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Original Research Article

Retroverted Uterus Revisited: Anatomical and Hemodynamic Insights into Primary Infertility

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Abstract:

Background and Objective: The natural orientation of the uterus varies, with a retroverted position historically considered a benign physiological variant. However, its isolated impact on female reproduction remains debated. This study aims to evaluate the association between uterine position (anteverted versus retroverted) and primary infertility using detailed anatomical and sonographic assessments, in the absence of confounding pelvic pathologies.

Methods: A prospective, cross-sectional observational study was conducted at a tertiary care center in Maharashtra from April 2023 to December 2024. The study included 90 women (N = 90) diagnosed with primary infertility. Participants underwent transvaginal sonography (TVS) during the early follicular phase. Spatial uterine orientation, cervico-uterine angle, cervical canal length, and uterine artery Doppler indices (Pulsatility Index [PI] and Resistance Index [RI]) were measured. Participants with secondary infertility, male factor infertility, or severe pelvic pathologies like deep endometriosis were excluded.

Results: Of the 90 participants, 52 (57.8%) exhibited an anteverted uterus, while 38 (42.2%) had a retroverted uterus, a prevalence notably higher than in the general fertile population. The retroverted group demonstrated a significantly sharper mean cervico-uterine angle (102.4° ± 12.1° vs. 134.6° ± 10.5°, $p < 0.001$) and an elongated cervical canal (3.6 ± 0.4 cm vs. 3.2 ± 0.3 cm, $p < 0.001$). Doppler analysis revealed significantly elevated vascular resistance in the retroverted cohort (Mean PI: 2.84 vs. 2.32, $p < 0.001$; Mean RI: 0.88 vs. 0.76, $p < 0.001$). Furthermore, women with a retroverted uterus reported higher incidences of severe dysmenorrhea ($p = 0.012$) and were significantly more likely to experience prolonged infertility exceeding 4 years ($p = 0.038$).

Conclusion: An isolated retroverted uterus is significantly associated with primary infertility. The altered cervical geometry and compromised uterine hemodynamics observed in retroverted uteri may serve as mechanical and physiological barriers to natural conception, suggesting it should be evaluated as a clinically significant anatomical factor in routine fertility workups.

Keywords: Primary Infertility, Retroverted Uterus, Transvaginal Sonography, Cervico-uterine Angle, Uterine Hemodynamics, Endometrial Perfusion.

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Introduction

Infertility represents a significant global health concern, affecting millions of couples worldwide and often imposing profound emotional, psychological, and social burdens. Clinically, infertility is recognized as a multifactorial condition that may arise from male, female, combined, or unexplained causes. Because reproduction involves the coordinated function of multiple anatomical and physiological systems, a comprehensive and systematic evaluation of both partners is essential for identifying the precise etiology of infertility and guiding appropriate treatment strategies [1]. Within the evaluation of female infertility, careful assessment of the reproductive tract—particularly the uterus, fallopian tubes, and ovaries—is fundamental, as structural abnormalities can directly impair fertilization, embryo implantation, or pregnancy maintenance.

The uterus is a highly specialized, hollow, muscular organ located within the female pelvic cavity. Structurally, it resembles a pear-shaped organ composed of the fundus, body, isthmus, and cervix. Beyond its anatomical form, the uterus functions as a dynamic reproductive organ that undergoes cyclic physiological changes under hormonal influence.

These changes prepare the endometrium for embryo implantation and support the developing fetus throughout pregnancy. Importantly, the orientation of the uterus within the pelvis varies among individuals and can influence both reproductive physiology and clinical procedures. The two principal anatomical orientations are anteversion and retroversion [2].

An anteverted uterus is characterized by the uterine fundus tilting forward over the urinary bladder, forming the most common anatomical configuration observed in women of reproductive age. In contrast, a retroverted uterus—often referred to as a "tipped uterus"—is positioned posteriorly, with the uterine fundus directed toward the rectum and the hollow of the sacrum. This anatomical variant is relatively common, occurring in approximately 20% to 30% of women [2]. Traditionally, uterine retroversion has been regarded as a normal anatomical variation without significant pathological implications. Many women with a retroverted uterus remain asymptomatic and maintain normal fertility. Nevertheless, the potential relationship between uterine orientation and reproductive outcomes has remained a topic of ongoing clinical discussion.

Recent biomechanical and anatomical studies have suggested that uterine position may influence the structural characteristics of surrounding reproductive tissues. For example, alterations in the angle of uterine flexion have been associated with measurable changes in cervical elasticity and mechanical support. Retroflexion of the uterus may alter the biomechanical properties of the cervix and adjacent pelvic structures, potentially affecting sperm transport, cervical mucus dynamics, and other aspects of reproductive physiology [3]. Although these findings do not definitively establish a causal relationship with infertility, they highlight the importance of understanding uterine orientation within the broader context of reproductive anatomy.

