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Evaluation of Follicular Oocyte Index (FOI) as a Predictive Marker in Association with Female Age for Clinical Pregnancy Rate in IVF Cycles

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Abstract

Objective: To evaluate the Follicular Oocyte Index (FOI) as a dynamic marker of ovarian responsiveness and its predictive value for clinical pregnancy, particularly in association with female age, in patients undergoing IVF cycles.
Methods: This prospective cohort study included 114 women undergoing IVF cycles at a tertiary care fertility center. FOI was calculated as the ratio of oocytes retrieved to antral follicle count (AFC) and categorized into four ranges (<40%, 40–60%, 61–80%, >80%). Statistical analyses included correlation, regression, and ROC curve validation to assess FOI's predictive value.
Results: FOI showed a strong positive correlation with beta-HCG positivity ($r = 0.72$) and clinical pregnancy rate ($r = 0.67$, $p < 0.001$). FOI values declined with age: patients aged 20–30 years had the highest mean FOI (78.4%), while those aged 41–45 had the lowest (43.5%). Logistic regression confirmed FOI as an independent predictor of clinical pregnancy (OR = 2.57). Patients with FOI >80% achieved a 73.8% pregnancy rate versus 27.6% in those with FOI <40%.
Conclusion: FOI is a robust, independent predictor of clinical pregnancy in IVF. Its integration with age and other markers enhances IVF planning, allowing personalized treatment strategies.

Keywords: Follicular Oocyte Index, IVF, Clinical Pregnancy Rate, Female Age, Ovarian Response

INTRODUCTION

Infertility is a global health challenge, affecting approximately 10–15% of reproductive-aged couples. In-vitro fertilization (IVF) has emerged as a widely adopted assisted reproductive technique; however, success rates remain suboptimal, particularly due to variability in ovarian response. Traditional ovarian reserve markers such as anti-Müllerian hormone (AMH), antral follicle count (AFC), and baseline follicle-stimulating hormone (FSH) are routinely used to assess ovarian capacity. Yet, these markers often fail to accurately predict clinical pregnancy outcomes.

The Follicular Oocyte Index (FOI), calculated as the ratio of the number of oocytes retrieved to the baseline AFC, is a novel, dynamic metric proposed to evaluate functional ovarian responsiveness. FOI not only reflects the static reserve but also quantifies ovarian sensitivity to stimulation. Previous studies have highlighted FOI's association with improved embryo development and clinical pregnancy outcomes. However, the relationship between FOI and female age—a well-established determinant of fertility—requires further exploration.

This study aims to assess FOI as an independent predictor of clinical pregnancy and to examine its interaction with female age. By evaluating both FOI and age together, we hope to enhance the predictive accuracy for IVF outcomes and inform more tailored clinical strategies.

2. Materials and Methods

This prospective cohort study was conducted at the Pacific IVF Centre, Pacific Medical College and Hospital, Udaipur, Rajasthan, from June 2023 to June 2024. The study included 114 women aged between 20 and 49 years who were undergoing IVF treatment and met the inclusion criteria.

Inclusion and Exclusion Criteria

Inclusion Criteria

1. Women aged 20–49 years undergoing IVF cycles.

Exclusion Criteria

1. Women diagnosed with uterine anomalies.
2. Patients with no oocytes retrieved during ovarian stimulation.
3. Women with polycystic ovarian disease (PCOD).

FOI was calculated using the formula:

FOI (%) = (Number of oocytes retrieved / Antral Follicle Count) × 100

Ovarian Stimulation Protocol and Oocyte Retrieval

Baseline Assessment: On Day 2 or 3 of the menstrual cycle, a transvaginal ultrasound scan is performed to measure antral follicle count (AFC), which serves as the baseline indicator of ovarian reserve.

Stimulation Protocol: Ovarian stimulation begins on the same day with the administration of Human Menopausal Gonadotropin (HMG) or Recombinant Follicle-Stimulating Hormone (rFSH). The starting dose of HMG is 75-150 units IU (adjustable up to 450 IU), while rFSH starts at 150 IU (adjustable up to 300 IU). A repeat ultrasound scan is performed on Day 7 or 8 (five days post-stimulation) to monitor follicular growth, and the dosage of gonadotropins is adjusted as required. Starting on Day 7 or 8, a GnRH antagonist (Inj cetrorelix acetate 0.25 mg, subcutaneous) is introduced to prevent premature ovulation.

Follicular Maturation: On Day 12 or 13, the final follicular study is conducted to ensure the presence of mature follicles (16–22 mm in diameter). The GnRH antagonist is continued until the trigger injection is administered.

Trigger Injection and Oocyte Retrieval: The trigger injection—Inj leuprolide acetate 3 mg or Inj human chorionic gonadotropin (hCG) 5000- 10,000 units —is administered at least 5 hours after the last dose of GnRH antagonist. Oocyte retrieval is performed 36 hours after the trigger injection via transvaginal ovum pick-up, ensuring optimal timing for follicular aspiration.

