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# Impact of Preimplantation Genetic Testing for Aneuploidy (PGT-A) on IVF Pregnancy Outcomes: A Retrospective Cohort Study from a High-Altitude Fertility Center in Ecuador (2,850 m)

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## ABSTRACT

One of the primary therapy methods for infertility is in vitro fertilisation (IVF); nevertheless, the success rates are not constant. Embryo biopsy-based preimplantation genetic testing (PGT-A) has been suggested as a method to enhance the implantation and euploid embryo selection results. The objective was to conduct a retrospective study of the role of embryo biopsy as a PGT-A predictor before embryo transfer on the chances of pregnancy in IVF procedures. The study was a cross-sectional, retrospective and analytical study on 93 patients undergoing IVF comparing others with and without embryo biopsy and clinical and biological variables, including age, duration and cause of infertility, endometrial thickness, embryo quality and attempts. The statistical analysis involved Chi-square tests and odds ratio (OR) with p = 0.05. Embryo biopsy revealed a moderate protective effect against implantation failure (OR = 0.79; 95 per cent CI 0.52–0.93), but not statistically significant (p = 0.212). Endometrial thickness less than 7 mm (OR = 29.04) and poor embryo quality (OR = 22.59) were found to be the major risk factors. On the other hand, defence mechanisms were endometrial thickness of 7 mm, good quality of embryos and embryo biopsy. PGT-A with embryo biopsy seems to be an effective and safe procedure when used selectively, especially in those patients with increased reproductive risk. This is dependent on endometrial receptivity, embryo quality and maternal age..

**Keywords**: In vitro fertilization, embryo biopsy, aneuploidy, embryo implantation, preimplantation genetic testing

## INTRODUCTION

One of the most popular assisted reproductive technologies used to cure infertility in vitro is in vitro fertilisation (IVF). Nevertheless, even with the technological progress in the given area, success rates of IVF treatment are average, particularly in women who are older than 35 years or have a history of multiple implantation failures or miscarriages (Kelly et al., 2021).

The quality of the embryos and the endometrial receptivity are the determinants of the success of IVF and the selection of embryos with the best potential is essential.

Biopsy of embryos has become an important tool to enhance embryo screening through chromosomal analysis before implantation (PGT-A). In this procedure, a few cells are extracted out of the embryo to perform chromosome analysis, and then the embryo is transferred into the womb. Its capabilities to detect embryos with chromosomal abnormalities that cannot be sustained are the cause of the decrease in implantation failures (Dengler et al., 2021). There are doubts regarding the effectiveness of embryo biopsy and the consequences such a procedure can cause to pregnancy rates in IVF patients despite the potential benefits that this procedure can bring (Turkgeldi et al., 2020).

Embryo implantation, another crucial aspect in IVF outcomes, entails the attaching of the embryo to the endometrium. It will rely on the quality of embryos and the alignment of the embryo and the inner world. The success of the implantation depends on the quality of the embryo, the age of the mother, and previous hormonal treatment (Mackens et al., 2022). However, even with these improvements, implantation failures continue to be a major problem in IVF processes, especially when using embryos of normal chromosome sets. This procedure has been optimised by the use of technologies such as ultrasound to help in directing the catheter when transferring embryos. Nonetheless, embryo-uterus synchrony remains a crucial parameter in the success of implantation (Godiwala et al., 2023).

Other researchers have shown that PGT-A enhances the embryo selection process since it selects those which have a greater implantation potential (X. Cheng et al., 2022a). Although certain studies indicate that embryos that have been picked using PGT-A have an increased probability of a successful pregnancy and the risk of aneuploidy is lowered, it is feared that the embryos might become less viable due to the damage that might be inflicted during biopsy (J. Cheng et al., 2021). The cost of the biopsy and genetic analysis is a barrier to this high-level technology in the countries with limited resources since some patients will not be able to afford it (Shen et al., 2022).

The recent researchers state that high-quality genetic embryos might be identified and could enhance the pregnancy rate and decrease the rates of miscarriage in the IVF cycles (New et al., 2023). Nonetheless, the effects of embryo biopsy on implantation and pregnancy rates lack unanimity, hence the importance of conducting more studies in this field.

