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Original

Maternal and paternal predictors of pregnancy outcomes following intrauterine insemination: A retrospective cohort analysis

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Abstract

Background: Intrauterine insemination (IUI) is a commonly used first‑line fertility treatment, yet pregnancy rates vary widely, and the relative influence of maternal and paternal factors remains unclear. Few studies have evaluated these determinants simultaneously, creating a gap in evidence for optimizing patient selection. This study examined key maternal and semen‑related predictors of IUI success.

Methods: This retrospective descriptive‑analytical study included 211 infertile couples undergoing 335 IUI cycles at an academic infertility center between 2017 and 2018. Eligible couples had ≥1 year of infertility, normal semen thresholds (motility ≥20%, total count ≥4 million, morphology ≥4%), no severe systemic disease, and complete follow‑up. Maternal variables included age, body mass index (BMI), endometrial thickness, follicle size, and number of mature follicles. Paternal variables included sperm count, progressive motility, and morphology. Pregnancy outcomes were assessed using β‑hCG testing and confirmed by ultrasound. Associations were examined using standard comparative analyses.

Results: The pregnancy rate was 20.4% per couple and 12.8% per cycle. Endometrial thickness was significantly greater in successful cycles (8.3 ± 0.9 mm) compared with unsuccessful cycles (7.4 ± 1.7 mm; p = 0.002). Shorter infertility duration (p = 0.007) and fewer IUI attempts (p = 0.037) also predicted success. Maternal age, BMI, sperm count, progressive motility, and morphology showed no significant associations with pregnancy.

Conclusion: Endometrial thickness was the strongest predictor of IUI success, with optimal outcomes observed at 7–9 mm. Infertility duration and number of IUI attempts also influenced pregnancy likelihood, while semen parameters and most maternal characteristics did not. These findings highlight the importance of uterine receptivity and timely intervention. Further multicenter studies with additional biomarkers are recommended to enhance predictive models and guide individualized fertility care.

Keywords: Endometrial thickness, Fertility factors, Infertility outcomes, Intrauterine insemination semen analysis

Introduction

Infertility is defined as failure to achieve pregnancy after one year of unprotected intercourse (or six months in women over 35 years old) (1). It is a significant social problem, with psychological, economic, and spiritual impacts on couples. Increasing demand for assisted reproductive technologies (ARTs) is evident due to rising infertility rates, which affect approximately 10–15% of couples in our country and 16.7% globally (1,2).

Infertility is defined as the failure to achieve pregnancy after one year of unprotected intercourse, or after six months in women older than 35 years (1). It is recognized as a major global health concern with substantial psychological, social, economic, and spiritual consequences for affected couples. The

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worldwide prevalence of infertility is estimated at 16.7%, while national rates range from 10% to 15%, resulting in a growing demand for ARTs (1,2).

Among available ART options, intrauterine insemination (IUI) remains one of the most widely utilized first-line treatments for infertile couples, despite the increasing use of more advanced procedures such as in vitro fertilization (IVF) (3,4). Its relative affordability, less invasive nature, and accessibility have sustained its popularity. However, the overall success rate of IUI remains variable, and identifying reliable predictors of treatment outcome continues to be a major clinical priority.

Previous studies have investigated a wide range of prognostic factors associated with IUI success, focusing primarily on maternal characteristics such as age, ovarian reserve, and ovulatory status as well as paternal factors, particularly semen analysis parameters (5). Although individual studies have reported associations between these variables and pregnancy outcomes, their findings are often inconsistent, limited by small sample sizes, or concentrated on isolated factors rather than comprehensive evaluations.

Given the rising maternal age at conception, the increasing number of couples seeking fertility treatment, and the economic burden associated with repeated unsuccessful ART cycles, there is a pressing need for more robust, integrative studies that examine how both maternal fertility factors and paternal semen characteristics jointly influence IUI success. Such evidence is essential not only for improving patient counseling and optimizing treatment selection but also for reducing financial strain on couples who may undergo multiple cycles with limited chances of success (6,7). Furthermore, considering the broader demographic and social implications of declining fertility rates, enhancing the effectiveness of first-line reproductive treatments such as IUI carries significant public health value.

Therefore, the present study aims to evaluate the relationship between IUI success rates and key maternal and paternal prognostic factors in a comprehensive cohort of infertile couples undergoing IUI. By systematically assessing these variables, we seek to (1) clarify their individual and combined contributions to treatment outcomes and (2) support more evidence-based decision-making in clinical practice.

