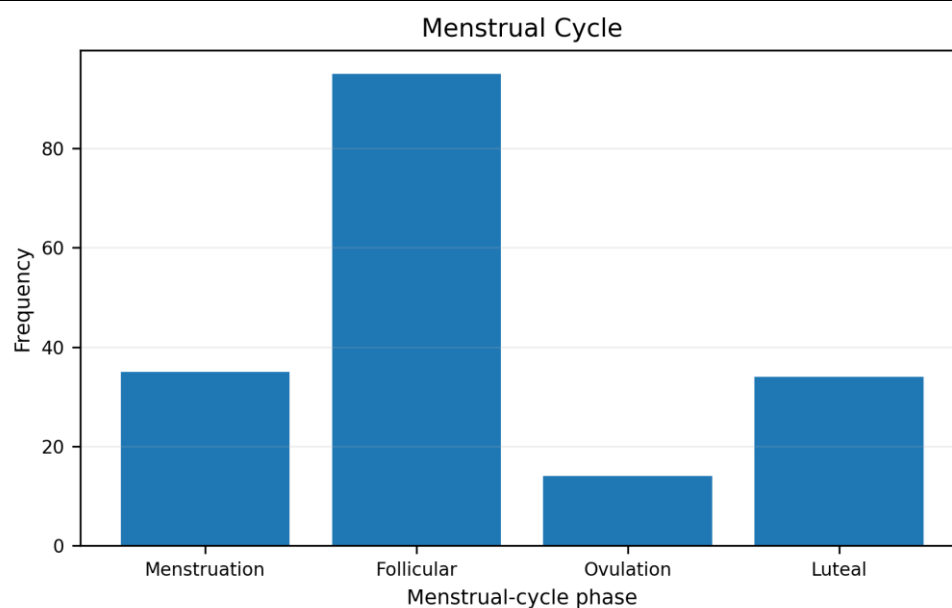


Figure 7. Frequency of menstrual cycle

3.8 Uterus size and age

The thesis reported a statistically highly significant association between uterus-size

category and age group ($p=0.000$). The full crosstabulation is reproduced below.

Table 8. Uterus size (cm) by age crosstabulation

Uterus size (cm)	15-25	26-35	Above 35	Total	P value
3x4	4	0	0	4	0.000
4x4	0	6	0	6	
5x2	6	8	7	21	
5x3	6	0	0	6	
5x4	6	0	0	6	
5x5	5	0	0	5	
6x1	5	0	0	5	
6x2	4	5	0	9	

Uterus size (cm)	15-25	26-35	Above 35	Total	P value
6x3	4	16	1	21	
7x2	0	7	1	8	
7x3	0	14	7	21	
7x4	9	17	0	26	
7x5	8	0	6	14	
8x2	5	0	0	5	
8x3	0	4	0	4	
8x4	0	15	1	16	
9x6	0	0	1	1	
Total	62	92	24	178	

3.9 Uterus size and menstrual cycle

Uterus-size categories also differed across menstrual-cycle phases; the thesis reported $p=0.000$.

Table 9. Uterus size (cm) by menstrual-cycle phase crosstabulation

Uterus size (cm)	Menstruation	Follicular	Ovulation	Luteal	Total	P value
3x4	4	0	0	0	4	0.000
4x4	0	0	0	6	6	
5x2	0	13	8	0	21	
5x3	0	6	0	0	6	
5x4	0	6	0	0	6	
5x5	1	3	1	0	5	
6x1	0	5	0	0	5	
6x2	0	9	0	0	9	
6x3	8	6	0	7	21	
7x2	0	1	0	7	8	
7x3	8	9	0	4	21	
7x4	7	15	0	4	26	
7x5	0	14	0	0	14	
8x2	0	4	0	1	5	
8x3	0	4	0	0	4	
8x4	6	0	5	5	16	
9x6	1	0	0	0	1	
Total	35	95	14	34	178	

3.10 Uterine pathologies and age

The distribution of uterine pathologies differed by age group, with a thesis-reported p value of 0.007.