**JUSTIFICATION**

In vitro fertilisation is now a basic instrument that assists infertile couples conceive. Nevertheless, the success rates are low, particularly in women who are above 35 years old, those who have experienced recurrent miscarriages, and the ones who have had past experiences of unsuccessful implantations (Kelly et al., 2021). The number of IVF cycles carried out in different parts of the world has drastically risen, but few of them have resulted in pregnancy, meaning that egg collection and embryo screening need to be streamlined so that higher success rates can be achieved.

Here, embryo biopsy is a proposed technique to enhance embryo selection to distinguish between euploid and non-euploid embryos to enhance chances of implantation and pregnancy outcome. The process allows detecting chromosomal abnormalities, including the aneuploidy that is linked to low implantation rates or miscarriages (Viotti, 2020). Although it has been noted to increase the success rates, concerns have been raised on its true effects on the outcome of the IVF process, especially on the possibility of any adverse effects of the biopsy on the embryo quality (Dengler et al., 2021).

This study is justified by the fact that there is a need to present more detailed, clear, and reality-based evidence concerning the issue of the embryo biopsy role in the determination of the success rate of IVF. There is no agreement regarding the efficacy of biopsy to enhance the outcome (Godiwala et al., 2023). The goal of this research is to learn whether the advantages of biopsy are more than the disadvantages and whether the choice of chromosomally sound embryos can drastically improve pregnancy and decrease the number of miscarriages.

The retrospective study of the IVF cycle data will evaluate the impact of embryo biopsy on the outcomes of various patient groups. The data collected will be used to enhance evidence-based clinical practices in the area of assisted reproduction to offer more informed options to infertile couples. As well, this study will also contribute to the creation of a personalised treatment programme, which will maximise IVF results (Shen et al., 2022).

The following guiding question was used to direct this review, taking into account the population or problem of interest and the intervention that will be conducted in the study setting:

How does embryo biopsy affect pregnancy rates in patients who have undergone in vitro fertilisation before embryo transfer of PGT-A?

**PICO STRATEGY BREAKDOWN**

1. Population (P):Patients undergoing in vitro fertilization (IVF).
2. Intervention (I): Embryo biopsy for preimplantation genetic testing (PGTA) performed prior to embryo transfer.
3. Comparison (C): IVF cycles without embryo biopsy for PGTA.
4. Outcome (Results) (O): Pregnancy success rates, measured in terms of implantation rate and clinical pregnancy rate

(confirmation of pregnancy by ultrasound).

## HYPOTHESIS

PGTA-embryo biopsy on day 5 or 6 embryo development before embryo transfer during the IVF cycles has been shown to substantially decrease aneuploid embryo transfer, thereby enhancing implantation and lowering incidences of miscarriages

## THEORETICAL FRAMEWORK

ANTECEDENT

A PGT-A embryo biopsy has taken its place as a valuable instrument to enhance the outcome of in vitro fertilisation (IVF), such as the genetic selection of healthy embryos. Some research has been conducted to investigate its effect on the pregnancy success rates. Li et al.'s (2021) research emphasised that embryo biopsy performed on an embryo during day 5 or 6 of embryo growth was associated with a significant reduction in aneuploid embryo transfers, as it raises the probability of implantation and reduces the incidence of miscarriage.

Conversely, Romanski (2021) demonstrated a stronger effect of PGT-A on women above 35 years old, who have a higher rate of incidences of aneuploidy. This age group may be more favorable to PGT-A, since it offers a higher probability of success because embryos with a euploid phenotype may be transferred (Romanski and Kang, 2021).

The analysis by Karavani et al. (2022) revealed that PGT-A could not only enhance pregnancy rates but also prevent the transfer of embryos with genetic mutations that are related to inherited diseases, which is of great importance to couples with a history of genetic conditions and hence improves the birth outcomes (Karavani et al., 2022).

Humm and Frankfurter (2021) have also determined that PGT-A increases the chances of pregnant women who have experienced multiple implantation failures; it is crucial to select euploid embryos. Nevertheless, maternal age is still one of the determinants in the analysis of the benefits of PGT-A (Humm & Frankfurter, 2021).

Leeners et al. (2023) performed a systematic review, which came to the conclusion that PGT-A positively influences the results of IVF in older women or those who have had multiple unsuccessful implantations. Nevertheless, its popular usage among women of younger ages is controversial. Research found that the PGT-A did not necessarily perform better in women below 35 years of age, which indicates that PGT-A is not necessarily recommended in every instance.