Our working hypothesis is that specific maternal fertility characteristics and semen analysis parameters are independently associated with the likelihood of achieving pregnancy following IUI.

Materials & Methods

This retrospective, descriptive-analytical study evaluated infertile couples who underwent IUI at the Kamali Hospital Infertility Center in Karaj between 2018 and 2021. Eligible participants were couples diagnosed with infertility after at least one year of regular unprotected intercourse and who met standardized clinical and laboratory prerequisites for IUI. Inclusion criteria consisted of a documented infertility diagnosis, a seminal fluid analysis demonstrating normal sperm morphology (≥4%), motility (≥20%), and a total sperm count of at least 4 million, as well as the absence of severe systemic or chronic medical conditions in either partner that could interfere with treatment outcomes. Couples were required to show adequate cooperation with follow-up assessments and to complete the IUI treatment cycle without withdrawing. Written informed consent for participation in the infertility treatment process was obtained from all participants. Maternal criteria for IUI candidacy were also confirmed and included normal cervical mucus characteristics, the presence of at least one patent Fallopian tube based on prior hysterosalpingography or laparoscopy, sufficient post-processing motile sperm count provided by the partner, and the absence of active cervical or uterine infections at the time of insemination.

Semen analysis and preparation were performed under standardized laboratory conditions. All semen samples were obtained after 2–3 days of sexual abstinence and collected via masturbation without lubricants in a designated private room within the infertility center. Samples were allowed to liquefy at room temperature and were evaluated according to WHO-recommended parameters. Those meeting the minimum thresholds required for IUI underwent sperm processing using the conventional swim-up technique to isolate progressively motile spermatozoa and eliminate seminal plasma, immotile sperm, leukocytes, and cellular debris. A quality check was conducted post-processing to confirm that the prepared specimen contained at least 5 million motile sperm. Samples not reaching this threshold were excluded from the IUI protocol, and couples were counseled regarding alternative assisted reproductive technologies such as IVF.

The IUI procedure was carried out based on the center's standardized clinical pathway. Ovulation

timing was determined primarily through serial monitoring of urinary luteinizing hormone (LH) levels, with insemination scheduled after detection of the LH surge. Most cycles were stimulated using oral clomiphene citrate administered on days 3 to 5 of the menstrual cycle to enhance follicular development. Patients underwent transvaginal sonographic monitoring as clinically indicated until an appropriate pre-ovulatory follicle was observed. On the day of insemination, the prepared sperm sample was gently introduced into the uterine cavity using a sterile soft catheter under aseptic conditions. Patients were advised to rest briefly after the procedure and subsequently resume normal activities.

Pregnancy outcomes were evaluated in two stages. A urine β-hCG test was performed 14 days after insemination to determine chemical pregnancy. Those with positive test results were scheduled for a transvaginal ultrasound approximately six weeks after IUI to assess clinical pregnancy, defined as visualization of a gestational sac with cardiac activity. Following confirmation of clinical pregnancy, patients continued routine follow-up in accordance with established clinical guidelines.

Maternal demographic and clinical variables were recorded prior to insemination. Maternal age and body mass index (BMI) were documented at baseline. Endometrial thickness, dominant follicle size, and the number of mature follicles were measured by transvaginal ultrasonography immediately before the IUI procedure. Semen analysis variables from the male partner were also recorded for correlation with reproductive outcomes. The study aimed to determine the overall success rate of IUI cycles and to evaluate the association between pregnancy outcomes and key maternal factors as well as semen analysis parameters.

This study was approved by the Medical Ethics Committee of Alborz University of Medical Sciences (Ethics Code: IR.ABZUMS.REC.1399.292), and all procedures were conducted in accordance with ethical standards for human research and clinical reproductive practice.

Results

A total of 211 infertile couples underwent 335 IUI cycles, with an average of 1.6 cycles per couple (range 1–5). Most couples (n = 113; 53.8%) completed only one cycle, and 99.0% had completed three cycles by the end of treatment (Table 1).

As summarized in Table 3, cycles resulting in pregnancy demonstrated significantly greater endometrial thickness (8.3 ± 0.9 mm) compared with non-conception cycles (7.4 ± 1.7 mm; p = 0.002). Successful cycles were also associated with a shorter duration of infertility (3.1 ± 2.1 vs. 4.4 ± 3.2 years; p = 0.007) and fewer IUI attempts (1.3 ± 0.4 vs. 1.6 ± 0.7; p = 0.037). Maternal age, BMI, sperm concentration, progressive motility, and normal morphology did not differ significantly between the two groups (all p > 0.05). Pregnancies predominantly occurred with an endometrial thickness in the 7–9 mm range.