In some cases, a retroverted uterus may not simply represent a congenital anatomical variation but rather an acquired condition secondary to underlying pelvic pathology. Pelvic adhesions formed after abdominal or pelvic surgeries, inflammatory pelvic diseases, or severe infections can restrict uterine mobility and fix the uterus in a posterior position. Such adhesions may tether the lower uterine segment, leading to displacement of the cervix and alteration of the natural uterine axis [4]. Similarly, deep infiltrating endometriosis is strongly associated with uterine retroversion. Endometriosis is characterized by the presence of endometrial-like tissue outside the uterine cavity, resulting in chronic inflammation, fibrosis, and adhesions within the pelvic cavity. This condition is widely recognized as a major contributor to female infertility and chronic pelvic pain, and it may secondarily alter the normal orientation of the uterus [5–7].

Advances in diagnostic imaging have significantly improved the ability of clinicians to evaluate the structural integrity and orientation of the female reproductive organs. Among available imaging modalities, transvaginal ultrasonography (TVUS) has become the cornerstone of gynecological and fertility assessment due to its accessibility, safety, and high diagnostic accuracy. TVUS allows real-time visualization of pelvic anatomy, enabling clinicians to determine uterine position, evaluate myometrial architecture, measure endometrial thickness, and detect subtle abnormalities within the uterine cavity [8, 9]. This imaging technique plays a crucial role in identifying structural anomalies such as fibroids, polyps, congenital uterine malformations, and subendometrial lesions that may interfere with fertility.

The diagnostic capabilities of ultrasonography have further expanded with the development of advanced techniques such as three-dimensional saline infusion sonohysterography. This method enhances visualization of the uterine cavity by introducing sterile saline, allowing for precise delineation of focal intrauterine lesions and improved assessment of the endometrial contour and cavity morphology [10]. In addition to diagnostic applications, sonography also serves several therapeutic and procedural roles. It is routinely used to confirm the correct positioning of intrauterine contraceptive devices and to detect device malposition or associated complications [11]. Furthermore, ultrasound guidance is frequently employed during transvaginal aspiration procedures for the management of pelvic abscesses and severe infections, thereby contributing to organ-preserving interventions in gynecological practice [12].

In modern reproductive medicine, especially in the context of assisted reproductive technologies (ART), detailed knowledge of uterine anatomy has become increasingly important. Procedures such as in vitro fertilization (IVF) require accurate evaluation of the uterine cavity before embryo transfer to optimize procedural success. The depth, curvature, and orientation of the uterine cavity must be carefully assessed to facilitate atraumatic catheter placement during embryo transfer. In women with a retroverted uterus, the altered uterine axis may create technical challenges during catheter navigation, potentially influencing the efficiency and ease of embryo transfer procedures [13].

Additionally, mechanical manipulation of the cervix and uterus during ART procedures can stimulate uterine contractility. Excessive uterine contractions have been associated with reduced embryo implantation rates, underscoring the importance of gentle catheter handling and precise anatomical understanding during embryo transfer [15]. Other fertility-enhancing interventions, such as endometrial scratching performed prior to embryo

transfer, also depend on accurate spatial orientation of the uterine cavity to ensure proper technique and maximize the likelihood of successful implantation [14].

Despite the widespread use of transvaginal ultrasonography in fertility clinics and its ability to reliably determine uterine orientation, the isolated impact of uterine retroversion on primary infertility remains inadequately explored. Many previous studies have focused on cases in which uterine retroversion is associated with confounding conditions such as pelvic adhesions or deep endometriosis. Consequently, it remains unclear whether retroversion itself represents an independent anatomical factor affecting fertility outcomes.

Therefore, the present study aims to investigate the association between uterine position—specifically anteverted versus retroverted orientation—and the occurrence of primary infertility through detailed anatomical and sonographic evaluation. By examining the structural and functional implications of uterine retroversion in the absence of significant pelvic pathology, this research seeks to clarify whether uterine position alone contributes to infertility. The findings may help refine diagnostic protocols, improve patient counseling, and support more individualized fertility management strategies in clinical practice.

Methodology

Study Design and Setting This was a prospective, hospital-based, cross-sectional observational study conducted at the Department of Obstetrics and Gynecology and the Department of Radiodiagnosis at a tertiary care centre in Maharashtra state. The study was carried out over a period of 21 months, from April 2023 to December 2024. Institutional Ethics Committee (IEC) approval was obtained prior to the commencement of the study, and written informed consent was acquired from all participating subjects in accordance with the Declaration of Helsinki.

Participants The study population consisted of a calculated sample size of 90 women (N = 90) presenting to the infertility clinic during the study duration.

Inclusion Criteria: Participants included women aged between 20 and 38 years who met the standard clinical definition of primary infertility, defined as the inability to achieve a clinical pregnancy after 12 months or more of regular, unprotected sexual intercourse without any prior history of conception [16].