Embryo Transfer: Following oocyte retrieval, embryos are transferred either fresh or frozen, depending on the patient's specific protocol and response to stimulation.

Clinical pregnancy was defined by the presence of a gestational sac with cardiac activity on ultrasonography at 6 weeks. Data on age, BMI, AFC, oocyte retrieval, and pregnancy outcomes were collected.

Statistical analysis was conducted using SPSS version 22. Descriptive statistics were expressed as means and percentages. Pearson's correlation and logistic regression were used to assess associations. ROC curves evaluated the sensitivity and specificity of FOI as a predictor of clinical pregnancy. A p-value <0.05 was considered statistically significant.

RESULTS

Among 114 patients included in the study, FOI values ranged from 28% to 92%. The mean FOI decreased progressively with age. Women aged 20–30 years had a mean FOI of 78.4%, while those aged 41–45 years had a mean FOI of 43.5%.

Table 1: FOI and Pregnancy Success Across IVF Patients

FOI (%) Range	Number of Patients	Beta-HCG Presence (%)	Clinical Pregnancy Rate (%)
<40	21	38.1	27.6
40–60	30	57.4	45.3
61–80	35	75.2	64.1
>80	28	84.6	73.8

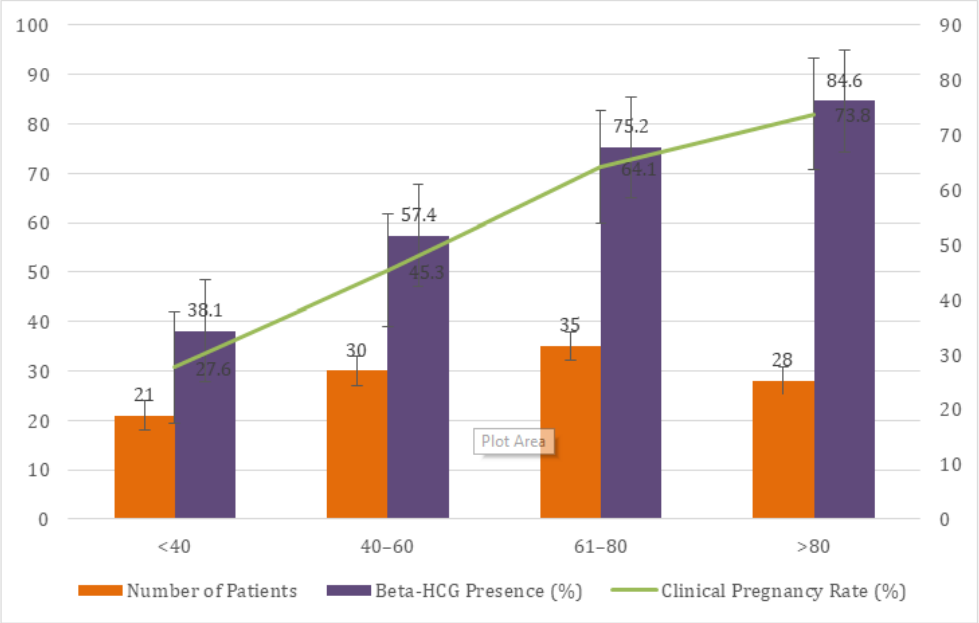

Fig 1- FOI and Pregnancy Success Across IVF Patients

Table 2: Descriptive Statistics of FOI Across Age Groups and Pregnancy Outcomes

Age Group (Years)	Mean FOI (%)	Median FOI (%)	Standard Deviation	Beta-HCG Presence (%)
20–30	78.4	80.1	12.3	85.2
31–35	68.7	69.2	10.8	76.4
36–40	58.9	57.8	11.5	62.8
41–45	43.5	41.7	9.7	40.2

Table 3: FOI and Pregnancy Success Across Different Subgroups

Subgroup	Mean FOI (%)	Beta-HCG Presence (%)	Clinical Pregnancy Rate (%)
Age 20–30 years	78.6	85.3	72.8
Age 31–35 years	68.9	76.5	64.9
Age 36–40 years	59.2	62.9	50.2
Age 41–45 years	43.1	39.8	30.4
Male Age <35 years	71.3	81.2	68.5
Male Age ≥35 years	60.7	64.1	49.3
BMI <25	72.1	78.6	65.7
BMI ≥25	55.8	60.2	45.8
Primary Infertility	69.5	74.3	63.4
Secondary Infertility	62.8	66.9	52.9
Tobacco Use (Yes)	58.3	62.7	47.5
Tobacco Use (No)	72.4	80.5	67.8