Table 10. Uterine pathologies by age crosstabulation

Uterine pathologies	15-25	26-35	Above 35	Total	P value
None	26	36	9	71	0.007
No dominant follicles on both sides	0	6	1	7	
PCOs	18	29	8	55	
Small echogenic lesion	0	4	0	4	
Complex adnexal cyst	0	8	0	8	
Hormonal problem	0	1	0	1	
Simple cyst	4	0	0	4	
Nabothian cyst	6	5	1	12	
Fibroids	8	3	5	16	
Total	62	92	24	178	

3.11 Uterine pathologies and menstrual cycle

The uterine-pathology categories also varied across menstrual-cycle phases; the thesis reported p=0.000.

Table 11. Uterine pathologies by menstrual-cycle phase crosstabulation

Uterine pathologies	Menstruation	Follicular	Ovulation	Luteal	Total	P value
None	13	34	10	14	71	0.000
No dominant follicles on both sides	0	4	0	3	7	
PCOs	14	37	0	4	55	
Small echogenic lesion	0	0	0	4	4	
Complex adnexal cyst	6	0	0	2	8	
Hormonal problem	0	0	0	1	1	
Simple cyst	0	4	0	0	4	

Uterine pathologies	Menstruation	Follicular	Ovulation	Luteal	Total	P value
Nabothian cyst	2	6	4	0	12	
Fibroids	0	10	0	6	16	
Total	35	95	14	34	178	

3.12 Endometrial thickness and age

Endometrial-thickness categories differed across age groups, with a thesis-reported p value of 0.000. Repeated integer labels are retained as reported.

Table 12. Endometrial thickness (mm) by age crosstabulation

Endometrial thickness (mm)	15-25	26-35	Above 35	Total	P value
4	0	7	0	7	0.000
5	8	6	0	14	
5	0	0	6	6	
5	16	11	1	28	
6	0	1	7	8	
6	11	0	1	12	
7	6	0	0	6	
7	0	29	0	29	
8	0	14	0	14	
9	4	9	0	13	
10	0	7	0	7	
10	13	0	7	20	
11	0	0	1	1	
12	0	4	1	5	
13	0	4	0	4	
14	4	0	0	4	
Total	62	92	24	178	

3.13 Endometrial thickness and menstrual cycle

The research reported a statistically highly significant association between endometrial-thickness category and menstrual-cycle phase ($p=0.000$).

Table 13. Endometrial thickness (mm) by menstrual-cycle phase crosstabulation

Endometrial thickness (mm)	Menstruation	Follicular	Ovulation	Luteal	Total	P value
4	7	0	0	0	7	0.000

Endometrial thickness (mm)	Menstruation	Follicular	Ovulation	Luteal	Total	P value
5	6	8	0	0	14	
5	0	6	0	0	6	
5	13	10	1	4	28	
6	0	8	0	0	8	
6	1	11	0	0	12	
7	0	6	0	0	6	
7	8	6	0	15	29	
8	0	6	8	0	14	
9	0	9	0	4	13	
10	0	0	0	7	7	
10	0	16	0	4	20	
11	0	1	0	0	1	
12	0	0	5	0	5	
13	0	4	0	0	4	
14	0	4	0	0	4	
Total	35	95	14	34	178	

4. Discussion

The current randomized controlled trial compared the endometrial thickness, uterine size and position, menstrual-cycle phase, and reported the presence of uterine pathology, in 178 infertile females undergoing grayscale transabdominal ultrasonography. The age group most represented was that of 26-35 years, most of the participants were married 1-10 years and over half were studied during the follicular phase. In the thesis tables entries of endometrial-thickness ranged 4-14 mm with the most frequent category of uterine-size in 7x4 cm. In 92.1 percent of the participants, an anteverted uterus was reported. The PCOs (30.9%) was the most prevalent of the abnormal types followed by fibroids (9.0%) and those containing nabothian cysts (6.7%).