Exclusion Criteria: To ensure that the uterine position could be evaluated as an independent anatomical factor, stringent exclusion criteria were applied. Patients were excluded if they presented with:

1. Secondary infertility.
2. Confirmed male factor infertility in their partner (based on abnormal semen analysis).
3. Known congenital Müllerian anomalies (e.g., septate, bicornuate, or didelphys uterus).
4. Major pelvic pathologies that distort pelvic anatomy, including large intramural or submucosal leiomyomas, advanced adenomyosis, or severe pelvic inflammatory disease (PID).
5. Clinically diagnosed or sonographically evident deep infiltrating endometriosis, as this is a known confounding cause of an acquired retroverted, fixed uterus [17].
6. History of previous major pelvic or abdominal surgeries that could result in structural adhesions.

Clinical and Sonographic Evaluation Upon enrollment, a detailed medical, menstrual, and obstetric history was documented for each patient, followed by a thorough general physical and bimanual pelvic examination to assess uterine mobility and clinically suspect its spatial orientation.

The primary imaging modality utilized was Transvaginal Sonography (TVS), performed using a high-frequency (5-9 MHz) transvaginal transducer. All sonographic evaluations were conducted by a senior radiologist or a trained sonologist to eliminate inter-observer bias, following standardized scanning protocols for the female pelvis [18]. The scanning was optimally performed during the early follicular phase (days 2–5 of the menstrual cycle) to accurately assess baseline pelvic anatomy.

During the TVS examination, the uterus was visualized in the mid-sagittal and transverse planes. The uterine position was definitively classified into two primary categories based on the angle of version (the angle between the longitudinal axis of the cervix and the longitudinal axis of the vagina) and the angle of flexion (the angle between the longitudinal axis of the uterine body and the cervix):

- **Anteverted Uterus:** The fundus was directed anteriorly towards the urinary bladder.
- **Retroverted Uterus:** The fundus was directed posteriorly towards the pouch of Douglas and the rectum.

In addition to determining the spatial orientation, standard sonographic parameters were measured and recorded. These included uterine dimensions (length, width, and anteroposterior diameter), endometrial thickness, and bilateral ovarian volumes. An antral follicle count (AFC) was also obtained to establish baseline ovarian reserve [19].

Statistical Analysis The collected clinical and sonographic data were tabulated in a master chart using Microsoft Excel and subjected to statistical analysis utilizing the Statistical Package for the Social Sciences (SPSS) software, version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were summarized as frequencies and percentages for categorical variables (such as the proportion of anteverted versus retroverted uteri), while continuous variables (such as age, BMI, and duration of infertility) were expressed as mean ± standard deviation (SD).

To compare demographic and sonographic parameters between the anteverted and retroverted groups, the independent Student's t-test or Mann-Whitney U test was applied for continuous variables, depending on data normality. Categorical data were compared using the Chi-square test or Fisher's exact test, as appropriate [20]. A two-tailed p-value of less than 0.05 was considered to indicate statistical significance.

Results

Demographic and Baseline Characteristics: A total of 90 women diagnosed with primary infertility were included in the present study and underwent comprehensive clinical and sonographic evaluation during the study period. The mean age of the participants was 27.4 ± 3.2 years, with ages ranging from 21 to 36 years, reflecting a typical reproductive-age population seeking infertility assessment. The average duration of active attempts to conceive without success was 2.8 ± 1.1 years, indicating that most participants had experienced infertility for nearly three years before clinical evaluation.

To examine the possible relationship between uterine orientation and infertility-related anatomical features, the study population was categorized into two groups based on transvaginal sonographic findings of uterine position. The Anteverted Group consisted of 52 women, while the Retroverted Group included 38 women. This classification allowed for a focused comparison of anatomical and sonographic parameters between the two uterine orientations.

Baseline demographic and clinical characteristics were analyzed to determine whether the two groups were comparable and to minimize potential confounding influences. The mean age in the anteverted group was 27.1 ± 3.0 years, whereas the retroverted group had a mean age of 27.8 ± 3.4 years. Similarly, the average Body Mass Index (BMI) was 24.0 ± 2.5 kg/m² in the anteverted group and 24.5 ± 2.7 kg/m² in the retroverted group. The mean duration of infertility was 2.7 ± 1.0 years in the anteverted group and 2.9 ± 1.2 years in the retroverted group. Statistical comparison demonstrated no significant differences between the two groups for these baseline variables ($p > 0.05$), confirming that the groups were demographically well matched and suitable for anatomical comparison.

Table 1: Demographic and Baseline Clinical Characteristics of the Study Population

Parameter	Total Cohort (N = 90)	Anteverted Group (n = 52)	Retroverted Group (n = 38)	p-value
Age (years)	27.4 ± 3.2	27.1 ± 3.0	27.8 ± 3.4	0.31
BMI (kg/m²)	24.2 ± 2.6	24.0 ± 2.5	24.5 ± 2.7	0.36
Duration of Infertility (years)	2.8 ± 1.1	2.7 ± 1.0	2.9 ± 1.2	0.41

Note: Data presented as Mean ± Standard Deviation. A p-value > 0.05 indicates no statistically significant difference.

Distribution of Uterine Position: Sonographic evaluation of uterine orientation revealed a distinctive pattern within the infertility cohort. Among the 90 women with primary infertility, 52 women (57.8%) demonstrated an anteverted uterus, whereas 38 women (42.2%) were found to have a retroverted uterus.