Table 1. Distribution of IUI Cycles per Couple (n= 210)

Number of IUI cycles	n	%	Cumulative %
1	113	53.8	53.8
2	72	34.3	88.1
3	23	11.0	99.0
4	1	0.5	99.5
5	1	0.5	100.0
Total (valid)	210	100.0	—

Note. One observation had missing data regarding the number of IUI cycles Percentages are based on valid cases.

The highest pregnancy success rate occurred during the first cycle. Overall, 43 couples achieved chemical pregnancy, corresponding to a pregnancy rate of 20.4% per couple and 12.8% per cycle.

Table 2. Descriptive Statistics of Maternal Characteristics and Semen Parameters (n= 210)

Variable	n	Min	Max	Mean	SD
Maternal BMI (kg/m²)	210	18	39.4	25.7	3.8
Maternal age (years)	211	21	45	31.5	4.9
Endometrial thickness (mm)	211	3	13.5	7.6	1.6
Sperm count (million/mL)	211	2	72	21.9	11.1
Progressive sperm motility (a+b, %)	211	3	65	23.8	11.5
Normal sperm morphology (%)	211	0	25	2.1	2.2

Note. Values are presented as mean (M) and standard deviation (SD). BMI = body mass index. Progressive motility refers to WHO motility grades a + b.

Table 4 shows that the type of infertility (primary vs. secondary) was not significantly associated with conception outcomes (p > 0.05).

Table 3. Comparison of clinical and semen parameters between successful and unsuccessful IUI cycles (n=211)

Variable	Successful pregnancy (n = 43) Mean (SD)	No pregnancy (n = 168) Mean (SD)	p-value
Endometrial thickness (mm)	8.3 (0.9)	7.4 (1.7)	0.002*
Duration of infertility (years)	3.1 (2.1)	4.4 (3.2)	0.007*
Maternal age (years)	30.4 (4.0)	31.8 (5.05)	0.124
Body mass index (kg/m²)	25.2 (3.2)	25.8 (3.9)	0.388
Sperm count (million/mL)	23.2 (11.2)	21.6 (11.1)	0.682
Progressive sperm motility (%)	21.5 (10.7)	24.4 (11.7)	0.440
Normal sperm morphology (%)	1.8 (0.9)	2.2 (2.4)	0.780
Number of IUI cycles	1.3 (0.4)	1.6 (0.7)	0.037*

Note. Values are presented as mean (SD) unless otherwise indicated. BMI = body mass index. *p < 0.05 indicates statistical significance.

Table 4. Type of infertility (n=211)

Type of infertility	Successful pregnancy n (%)	No pregnancy n (%)	p-value
Primary infertility	26 (60.5)	101 (60.1)	0.628
Secondary infertility	17 (39.5)	67 (39.9)	0.759

Discussion

The present study evaluated the relationship between maternal fertility characteristics and paternal semen parameters with the success rate of IUI in couples undergoing treatment for infertility. The findings demonstrated that endometrial thickness, duration of infertility, and number of IUI cycles were significantly associated with pregnancy outcomes, whereas maternal age, BMI, and conventional semen parameters did not show statistically significant relationships with IUI success. These results highlight the multifactorial nature of fertility and emphasize the importance of uterine receptivity and timely intervention in optimizing reproductive outcomes.

One of the most notable findings of this study was the significant association between endometrial thickness and IUI success. Women who achieved pregnancy had a significantly greater mean endometrial thickness compared with those who did not conceive, with the most favorable outcomes observed when endometrial thickness ranged between 7 and 9 mm. Adequate endometrial development is widely recognized as a key factor for successful implantation, as it reflects optimal estrogenic stimulation and a receptive uterine environment.

Several previous studies have reported similar findings, suggesting that insufficient endometrial thickness may compromise implantation potential and reduce pregnancy rates following assisted reproductive procedures (5,8). Our findings therefore support the clinical importance of careful monitoring of endometrial development during ovulation induction cycles and suggest that optimizing endometrial receptivity may improve IUI outcomes.