A high correlation indicated between the endometrial-thickness category and menstrual-cycle phase is consistent with the cyclic nature of the endometrium which is well known. The regulation of endometrial morphology is controlled by the ovarian steroid hormones and varies between the proliferative and secretory

phase. Prospectively, De Geyter et al. observed a significant difference in sonographic characteristics of the endometrium between infertile women under various conditions of hormones and treatment protocol [2]. The biological divergence plays a significant role in explaining the recurring endometrial-thickness groups in the current cross-sectional data since thickness during various periods of the menstrual cycle does not imply a similar physiological condition.

The original studies on the topic have examined the predictive value of endometrial thickness to reproductive success, especially assisted reproduction. Kovacs et al. found increased pregnancy rates as the endometrial thickness increased, but dismissed that endometrial thickness in and of itself was what resulted either in a pregnancy or a pregnancy maintained [3]. Similarly Richter et al. discovered that, in cycles of blastocyst-transfer, pregnancy and continuing pregnancy or live birth ratios rose together with the endometrial thickness [4]. Among the selected patients who used IVE, Zhang et al.

found better results with increasing thickness [5]. On the contrary, Weissman et al. report worse results of those women who had significantly enlarged endometrial thickness [6]. These seemingly incompatible results can help to portray that endometrial thickness cannot be regarded as a standardised independent metric of receptivity.

Massive modern data has provided an additional touch. In an analysis of 25,767 fresh embryo transfers, Gallos et al. discovered that very thin endometrium correlated with low live-birth rates and high rates of pregnancy loss and live-birth rates tended to rise with thicker endometrial lining types [7]. Mahutte et al., who studied some 96,000 autologous embryo transfers, observed an increase of live-birth rates to about 10-12 mm in fresh transfer cycles, followed by a leveling off [8]. These studies are different in essence compared with the current cohort of infertility on a descriptive basis since these studies measured the effects of treatment once the embryo was transferred. However they have advised the interpretation that individual endometrial-thickness with clinical context, phase of the cycle, exposure to therapy and reproduction outcome should be regarded collectively.

In this cohort, the size of the uterus was found to make significant differences with age and in a significant correlation with the menstrual-cycle period in the thesis analysis. Age, parity, hormone status, fibroids, adenomyosis, congenital variation and method of measuring can affect the size of the uterus. Due to the lack of the inclusion of parity, of BMI, body size, and detailed reproductive history in the reported crosstabulations, the identified age association cannot be regarded as an independent causal effect. The cross-sectional design also does not allow establishing whether any of the categories of uterine size was a contributor to infertility.

A wide spectrum of sonographic abnormalities was also recorded in the study. The most common type of abuse was PCOs. This is also a clinically plausible cause since ovulatory dysfunction and polycystic ovarian syndrome are typical causes of female infertility. Haque et al. reported clinical, biochemical, and ultrasonographic appearance of infertile women with PCOS in Karachi and noted that sonographic morphology with clinical and biochemical evaluation are important [14]. In

the current thesis, this category was entered as PCOs; hence, the term is maintained in the manuscript instead of thinking that all the sonographic entries meet all the diagnostic criteria of PCOS.

The fibroid was noted in 9.0% of the participants. Fibroids can influence fertility in relation to their number, size and proximity to the endometrial cavity especially in cases where they deform the cavity. Most fibroids can be detected with regular transabdominal ultrasound, although transvaginal ultrasound, saline-infusion sonohysterography, three-dimensional ultrasound, or hysteroscopy may be needed to thoroughly evaluate the cavity. Loverro et al. compared the results of transvaginal ultrasound with hysteroscopy in infertile women and revealed the usefulness of sonography in the assessment of the uterine-cavity [9]. Alatas et al. and Grimbizis et al. demonstrated that sonohysterography was helpful in cases of intrauterine abnormalities among infertile women [10] and saline-infusion sonohysterography could be complimentary in the case of intracavitary masses [11].