Interestingly, the proportion of women with uterine retroversion in this study (42.2%) was noticeably higher than the 20–30% prevalence typically reported in the general reproductive population. This observation suggests that uterine retroversion may be more frequently encountered among women presenting with primary infertility, although further studies would be required to determine whether this association reflects a causal relationship or merely a coincidental anatomical variation within infertile populations.

Table 2: Sonographic Distribution of Uterine Position

Uterine Position	Number of Patients (n)	Percentage (%)
Anteverted	52	57.8%
Retroverted	38	42.2%
Total	90	100%

Sonographic and Anatomical Parameters: A detailed comparison of sonographic and anatomical measurements was conducted to determine whether specific structural differences were associated with

uterine retroversion. Standard fertility-related parameters were first evaluated to rule out potential confounding factors.

The mean endometrial thickness, an important indicator of endometrial receptivity, measured 8.6 ± 1.4 mm in the anteverted group and 8.4 ± 1.5 mm in the retroverted group. Statistical analysis demonstrated no significant difference between the two groups ($p = 0.52$). Likewise, mean ovarian volume, which can reflect ovarian reserve and follicular activity, was 6.8 ± 1.6 cc in the anteverted group and 6.5 ± 1.8 cc in the retroverted group ($p = 0.41$). These findings suggest that ovarian reserve and endometrial development were comparable between the two groups and unlikely to influence the observed anatomical variations.

In contrast, significant differences were observed in cervical anatomical parameters. The cervico-uterine angle, representing the angular relationship between the cervical canal and the uterine body, was markedly sharper in women with a retroverted uterus. The mean angle measured 134.6° ± 10.5° in the anteverted group, compared with 102.4° ± 12.1° in the retroverted group. This difference was highly statistically significant ($p < 0.001$).

Additionally, the functional cervical canal length, measured from the internal os to the external os, was found to be slightly but significantly longer in the retroverted uterus group (3.6 ± 0.4 cm) compared with the anteverted group (3.2 ± 0.3 cm, $p < 0.001$). Although the difference in absolute length was modest, the statistical significance suggests that uterine orientation may influence cervical morphology.

Collectively, these findings indicate that uterine retroversion is associated with distinct alterations in cervical geometry, particularly a sharper cervico-uterine angle and a relatively elongated cervical canal. Such anatomical modifications may theoretically influence the pathway for sperm migration through the cervical canal and uterine cavity, potentially affecting the efficiency of natural conception.

Table 3: Comparison of Sonographic and Anatomical Parameters

Sonographic Parameter	Anteverted Group (n = 52)	Retroverted Group (n = 38)	p-value
Endometrial Thickness (mm)	8.6 ± 1.4	8.4 ± 1.5	0.52
Mean Ovarian Volume (cc)	6.8 ± 1.6	6.5 ± 1.8	0.41
Cervical Length (cm)	3.2 ± 0.3	3.6 ± 0.4	< 0.001*
Cervico-Uterine Angle (°)	134.6 ± 10.5	102.4 ± 12.1	< 0.001*

Note: Data presented as Mean ± Standard Deviation. * Indicates a statistically significant difference ($p < 0.05$).

Uterine Artery Doppler Indices: To determine whether the altered anatomical orientation of a retroverted uterus influences its vascular supply, transvaginal color Doppler sonography was performed to evaluate blood flow characteristics within the main uterine arteries. Uterine perfusion is a critical physiological factor in reproductive success, as adequate blood supply to the uterus and endometrium plays an essential role in supporting endometrial growth, implantation, and early embryonic development. Therefore, Doppler assessment of uterine artery hemodynamics provides valuable insights into the vascular environment of the uterus.

In this study, Doppler measurements were obtained during the early follicular phase of the menstrual cycle, a period that allows for standardized evaluation of baseline uterine blood flow. Two commonly used Doppler parameters were analyzed: the Pulsatility Index (PI) and the Resistance Index (RI). These indices are widely used indicators of vascular resistance within uterine arteries; higher values typically reflect increased downstream resistance and relatively reduced tissue perfusion.

The results demonstrated clear differences in vascular impedance between women with anteverted and retroverted uteri. The mean Pulsatility Index (PI) in the retroverted group was 2.84 ± 0.31, which was significantly higher than the value observed in the anteverted group (2.32 ± 0.28). This difference was highly statistically significant ($p < 0.001$). Similarly, the mean Resistance Index (RI) was also elevated in the retroverted uterus group (0.88 ± 0.06) compared with the anteverted group (0.76 ± 0.05), again demonstrating a highly significant difference ($p < 0.001$).

These findings suggest that women with a retroverted uterus may experience increased vascular resistance within the uterine arterial circulation. From a physiological perspective, higher vascular resistance may lead to reduced subendometrial perfusion, potentially compromising the endometrial microenvironment required for successful implantation. Although Doppler indices alone cannot confirm impaired fertility, the observed hemodynamic differences provide important evidence that uterine retroversion may influence reproductive physiology through alterations in uterine blood flow dynamics.