The duration of infertility also emerged as a significant predictor of treatment success. Couples who conceived had a shorter mean duration of infertility compared with those who did not achieve pregnancy. This observation is consistent with prior research indicating that prolonged infertility may reflect underlying reproductive pathologies that are less amenable to treatment with relatively simple interventions such as IUI (1,10). Early referral for fertility evaluation and timely initiation of treatment may therefore enhance the probability of success by addressing potentially reversible factors before more complex reproductive dysfunction develops.

Another finding of this study was the inverse relationship between the number of IUI cycles and pregnancy success. Couples who achieved pregnancy tended to conceive in earlier treatment cycles, while those requiring multiple cycles had lower success rates. This pattern has been reported in several fertility studies and may indicate that patients with more favorable reproductive characteristics tend to respond quickly to treatment, whereas those with more complex infertility factors may require alternative assisted reproductive technologies (10,11). From a clinical

perspective, these findings may help inform treatment planning and counseling, particularly regarding the optimal number of IUI attempts before considering more advanced approaches such as in vitro fertilization.

In contrast to some previous reports, maternal age did not demonstrate a statistically significant relationship with IUI success in this study. Although increasing age is widely recognized as a major determinant of female fertility, the absence of a significant association in our findings may be explained by the relatively limited number of women of advanced reproductive age included in the study population. In addition, most participants were under 40 years of age, a range in which ovarian reserve and oocyte quality may still remain relatively preserved. Similar observations have been reported in some studies in which maternal age did not significantly influence IUI outcomes when the majority of participants were within younger reproductive age groups (8,12). Nonetheless, the broader literature consistently supports the importance of age as a determinant of reproductive potential.

Body mass index was also not significantly associated with pregnancy outcomes in this cohort. Although obesity has been linked to hormonal imbalance, ovulatory dysfunction, and impaired endometrial receptivity, the majority of participants in the present study had BMI values within the normal or mildly elevated range. This limited variation may have reduced the ability to detect a meaningful association between BMI and IUI success. Previous studies have reported mixed findings regarding the impact of BMI on fertility treatment outcomes, with some identifying negative effects primarily in cases of severe obesity (9,14).

Similarly, conventional semen parameters including sperm count, progressive motility, and normal morphology did not demonstrate significant associations with pregnancy outcomes in this study. One explanation may be that all semen samples met the minimum eligibility threshold for IUI following sperm preparation, thereby reducing variability among participants. Once adequate motile sperm counts are achieved after processing, additional improvements in semen quality may have limited incremental effects on fertilization probability in the context of IUI. Comparable findings have been reported in some clinical studies suggesting that beyond a certain threshold, semen parameters may play a less decisive role in determining treatment success (11,12). Nonetheless, severe male factor infertility remains an important indication for alternative assisted reproductive technologies.

Despite providing meaningful insights, this study has several limitations that should be acknowledged when interpreting its findings. As a retrospective analysis, it was inherently dependent on the accuracy and completeness of clinical records, which may have introduced information bias and limited the ability to control for all potential confounders. The study was conducted at a single infertility center, which may restrict the generalizability of the results to broader or more diverse populations, particularly given that clinical practice patterns, sperm preparation techniques, and stimulation protocols can vary across institutions. Additionally, although important maternal and paternal parameters were evaluated, other potentially influential factors—such as ovarian reserve markers including anti‑Müllerian hormone or antral follicle count, lifestyle characteristics such as smoking, alcohol consumption, and physical activity, and psychosocial stressors were not systematically assessed, despite their recognized relevance in predicting IUI outcomes in previous studies (1,5,8). The study population also included a limited proportion of women over 40 years of age and individuals with extreme BMI values, which may have reduced the ability to detect stronger associations related to age‑related reproductive decline or obesity‑related endocrine effects. Furthermore, semen analysis was performed using standard WHO parameters, yet advanced sperm functional tests such as DNA fragmentation, which have been associated with reproductive outcomes in some reports (9,11,12), were not available in this dataset. Finally, cumulative pregnancy outcomes across multiple cycles were not fully explored, although such measures are increasingly recognized as important indicators of treatment effectiveness.

Conclusion

In conclusion, the findings of this study suggest that endometrial thickness and duration of infertility are important predictors of IUI success, while maternal age, BMI, and conventional semen parameters may have less influence within appropriately selected patient populations. These results emphasize the importance of careful patient selection, optimization of endometrial receptivity, and timely initiation of fertility treatment to improve reproductive outcomes. Future prospective multicenter studies incorporating broader

patient populations and additional reproductive biomarkers are warranted to further refine predictive models and guide individualized fertility treatment strategies.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

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