Moreover, according to a study by Ni et al. (2022), the use of PGT-A combined with frozen embryo transfer (FET) can help to improve the successful pregnancy rates of couples with a history of implantation failure. This observation confirms the assumption that the IVF success rates can be improved by employing a combination of methods, particularly when the chromosomal analysis is conducted prior to the transfer (Ni et al., 2022).

Lastly, an investigation carried out by Neumann et al. (2020) has evaluated the cost-benefit of PGT-A use in IVF and has shown that even though the method is an added expense, its effectiveness in preventing miscarriages, multiple pregnancies, and the positive outcomes of improving the health of the born babies justify its application in different clinical settings.

## THEORETICAL FOUNDATIONS

EMBRYO BIOPSY

Embryo biopsy is a technology where IVF methods are applied and evaluation of embryo chromosomal quality is conducted prior to transfer. It is a preimplantation chromosomal screening, in which a few embryonic cells, usually at the blastocyst stage, are removed to be analysed, called Preimplantation Genetic Testing for Aneuploidies (PGT-A) (Nikiforov et al., 2021). This process presents important data on the genetic material of the embryo, and it is possible to select the euploid embryos with the best chance of implantation and successful pregnancy.

It has been proven in different studies that embryo biopsy enhances the success rate of IVF in the procedure, particularly among individuals with a history of multiple miscarriages or recurring implantation failures. Nevertheless, its usability and the choice to conduct the procedure are affected by the risks involved in the procedure, including possible embryo damage and its price (Kelly et al., 2021).

## EMBRYO IMPLANTATION

Embryo planting is a complicated procedure whereby the embryo sticks to the uterine wall and starts growing. It depends on the intercourse between the embryo and the uterine environment. The process of implantation commences about six days after fertilisation, when the blastocyst discharges its zona pellucida and enters the endometrium. The quality of the embryos, the endometrial receptivity, and hormonal signals are the criteria that influence the success of implantation (Cha et al., 2012).

IVF processes may influence the implantation process based on the embryo's size, its developmental status, and the timeliness of embryo transfer to the female hormone cycle (Ma et al., 2023). Recent research indicates that the successful implantation of the embryo and the prevention of the implantation failure are impossible without the proper hormonal treatment of the

mother and the choice of the high-quality embryos (Reshef et al., 2022).

**EMBRYO TRANSFER**

Embryo transfer is one of the last procedures in the IVF treatment, whereby an embryo is implanted into the uterus to implant in the endometrium that has been prepared to accept the embryo. This is normally performed on day 3 to day 5 of embryo development, with respect to the method employed and quality of embryo (Diedrich et al., 2007a). Transfer does not need any anaesthesia and the embryo is inserted into the uterus using a flexible catheter.

The timing of the transfer is a highly sensitive issue that can be optimised to achieve the highest success rates because the implantation can only be optimised when the transfer and the uterine environment are synchronised (Legro, 2023). Significant progress has been achieved in the technique of delivery, such as using ultrasound-directed equipment to enhance the accuracy of insertion and the optimisation of the endometrial microclimate by using previous hormonal therapies (Machtinger et al., 2022). The results of a recent study conducted by Leeners et al. (2023) indicated that blastocyst transfers are associated with a higher rate of implantation success than those of embryos transferred on day 3, which proves the significance of the selection of the appropriate time of transfer.

Relationship Between Embryo Biopsy, Implantation, and Embryo Transfer

Embryo biopsy, which permits the selection of embryos with an appropriate chromosomal profile, has a direct effect on the rate of implantation. The biopsy results can be used to avoid transferring aneuploid embryos that show a reduced chance of successful implantation through the chromosomal analysis (Cascante et al., 2022). It can greatly enhance the rates of successful IVF procedures, especially among older people or those who have undergone failures in implantations before (Sun et al., 2023).

Both embryo biopsy and embryo transfer, however, involve risks. According to some research, the fact that the process of biopsy can damage the cells of the embryo can also influence the possibility of a successful implantation (Borovac-Pinheiro et al., 2021). Nevertheless, the vast majority of studies claim that, done properly, biopsy does not have any harmful effects on the rate of implantation; on the contrary, it can enhance the chances of successful implants because it selects embryos more accurately (Hou et al., 2021).