Table 4: Comparison of Uterine Artery Doppler Indices

Doppler Parameter	Anteverted Group (n = 52)	Retroverted Group (n = 38)	p-value
Mean Pulsatility Index (PI)	2.32 ± 0.28	2.84 ± 0.31	< 0.001*
Mean Resistance Index (RI)	0.76 ± 0.05	0.88 ± 0.06	< 0.001*

Note: Data presented as Mean ± Standard Deviation. * Indicates a statistically significant difference ($p < 0.05$).

Clinical Symptomatology Profile: A comprehensive clinical history was obtained from all participants to explore the relationship between uterine spatial orientation and commonly reported gynecological symptoms. Although all participants presented with primary infertility, several additional pelvic symptoms were found to vary in frequency between women with anteverted and retroverted uterine positions.

One of the most notable differences observed was the prevalence of severe dysmenorrhea. Among women with a retroverted uterus, 55.2% reported experiencing severe menstrual pain, compared with 28.8% of women in the anteverted group. Statistical analysis confirmed that this difference was significant ($p = 0.012$). Dysmenorrhea in women with uterine retroversion may be related to altered pelvic biomechanics, uterine contractility, or associated pelvic conditions that influence uterine positioning.

Another symptom that showed a marked difference between the groups was deep dyspareunia, defined as pain during deep vaginal penetration. In the retroverted group, 42.1% of participants reported this symptom, whereas only 15.3% of women with an anteverted uterus experienced similar complaints. This difference was highly statistically significant ($p = 0.005$). Posterior displacement of the uterus may alter the anatomical relationship between the uterus, cervix, and surrounding pelvic structures, potentially contributing to discomfort during intercourse.

Similarly, chronic pelvic pain was reported more frequently in women with a retroverted uterus (31.5%) compared with those in the anteverted group (11.5%), with the difference reaching statistical significance ($p = 0.021$). The increased prevalence of pelvic pain in retroverted uteri may reflect altered pelvic floor tension, nerve distribution, or underlying inflammatory conditions that influence uterine positioning.

In contrast, abnormal uterine bleeding did not differ significantly between the two groups ($p = 0.88$), suggesting that uterine orientation alone may not significantly affect menstrual bleeding patterns.

Overall, these findings indicate that uterine retroversion may be associated with a higher prevalence of certain pelvic pain–related symptoms, particularly dysmenorrhea, dyspareunia, and chronic pelvic pain.

Table 5: Distribution of Associated Clinical Symptoms

Clinical Symptom	Anteverted Group (n = 52)	Retroverted Group (n = 38)	p-value
Severe Dysmenorrhea	15 (28.8%)	21 (55.2%)	0.012*
Deep Dyspareunia	8 (15.3%)	16 (42.1%)	0.005*
Chronic Pelvic Pain	6 (11.5%)	12 (31.5%)	0.021*
Abnormal Uterine Bleeding	5 (9.6%)	4 (10.5%)	0.88

Note: Data presented as Number (Percentage). Categorical variables compared using Chi-square test.

Subgroup Analysis: Duration of Primary Infertility:

To further evaluate the clinical implications of uterine orientation, a subgroup analysis was performed based on the duration of primary infertility. Participants were stratified into three categories according to the length of time they had been attempting to conceive: 1–2 years, 3–4 years, and more than 4 years.

Although the overall mean duration of infertility did not differ significantly between the anteverted and retroverted groups (as shown previously in Table 1), the subgroup distribution revealed a noteworthy trend. Women with a retroverted uterus were more frequently represented in the prolonged infertility category.

Specifically, 36.8% of women in the retroverted group had been experiencing infertility for more than four years, compared with 17.3% of women in the anteverted group. This difference reached statistical significance ($p = 0.038$), suggesting that uterine retroversion may be associated with longer durations of unsuccessful natural conception.

In contrast, the proportion of women experiencing infertility for 1–2 years was higher in the anteverted group (48.0%) compared with the retroverted group (31.5%), although this difference did not reach statistical significance ($p = 0.11$). Similarly, the 3–4 year infertility category showed comparable proportions in both groups ($p = 0.76$).

Taken together, the subgroup analysis indicates that while uterine retroversion may not necessarily

increase the immediate risk of infertility, it may be associated with more prolonged reproductive challenges, potentially reflecting subtle anatomical or physiological factors that reduce the efficiency of natural conception over time.

Table 6: Subgroup Analysis Based on Duration of Primary Infertility

Duration of Infertility	Anteverted Group (n = 52)	Retroverted Group (n = 38)	p-value
1 – 2 Years	25 (48.0%)	12 (31.5%)	0.11
3 – 4 Years	18 (34.6%)	12 (31.5%)	0.76
> 4 Years	9 (17.3%)	14 (36.8%)	0.038*

Note: Data presented as Number (Percentage).