The literature available on diagnosing also highlights the fact that performance varies with the imaging technique. In a study, Niknejadi et al. were able to compare the accuracy of transvaginal sonography with hysteroscopy in infertile patients and published clinically advantageous diagnostic indicators of uterine defects [12]. The authors of the study led by Apirakviriyaya have indicated a high level of diagnosis through the use of the third-dimensional transvaginal ultrasound in identifying abnormalities in the uterine-cavity [13]. Unlike transvaginal or three-dimensional imaging, a 3.5-MHz transabdominal grayscale probe was used in the present study. Its findings are thus to be finalized as the first-line descriptive sonographic findings as opposed to the exhibition of diagnostic equivalentness of more rigorous or reference-standard methods.

There are a number of strengths. The analysis involved 178 women in two clinical locations and at the same time outlined various sonographic and demographic parameters that are pertinent to the infertility assessment. It even reported the complete frequency distributions and cross-tabulations such that the reader could observe the intersection between age and the

categories of menstrual-cycles and the factor of uterine size, endometrial thickness, and documented pathologies. Such local data could be used to formulate hypotheses and inform the development of more rigorous comparative imaging studies.

Critical constraints cannot be ignored. Sampling can be biased by convenience, and carries a weak external validity. Only infertile women were involved in the study and thus, cannot establish whether the observed measurements are any different to fertile women. There was no independent standard used to determine the diagnosis like hysteroscopy, MRI, and laparoscopy and thus diagnostic sensitivity and specificity cannot be obtained. Transabdominal ultrasonography might not be quite as sensitive as transvaginal ultrasound of delicate endometrial and intracavitary abnormalities. The reported analyses did not include several potentially important variables such as BMI, parity, infertility type, infertility duration, incomplete cycle day, hormonal profile and reproductive outcome. It is also limited as the integer labels of the thesis endometrial-thickness tables are repeated to interpret the underlying measurements precisely. Lastly, the chi-square results are repeated in the thesis and were not re-calculated during the preparation of this paper.

Prospective research of both fertile and infertile groups should be included in the future studies, the day of endometrial measurement during the menstrual cycle needs to be standardized, transvaginal and/or three-dimensional ultrasound (where necessary) should be considered, continuity of the values should be preserved, parity and BMI should be registered and the effect sizes should be provided with the confidence interval. Diagnostic validity would be better when suspected of the presence of uterine-cavity pathology when confirmed by means of saline-infusion sonography or hysteroscopy.

5. Conclusion

The research arrived at a conclusion that ultrasound could be helpful in the evaluation of the endometrial thickness and uterus size of infertile women. The size of the uterus category that was most common in this cohort was 7x4cm, most uteruses were anteverted and PCO and fibroids were outstanding abnormal

sonographic images. As shown in the thesis, there are significant relationships between uterus size, uterine pathologies, and endometrial thickness with age and/or menstrual-cycle phase. These results justify sonography as an affordable preliminary modality in structural evaluation in infertility, but because of a cross-sectional design, convenience sampling, a lack of fertile-control and a lack of a diagnostic-reference standard, the causal and diagnostic-accuracy inferences cannot be made.

6. Recommendations

Arguably, further research is justified to encompass fertile and infertile women, a larger sample size, standardized timing of menstrual-cycle ultrasound, and transvaginal or advanced imaging (where clinically relevant). Other measures would be to compare reproductive outcomes and use reference-standard studies to evaluate suspected abnormalities in the uterine-cavity.

Declarations

Ethics approval and consent to participate. The study followed the ethical rules and regulations of the Department of Diagnostic Medical Sonography, Women University Swabi. Written informed consent was obtained from all participants.

Consent for publication. No directly identifying participant information is presented in this manuscript.

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Competing interests. [Authors to complete the target journal's competing-interests declaration before submission.]

Data availability. [Authors provide a journal-compliant data-availability statement after confirming institutional permission for data sharing.]

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