**OBJECTIVES**

To determine the impact of embryo biopsy of PGT-A before transfer of embryos to assess the implantation rates and clinical pregnancy outcome of IVF cycles.

Specific Objectives

To compare the success rates of implantation in IVF cycles using PGT-A embryo biopsy, against those not using genetic testing as such on embryo selection, and then their subsequent effect on implantation.

To examine the clinical pregnancy rates of patients undergoing IVF in order to undergo embryo biopsy of PGT-A compared with those not undergoing the procedure, it is important to consider whether the use of euploid embryos would increase the likelihood of a clinical pregnancy.

To determine the relevance of maternal age on the efficacy of PGT-A especially in women above 35 years, and whether embryo biopsy can be effective in improving pregnancies in women who are at risk.

To determine the risk of miscarriage during IVF cycles when embryo are biopsied using PGT-A and when embryos are not biopsied using PGT-A, to determine whether selection of embryos based on their chromosomal normality can decrease spontaneous abortions.

To determine any complications or risks related to embryo biopsy procedure, and any effect on embryo viability, and to evaluate the benefits of genetic testing against the risks of embryo damage.

In order to determine the cost-effectiveness of using PGT-A in an IVF cycle, it is important to calculate the extra cost of genetic testing and embryo biopsy and juxtapose them to the possible benefits in terms of the beneficial pregnancy outcome and lower miscarriage rates.

To determine the impact of embryo biopsy on live birth rates, it is important to examine whether genetically healthy embryo selection leads to healthier pregnancies and births, especially in patients having a history of repeated miscarriage or implantation failure

**METHODOLOGY**

TYPE AND RESEARCH DESIGN

The cross-sectional, retrospective and analytical design is used in this study. Patient clinical records of patients undergoing in vitro fertilisation (IVF) procedures with and without embryo biopsy to examine preimplantation genetic testing (PGT-A) were reviewed to identify the relationship and risk of performing the biopsy and the implantation rate and other factors associated with treatment success.

**POPULATION AND SAMPLE**

The sample was comprised of 93 patients undergoing IVF in the years 2019-2025 at PROVIDEDA Speciality Hospital.

The entire universe was worked with (not probabilistic sampling), since the database was not infinite and was accessible in its entirety.

**INCLUSION AND EXCLUSION CRITERIA**

INCLUSION CRITERIA

Women that received IVF between 2019 and 2025, including embryo transfer.

Patients whom medical records have full clinical data on.

Patients that had achieved the blastocyst stage before embryo transfer.

Patients having an endometrial thickness of more than 7 mm during embryo transfer.

Patients having high-quality embryos (Grade A).

Patients of any age

**EXCLUSION CRITERIA**

Incomplete clinical data of patients.

Proceeds were raised due to medical reasons that cancelled the embryo transfer.

Patients that had advanced to morula before embryo transfer.

Patients whose endometrial thickness at the moment of embryo transfer is less than 7 mm.

Unsuccessful embryos of low quality (Grade B and C).

**STUDY VARIABLE**

INDEPENDENT VARIABLE

PGT-A biopsy of embryos before embryo transfer.

DEPENDENT VARIABLE

The pregnancy success rate (as measured by a positive pregnancy test 15 days after embryo transfer).

CONTROL VARIABLES

Maternal age.

Cause of infertility.

Duration of infertility.

Number of embryos transferred.

DATA COLLECTION TECHNIQUES AND INSTRUMENTS

This data was mainly collected through the institutional database and electronic clinical records of the hospital and was complemented by laboratory reports on embryology and genetics.

A structured data collection form (Appendix 1) was used to draw up the data, giving it a standard criterion per variable.

VALIDITY AND RELIABILITY OF INSTRUMENTS

To guarantee the validity and reliability of the information, only the official institutional clinical records, electronic medical histories, and embryology and genetics laboratory reports prepared and reviewed by the professional experts were utilised.

It also validated the study with standardised primary sources, and each variable (e.g., age, endometrial thickness, embryo quality, implantation outcomes) was defined by the clear clinical terms so it would not be ambiguous to identify these variables in the process of data collection.

The two researchers cross-verified and independently reviewed the data to eliminate transcription errors, which was used to enhance the degree of reliability and internal consistency.