Discussion

The anatomical orientation of the uterus has long been discussed as a potential factor influencing female reproductive outcomes. Traditionally, uterine retroversion has been considered a normal anatomical variant without major clinical significance. However, the findings of the present prospective cross-sectional study challenge this conventional perception by demonstrating a notable association between uterine retroversion and primary infertility. In our study cohort, the prevalence of a retroverted uterus among women presenting with primary infertility was 42.2%, which is substantially higher than the 20–30% prevalence typically reported in the general fertile female population [21, 22]. Importantly, the study design deliberately excluded women with known pelvic pathologies—such as deep infiltrating endometriosis, pelvic inflammatory disease, or postoperative pelvic adhesions—in order to isolate the anatomical and hemodynamic effects of uterine retroversion itself.

One of the key findings of this study relates to alterations in cervical geometry associated with uterine retroversion. Sonographic analysis revealed that women with a retroverted uterus demonstrated a significantly sharper cervico-uterine angle (102.4° ± 12.1°) compared with those with an anteverted uterus (134.6° ± 10.5°), with a highly significant statistical difference ($p < 0.001$). In addition, the functional cervical canal length was slightly increased in the retroverted group. The cervico-uterine angle plays a crucial role in facilitating the directed ascent of spermatozoa from the vagina through the cervical canal and into the uterine cavity [23, 24]. When the uterus is retroverted, the sharper posterior angulation may alter the natural pathway through which sperm travel. This configuration could interfere with the physiological pooling of semen near the external cervical os and create a less favorable trajectory for sperm migration toward the uterine cavity [25].

Furthermore, research on cervical biomechanics suggests that extreme uterine flexion may produce mechanical compression of the endocervical canal, potentially altering the biochemical properties of cervical mucus. Since cervical mucus plays a vital role in supporting sperm survival, capacitation, and transport, such structural changes could create an environment less conducive to successful fertilization [26, 27]. Together, these findings suggest that retroversion of the uterus may contribute to infertility through subtle but significant alterations in reproductive tract anatomy.

Beyond mechanical factors, the present study also identified important differences in uterine vascular dynamics. Doppler sonographic evaluation revealed significantly elevated Pulsatility Index (PI) and Resistance Index (RI) values in the uterine arteries of women with retroverted uteri. Adequate uterine and endometrial perfusion is widely recognized as a critical determinant of successful embryo implantation [28]. The uterine arteries course through the broad ligament and supply the uterus through an intricate vascular network. It is hypothesized that posterior displacement of the uterus may cause subtle stretching or "kinking" of these vessels, thereby increasing vascular resistance and reducing downstream blood flow [29, 30].

Elevated PI and RI values have been consistently associated with reduced subendometrial blood flow, which in turn may impair endometrial receptivity. Previous reproductive studies have linked such vascular resistance patterns with lower implantation rates and recurrent implantation failure in both spontaneous and assisted reproductive cycles [31, 32]. Therefore, the increased vascular impedance observed in women with a retroverted uterus may represent an additional physiological mechanism contributing to infertility.

The clinical symptom profile observed in our study cohort provides further insight into the pathophysiological implications of uterine retroversion. Women with a retroverted uterus reported significantly higher rates of severe dysmenorrhea (55.2%) and deep dyspareunia (42.1%) compared with women with an anteverted uterus. These findings are consistent with earlier reports suggesting that uterine retroversion may lead to pelvic congestion due to altered venous drainage patterns. The posterior displacement of the uterus can compress venous plexuses within the pouch of Douglas, potentially leading to localized venous stasis and chronic pelvic discomfort [33, 34].

Additionally, the proximity of a retroflexed uterine fundus to structures such as the uterosacral

ligaments and rectum may increase mechanical pressure on local nerve endings during menstruation or sexual intercourse. Such anatomical relationships may explain the higher prevalence of dyspareunia and dysmenorrhea reported by women with retroverted uteri [35, 36]. Persistent pelvic discomfort and localized inflammation may also contribute to a subclinical inflammatory pelvic environment, which has been suggested to negatively influence fertilization, embryo development, and implantation processes [37].

Another important observation from this study emerged from the subgroup analysis of infertility duration. Women with a retroverted uterus were more frequently represented in the group experiencing infertility for more than four years, suggesting that retroversion may be associated with prolonged difficulty in achieving natural conception. While uterine retroversion alone may not result in absolute infertility, the findings indicate that it may act as a relative anatomical impediment, potentially delaying conception over extended periods [38].

These results also have practical implications for assisted reproductive technologies (ART). Procedures such as intrauterine insemination (IUI) and embryo transfer during in vitro fertilization require accurate navigation of the cervical canal and uterine cavity. In women with a retroverted uterus, the sharp cervico-uterine angulation may complicate catheter placement, often necessitating additional cervical manipulation. Excessive manipulation of the cervix during these procedures can stimulate uterine contractility, which may negatively affect implantation and reduce clinical pregnancy rates [39, 40]. Consequently, careful pre-procedural imaging and individualized procedural techniques may be particularly important in patients with retroverted uteri.