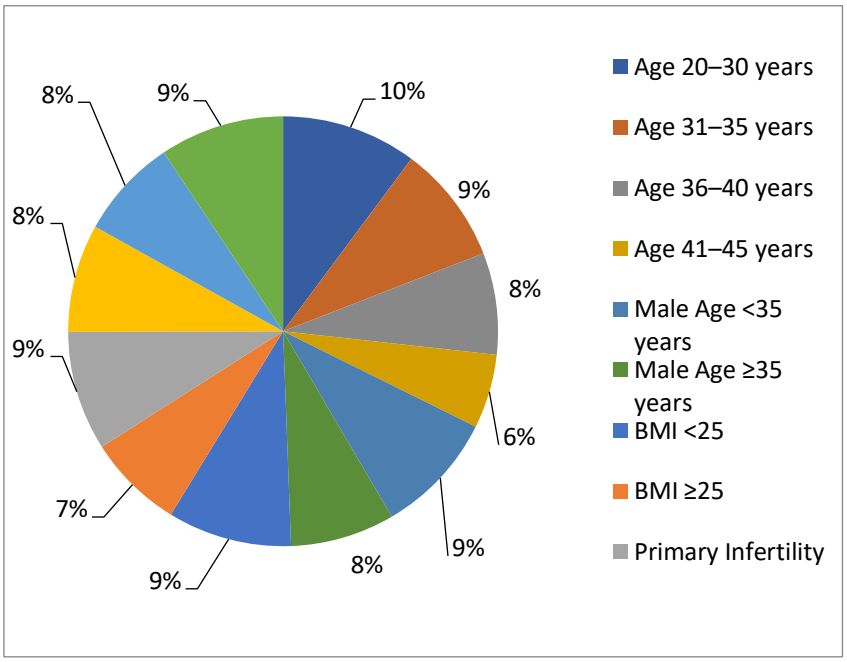

Fig-2 FOI and Pregnancy Success Across Different Subgroups

FOI positively correlated with beta-HCG positivity ($r = 0.72$) and clinical pregnancy rate ($r = 0.67$, $p < 0.001$). Logistic regression showed that FOI was an independent predictor of clinical pregnancy (OR = 2.57, 95% CI 1.89–3.51, $p < 0.001$). Other significant predictors included female age (OR = 0.65), AFC (OR = 1.52), and beta-HCG presence (OR = 3.49).

Patients with FOI >80% demonstrated a 73.8% clinical pregnancy rate, compared to 27.6% among those with FOI <40%. FOI was also positively associated with higher oocyte yield, usable embryos, and implantation rates. ROC analysis indicated that FOI values above 60% had the highest predictive accuracy for clinical pregnancy outcomes.

DISCUSSION

The present study confirmed a strong positive correlation between FOI and key IVF outcomes. Specifically, patients with FOI >80% exhibited a 73.8% clinical pregnancy rate, a finding comparable to Li and Chen (2022), who reported increased pregnancy rates across higher FOI tertiles in over 4,000 IVF cycles. This suggests that FOI is a reliable indicator of ovarian efficiency.

his study observed a marked decline in FOI with advancing female age, echoing findings by Geng et al. (2020), who reported that younger women with poor ovarian reserve still exhibited higher FOI compared to older women with normal reserve. Our data support this, showing patients aged 20–30 had mean FOI of 78.4% versus just 43.5% in those aged 41–45. These results emphasize the importance of age-adjusted reproductive strategies, such as early embryo freezing and personalized stimulation protocols.

BMI was inversely correlated with FOI and clinical outcomes, with patients having BMI ≥25 showing lower implantation and pregnancy rates. These results supported by Nguyen et al. (2023), who identified BMI as a significant determinant of FOI.

Tobacco use was associated with substantially lower FOI and pregnancy rates, consistent with findings by Sunkara et al. (2022), who highlighted the negative impact of smoking on oocyte competence and IVF outcomes.

Our logistic regression model showed FOI as a strong independent predictor of pregnancy success (OR = 2.57, $p < 0.001$), alongside factors such as age and AFC. ROC analysis confirmed FOI's predictive sensitivity and specificity, particularly at thresholds >60%, consistent with studies by Chen et al. (2020) and Alviggi et al. (2018), who emphasized FOI's clinical relevance in identifying hypo-responders.

CONCLUSION

The study concludes that FOI is a robust, independent predictor of clinical pregnancy in IVF cycles. This research establishes the Follicular Output Index (FOI) as a reliable and clinically valuable marker for predicting IVF outcomes and guiding individualized fertility treatments. FOI provides a more nuanced assessment of ovarian function than conventional measures, allowing clinicians to anticipate treatment response and success rates with greater precision.

Limitations and Recommendations

While FOI is a useful dynamic marker, variability in AFC assessment and stimulation protocols may affect consistency. Future studies should focus on standardizing FOI calculation, integrating it into AI-based IVF prediction models, and exploring its role in cumulative live birth rate across multiple cycles.

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