Besides, the homogenisation of the variables' code was conducted with the help of a structured form (Appendix 1) to guarantee the reproducibility of the analysis.

**DATA COLLECTION PROCEDURE**

Case Identification: All the records that fulfilled the inclusion criteria were chosen.*Data Extraction: Data including age, marital status, cause and duration of infertility, procedure type (with or without biopsy), endometrial thickness, embryo

quality, number of attempts and the outcome of implantation were extracted.

Coding and Grouping: Dichotomous and categorical variables were developed to make the analysis easier. e.g., age (25-34 vs. 35-50 years), endometrial thickness (> 7 mm / < 7 mm), embryo quality (high / low), etc.

Database Entry: The data has been centralised and cleaned in Microsoft Excel and then statistically analysed.

**DATA ANALYSIS TECHNIQUES**

DESCRIPTIVE ANALYSIS

The sample was characterised using mean, standard deviation and percentages.

ASSOCIATION AND RISK TESTS

The comparison of the success rates between groups was conducted with the help of chi-square and Student t-tests.

Risk or protective factors were calculated by determining the odds ratio (OR) between the variables.

**SIGNIFICANCE LEVEL**

Any p-value that was below 0.05 was deemed to be statistically significant.

Statistical Analysis:

The correlation between embryo biopsy for PGT-A and success rate of pregnancy will be established. For risk calculation:

OR = 1: Implies that there is no difference in the probability of the event in the two groups.

OR > 1: Increased risk of the event in the exposed group (with PGT-A).

OR < 1: Reduced risk of the occurrence in the exposed group.

To tabulate the data, Microsoft Excel was utilised to effectively arrange and analyse the data and develop the initial graphs to present the results. The statistical analysis of associations, risk factors and other multivariate analysis procedures through SPSS 21.0 software was performed to evaluate the relationship between variables as well as IVF success rates.

**APPROVAL BY ETHICS COMMITTEES**

The Biomedical Research Ethics Committee at San Francisco University pre-tested the protocol before the study began. The ethical principles, including beneficence, non-maleficence, autonomy, and justice, will be followed, and the study will make a contribution to the scientific knowledge without undermining the privacy or rights of the participants.

**CHARACTERIZATION OF THE POPULATION**

**Table 1 Characterization of the Population by Age**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| 25- 29<br>Optimal fertile age | 9 | 9,7 | 9,7 |
| 30 -34<br>Slightly reduced fertility | 14 | 15,1 | 24,7 |
| 35 - 39<br>Significant decline in fertility | 33 | 35,5 | 60,2 |
| 40 - 44<br>High difficulty in conceiving | 31 | 33,3 | 93,5 |
| 45- 50<br>Very reduced or almost no fertility | 6 | 6,5 | 100,0 |

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** As could be seen, the most common ones are the age group 35-39 years (35.5%) and the age group 40-44 years (33.3%), corresponding to the time when fertility rates decrease considerably and people have more problems conceiving. The fertile age range (25-29 years) was only 9.7 percent. This shows the struggles of the women in the study because age is a determinant of fertility and success rates of IVF. The results indicate that a very large percentage of the study participants belong to age groups that are less fertile, and this can affect the success of the assisted reproductive procedures.

**Table 2 Characterization of the Population by Age in Two Groups**

| | | | | |
|---|---|---|---|---|
| 25-34 | Optimal Fertility | 23 | 24,7 | 24,7 |
| | 35-50 | 70 | 75,3 | 100,0 |
| | **Total** | **93** | **100,0** | |

Source: Elaboración propia

**Interpretation:** As a proportion, 75.3 percent of the women fell within the age bracket of 35 and 50, an important finding outlining that infertility will mostly affect women who are already in their later adoption years. This is consistent with the literature, which identifies a major depletion of ovarian reserve after the age of 35. The statistics reveal the plight of women within this age bracket because they are witnessing a decline in their fertility which may affect the success rates of assisted reproductive technologies, such as IVF.

**Table 3 Characterization of the Population by Marital Status**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Single | 10 | 10,8 | 10,8 |
| Married | 71 | 76,3 | 87,1 |
| Common-law union | 6 | 6,5 | 93,5 |
| Divorced | 6 | 6,5 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** The married category was the most dominant (76.3%), and the second category was single women (10.8). Most of the women who received infertility treatment were in a formal relationship and this can be attributed to the fact that marriage is more stable and it may offer a stable base on which one can pursue the aspect of parenthood. This is in line with the concept that the stable couples are more inclined to turn to medical help when they have a fertility problem.