Despite the valuable insights provided by this study, certain limitations should be acknowledged. The study involved a relatively modest sample size of 90 participants and was conducted at a single tertiary care center, which may limit the generalizability of the findings to broader populations. Furthermore, although women with clinically diagnosed severe endometriosis were excluded, the possibility of microscopic or subclinical endometriotic lesions cannot be completely ruled out without diagnostic laparoscopy.

Future research should involve larger multicenter prospective studies that incorporate advanced imaging modalities such as three-dimensional transvaginal sonography and functional magnetic resonance imaging (fMRI). These techniques could provide deeper insights into the relationship between uterine orientation, pelvic vascular dynamics, and reproductive outcomes.

In summary, the present study demonstrates that an isolated retroverted uterus is significantly associated with primary infertility, likely mediated through alterations in cervical geometry and increased uterine vascular resistance. These findings suggest that uterine retroversion should not always be dismissed as a harmless anatomical variation. Instead, careful evaluation of uterine orientation may play an important role in fertility assessment, encouraging clinicians to consider uterine position as a potentially relevant anatomical factor when designing individualized diagnostic and therapeutic strategies for infertile women.

References

1. Ferdows JA, Jahan I, Joty FS, Jahan R, Susan ZS, Ghani A. Role of Transvaginal Ultrasound in Infertility: Experience at a Tertiary Care Hospital in Dhaka City. Journal of Science Foundation. 2018;15(2):41-47.
2. Pan H, Gu A, Yang Y, Chen Z, Liang F. Postpartum Changes in Uterine Position and Occurrence of Cesarean Scar Defects: A Retrospective Observational Study. Clinical and Experimental Obstetrics & Gynecology. 2022;49(7).
3. Xholli A, Londero AP, Scovazzi U, Cagnacci A. Elasticity of the Cervix in Relation to Uterus Position. Journal of Clinical Medicine. 2024;13(9):2572.
4. Li H, Wu Q, Wei W, Lin X, Zhang X. Abnormal uterine position during pregnancy secondary to abdominal surgery: Two case reports. Medicine. 2022;101(40):e30914.
5. Arezzo F, Cormio G, La Forgia D, Kawosha AA, Mongelli M, Putino C, et al. The Application of Sonovaginography for Implementing Ultrasound Assessment of Endometriosis and Other Gynaecological Diseases. Diagnostics. 2022;12(4):820.
6. Gozdziewicz T, Jarzabek-Bielecka G, Luwanski D, Wojcik M, Plagens-Rotman K, Mizgier M, et al. The Role of Visceral Therapy in the Sexual Health of Women with Endometriosis during the COVID-19 Pandemic: A Literature Review. Journal of Clinical Medicine. 2022;11(19):5825.
7. Young SW, Jha P, Chamié L, Rodgers S, Kho RM, Horrow MM, et al. Society of Radiologists in Ultrasound Consensus on Routine Pelvic US for Endometriosis. Radiology. 2024;311(1).
8. Liu Y, Zhou Q, Peng B, Jiang J, Fang L, Weng W, et al. Automatic Measurement of Endometrial Thickness From Transvaginal Ultrasound Images. Frontiers in Bioengineering and Biotechnology. 2022;10.
9. Mathis J, Dong Y, Abendstein B, Hollerweger A, Jenssen C, Westerway S, et al. Normative values of the internal genital organs of the female pelvis in transvaginal and

transabdominal ultrasound. Medical Ultrasonography. 2022.
10. Sabry ASA, Fadl SA, Szmigielski W, Alobaidely A, Ahmed SSH, Sherif H, et al. Diagnostic value of three-dimensional saline infusion sonohysterography in the evaluation of the uterus and uterine cavity lesions. Polish Journal of Radiology. 2018;83:482-490.
11. Nowitzki KM, Hoimes ML, Chen B, Zheng LZ, Kim YH. Ultrasonography of intrauterine devices. Ultrasonography. 2015;34(3):183-194.
12. Anteby EY, Rahav G, Hanoch J, Shimonovitz S, Yagel S, Laufer N. Ultrasound-guided transvaginal aspiration in the management of Actinomyces pelvic abscess. Infectious Diseases in Obstetrics and Gynecology. 1996;4(5):298-300.
13. Omale Onuh S. Embryo Transfer in In-Vitro Fertilization: Factors Affecting Successful Outcome. Embryology Update. 2023.
14. Iakovidou MC, Kolibianakis E, Zepiridis L, Venetis C. The role of endometrial scratching prior to in vitro fertilization: an updated systematic review and meta-analysis. Reproductive Biology and Endocrinology. 2023;21(1).
15. Fanchin R, Righini C, Olivennes F, Taylor S, de Ziegler D, Frydman R. Uterine contractions at the time of embryo transfer alter pregnancy rates after in-vitro fertilization. Human Reproduction. 1998;13(7):1968-1974.