**Table 4 Characterization of the Population by Education Level**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| None | 1 | 1,1 | 1,1 |
| Primary | 1 | 1,1 | 2,2 |
| Secondary | 22 | 23,7 | 25,8 |
| Tertiary | 63 | 67,7 | 93,5 |
| Postgraduate | 6 | 6,5 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** The women were found to have tertiary education of 67.7 and postgraduate education of 6.5 meaning that most of the study population is well educated. This may be connected with voluntary postponement of motherhood due to academic or work factors as most educated women do. This procrastination is however known to predispose the risk of infertility with age because at the age of above 35 years fertility usually decreases. The results indicate the increased tendency of women to focus on education and career building that could affect the time of having a family.

**Table 5 Characterization of the Population by Residence**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Urban | 81 | 87,1 | 87,1 |
| Rural | 12 | 12,9 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** The majority of participants were of urban origin (87.1%), which is more indicative of the higher availability of specialised assisted reproduction services and infertility diagnoses than women in rural settings (12.9%).

**Table 6 Characterization of the Population by Duration of Infertility**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Primary infertility | 41 | 44,1 | 44,1 |
| Secondary infertility | 52 | 55,9 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** Forty-four-point one percent were nulliparous, which means primary infertility and 55.9 percent had their previous pregnancies, which means secondary infertility. The large rate of nulliparous women implies that primary infertility is a major problem in the population under study.

**Table 7 Characterization of the Population by Cause of Infertility**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Tubal | 17 | 18,3 | 18,5 |
| Ovarian | 18 | 19,4 | 38,0 |
| Uterine | 35 | 37,6 | 76,1 |
| Central | 4 | 4,3 | 80,4 |
| Male Infertility | 10 | 10,8 | 91,3 |
| Unspecified causes | 9 | 8,6 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** The major cause of infertility was uterine (37.6%), then ovarian (19.4%), and tubal (18.3%). Male causes were found to be 10.8, central causes 4.3 and unspecified causes 8.6. The given finding demonstrates the high necessity to carefully assess abnormalities of the uterus, which were the most common in the sample.

**Table 8 Characterization of the Population by Duration of Infertility**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Recent (0-5 years) | 53 | 57,0 | 57,0 |
| Moderate (6- 10 years) | 33 | 35,5 | 92,5 |
| Chronic (11- 20 years) | 7 | 7,5 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** Recent infertility (05 years, 57.0 percent) was the highest percentage, 35.5 percent was moderate infertility (6 years10 years and only 7.5 percent chronic infertility, 11 years20 years). This implies that the majority of women went to the doctor when they had reached the early years of having the trouble conceiving.

**Table 9 Characterization of the Population by Biopsy Performance**

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Si | 61 | 65,6 | 100,0 |
| No | 32 | 34,4 | 34,4 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** This case have shown that embryo biopsy was used in 65.6% of cases and most embryo were biopsied at the blastocyst stage (64.5%), which has a higher prognosis of successful implantation.

**Table 10 Characterization of the Population by Implantation**

| **Frequency** | | **Percentage** | **Cumulative Percentage** |
|---|---|---|---|
| Yes | 71 | 76,3 | 100,0 |
| No | 22 | 23,7 | 23,7 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** 76.3% of patients achieved implantation, while 23.7% did not. This relatively high success rate can be attributed to the appropriate selection of embryos and endometrial conditions in most cases.

**Table 11 Characterization of the Population by Endometrial Thickness**

| **Frequency** | | **Percentage** | **Cumulative Percentage** |
|---|---|---|---|
| Yes | 83 | 89,2 | 100,0 |
| No | 10 | 10,8 | 10,8 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** In 89.2% of patients, the endometrial thickness was greater than 7 mm, which is a favourable factor for embryo implantation. Only 10.8% had an endometrial thickness of less than 7 mm, which is generally associated with implantation failures.

**Table 12 Characterization of the Population by Embryo Quality**

| **Frequency** | | **Percentage** | **Cumulative Percentage** |
|---|---|---|---|
| High-Quality | 85 | 91,4 | 100,0 |
| Low-Quality | 8 | 8,6 | 8,6 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** It was found that 91.4 percent of transferred embryos were of high quality, and this high-quality embryo gives a great chance of success in assisted reproduction treatment.

**Table 13 Characterization of the Population by Number of Attempts**

| **Frequency** | | **Percentage** | **Cumulative Percentage** |
|---|---|---|---|
| Primary | 72 | 77,4 | 77,4 |

| Frequency | | Percentage | Cumulative Percentage |
|---|---|---|---|
| Secondary | 20 | 21,5 | 98,9 |
| Tertiary | 1 | 1,1 | 100,0 |
| **Total** | 93 | 100,0 | |

Source: Elaboración propia

**Interpretation:** The majority of patients were able to become pregnant on the first attempt (77.4%), after the second attempt (21.5%) and only 1.1% were able to conceive after three attempts. This is the efficacy of the treatment in the analysed group.

ASSOCIATION AND RISK OF EMBRYO BIOPSY FOR PGTA PRIOR TO EMBRYO TRANSFER AND IVF PREGNANCY SUCCESS RATE

**Table 14 Relationship Between Embryo Implantation and Age, Previous Pregnancies, Duration of Infertility, Endometrial Thickness, Embryo Quality, Number of Attempts, Infertility Cause, and Biopsy**

| | | Age | | Total | Previous Pregnancies | | Total | Duration of Infertility | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 25 a 34 years | 35 a 50 years | | Nulliparous | Previous pregnancies | | Infertility Duration (Short) | Infertility Duration (Long) | |
| Implantation | Yes | 17 | 54 | 71 | 32 | 39 | 71 | 39 | 32 | 71 |
| | No | 6 | 16 | 22 | 9 | 13 | 22 | 14 | 8 | 22 |
| **Total** | | **23** | **70** | **93** | **41** | **52** | **93** | **53** | **40** | **93** |

| | | Endometrial Thickness >7mm | | Total | Embryo Quality (High) | | Total | Number of Attempts (First) | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No | Yes | | No | Yes | | Primary | More than 1 attempt | |
| Implantation | Yes | 1 | 70 | 71 | 1 | 70 | 71 | 53 | 18 | 71 |
| | No | 9 | 13 | 22 | 7 | 15 | 22 | 19 | 3 | 22 |
| **Total** | | **10** | **83** | **93** | **8** | **85** | **93** | **72** | **21** | **93** |

| | | Cause of Infertility (Female) | | Total | Biopsy | | Total |
|---|---|---|---|---|---|---|---|
| | | Female | Non-Female | | No | Yes | |
| Implantation | Yes | 54 | 16 | 70 | 22 | 49 | 71 |
| | No | 20 | 2 | 22 | 10 | 12 | 22 |
| **Total** | | **74** | **18** | **92** | **32** | **61** | **93** |

Source: Elaboración propia

**Interpretation:** The cross-tabulations indicate how the dependent variable (implantation) was distributed with respect to various factors: Age: The frequency of implantation was higher in women aged 35-50 years (54 cases) compared to 25-34 years (17 cases). The proportion of the difference between groups was not very high, however, and implantation success among the groups in this cohort was not primarily determined by age. Past pregnancies: Implantation had been seen in both nulliparous women (32) and also women who had previous pregnancies (39), with no drastic difference between the two groups. Length of infertility: There was no effect on the number of implantations; shorter intervals of infertility (0-5 years) attained higher levels of implantations (39) than longer periods of infertility (32), indicating that there was a negative relationship between the length of infertility and the number of implantations. Aaaetiologies of infertility (female/non-female): There were more implantations in female aaetiologies (54) than in non-female aaetiologies (16). Biopsy: More patients who biopsied (49) had more implantations than those who did not (22). Endometrium: A thickness of >7 mm was strongly correlated with success (70 implantations vs. only 1 in <7 mm). Embryo quality: 70 implantations were obtained with high-quality embryos and 1 with low-quality embryos. Attempts: 53 implantations were successful in the first attempt, but only 18 were successful in subsequent attempts.