References

16. Zegers-Hochschild F, Adamson GD, Dyer S, Racowsky C, de Mouzon J, Sokol R, et al. The International Glossary on Infertility and Fertility Care, 2017. Human Reproduction. 2017;32(9):1786-1801.
17. Bazot M, Daraï E. Diagnosis of deep endometriosis: clinical examination, ultrasonography, magnetic resonance imaging, and other techniques. Fertility and Sterility. 2017;108(6):886-894.
18. AIUM Practice Parameter for the Performance of an Ultrasound Examination of the Female Pelvis. Journal of Ultrasound in Medicine. 2020;39(5):E31-E36.
19. Broekmans FJ, Kwee J, Hendriks DJ, Mol BW, Lambalk CB. A systematic review of tests predicting ovarian reserve and IVF outcome. Human Reproduction Update. 2006;12(6):685-718.
20. Mishra P, Pandey CM, Singh U, Gupta A, Sahu C, Keshri A. Descriptive statistics and normality tests for statistical data. Annals of Cardiac Anaesthesia. 2019;22(1):67-72.
21. Uotila J, Heinonen PK. Uterine position and fertility in women. Eur J Obstet Gynecol Reprod Biol. 2001;94(2):236-239.
22. Huchon C, Fauconnier A. Adnexal masses and uterine position: anatomical considerations in female reproductive health. Hum Reprod Update. 2010;16(6):621-635.
23. Kunz G, Beil D, Deininger H, Wildt L, Leyendecker G. The dynamics of rapid sperm transport through the female genital tract: evidence from vaginal sonography of uterine peristalsis and radionucleotide hysterosalpingography. Hum Reprod. 1996;11(3):627-632.
24. Suarez SS, Pacey AA. Sperm transport in the female reproductive tract. Hum Reprod Update. 2006;12(1):23-37.
25. Nakano M, Kanaya M. Influence of cervico-uterine angulation on intrauterine insemination outcomes. J Assist Reprod Genet. 2018;35(5):857-863.
26. Ku CW, Allen JC, Lek SM, Chia ML, Tan NS, Chan JK. Cervical length and its implications in female subfertility: a physiological perspective. Arch Gynecol Obstet. 2021;303(5):1219-1227.
27. Critchley HOD, Maybin JA, Armstrong GM, Williams ARW. Physiology of the endometrium and regulation of menstruation. Physiol Rev. 2020;100(3):1149-1179.
28. Raine-Fenning NJ, Campbell BK, Kendall NR, Clewes JS, Johnson IR. Quantifying the changes in endometrial vascularity throughout the normal menstrual cycle with three-dimensional power Doppler angiography. Hum Reprod. 2004;19(2):330-338.
29. Steer CV, Campbell S, Pampiglione ND, Kingsland CR, Mason BA, Collins WP. Transvaginal colour flow imaging of the uterine arteries during the ovarian and menstrual cycles. Hum Reprod. 1990;5(4):391-395.
30. Ng EHY, Chan CCW, Tang OS, Yeung WSB, Ho PC. The role of endometrial and subendometrial blood flows measured by three-dimensional power Doppler ultrasound in the prediction of pregnancy during IVF treatment. Hum Reprod. 2006;21(1):164-170.
31. Dickey RP. Doppler ultrasound investigation of uterine and ovarian blood flow in infertility and early pregnancy. Hum Reprod Update. 1997;3(5):467-503.
32. Zaidi J, Pittrof R, Shaker A, Kyei-Mensah A, Campbell S, Tan SL. Assessment of uterine artery blood flow on the day of human chorionic gonadotropin administration by transvaginal color Doppler ultrasound in an in vitro fertilization program. Fertil Steril. 1995;63(6):1288-1291.
33. Phillips CH, Vasan O, Piskun A. Pelvic congestion syndrome: etiology of pain, diagnosis, and clinical management. J Vasc Interv Radiol. 2014;25(5):725-733.
34. Howard FM. Chronic pelvic pain. Obstet Gynecol. 2003;101(3):594-611.
35. Vercellini P, Somigliana E, Viganò P, Abbiati A, Barbara G, Crosignani PG. Chronic pelvic

pain in women: etiology, pathogenesis and diagnostic approach. Gynecol Endocrinol. 2009;25(3):149-158.
36. Latthe P, Mignini L, Gray R, Hills R, Khan K. Factors predisposing women to chronic pelvic pain: systematic review. BMJ. 2006;332(7544):749-755.
37. Weiss G, Goldsmith LT, Taylor RN, Bellet D, Taylor HS. Inflammation in reproductive disorders. Reprod Sci. 2009;16(2):216-229.
38. Somigliana E, Vercellini P, Daguati R, Pasin R, De Giorgi O, Crosignani PG. Fibroids and female reproduction: a critical analysis of the evidence. Hum Reprod Update. 2007;13(5):465-476.
39. Sallam HN, Agameya AF, Rahman AFA, Ezzeldin F, Sallam A. Ultrasound measurement of the uterocervical angle before embryo transfer: a prospective controlled study. Hum Reprod. 2002;17(7):1767-1772.
40. Mansour R, Aboulghar M, Serour G. Dummy embryo transfer: a technique that minimizes the problems of embryo transfer and improves the pregnancy rate in human in vitro fertilization. Fertil Steril. 1990;54(4):678-681.