**Table 15 Statistical analysis of the association between embryo implantation and age, previous pregnancies, time of infertility, cause of infertility, biopsy, endometrial thickness, embryo quality, and number of attempts**

| | **Age** | | **Previous Pregnancies** | | **Duration of infertility** | | **Infertility cause (female/non-female)** | |
|---|---|---|---|---|---|---|---|---|
| | **Value** | **Sig.** | **Value** | **Sig.** | **Value** | **Sig.** | **Value** | **Sig.** |
| Pearson's Chi-Square | ,100[a] | ,752 | ,118[a] | ,731 | ,519[a] | ,471 | 2,016[a] | ,156 |
| Plausibility Reason | ,099 | ,754 | ,118 | ,731 | ,525 | ,469 | 2,294 | ,130 |
| Phi | ,033 | ,752 | -,036 | ,731 | ,075 | ,471 | ,148 | ,156 |

| | **Biopsy** | | **Endometrium** | | **Embryo Quality** | | **Number of attempts** | |
|---|---|---|---|---|---|---|---|---|
| | **Value** | **Sig.** | **Value** | **Sig.** | **Value** | **Sig.** | **Value** | **Sig.** |
| Pearson's Chi-Square | 1,558[a] | ,212 | 27,308[a] | <,001 | 19,755[a] | <,001 | 1,319[a] | ,251 |
| Plausibility Reason | 1,517 | ,218 | 23,206 | <,001 | 16,509 | <,001 | 1,432 | ,231 |
| Phi | ,129 | ,212 | ,542 | <,001 | ,461 | <,001 | ,119 | ,251 |

Source: Elaboración propia

**Interpretation:** Age, previous pregnancies, and infertility period: there was no substantial correlation with implantation ($p > 0.05$). Biopsy: No important correlation was present ($p = 0.212$). Endometrium > 7 mm: There is a seriously significant association ($kh^2 = 27.308$; $p < 0.001$). High embryo quality: Association of high significance ($kh2 = 19.755$; $p < 0.001$).

Endometrial thickness of more than 7 mm and high quality of embryos proved to be the most influential factors of implantation that were statistically significant.

**Table 16 Statistical risk analysis between embryo implantation and age, previous pregnancies, time of infertility, cause of infertility, biopsy, endometrial thickness, embryo quality and number of attempts**

| **Age** |
|---|

| | Value | 95% Confidence Interval | |
|---|---|---|---|
| | | Lower | Upper |
| 25 a 34 years | 1,139 | ,513 | 2,531 |
| 35 a 50 years | ,956 | ,717 | 1,274 |
| **Previous Pregnancies** | | | |
| | Value | 95% Confidence Interval | |
| | | Lower | Lower |
| No pregnancies | ,908 | ,516 | 1,595 |
| Previous Pregnancies | 1,076 | ,716 | 1,615 |

| **Duration of Infertility** | | | |
|---|---|---|---|
| | Value | 95% Confidence Interval | |
| | | Lower | Superior |
| Short-term | 1,159 | ,792 | 1,694 |
| Long-term | ,807 | ,439 | 1,484 |
| **Causes of Infertility** | | | |
| | Value | 95% Confidence Interval | |
| | | Lower | Superior |
| Female | **1,178** | **1,081** | **1,416** |
| Non-female | **,398** | **,099** | **,596** |
| **Biopsy** | | | |
| | Value | 95% Confidence Interval | |
| | | Lower | Superior |
| No | **1,467** | **1,226** | **2,606** |
| Yes | **,790** | **,523** | **,930** |
| **Endometer more than 7mm** | | | |
| | Value | 95% Confidence Interval | |
| | | Lower | Superior |
| Endometer less than 7mm | **29,045** | **3,892** | **216,747** |
| Endometer more than 7mm | **,599** | **,423** | **,849** |
| **Embryonic Quality** | | | |
| | Value | 95% Confidence Interval | |
| | | Lower | Superior |
| Low quality | **22,591** | **2,938** | **173,735** |
| High-quality | **,692** | **,519** | **,921** |
| **Number of Attempts** | | | |
| | Value | 95% Confidence Interval | |

| | | Lower | Superior |
|---|---|---|---|
| First | 1,157 | ,934 | 1,434 |
| More than 1 | ,538 | ,175 | 1,656 |

Source: Elaboración propia

**Interpretation:**

Protective Factors (values in green, OR < 1, valid CI): Endometrium >7 mm: OR = 0.599 (95% CI: 0.4230849) → Highly important protective factor of implantation. Good embryo quality: OR = 0.692 (95% CI: 0.519 -0.921) -Protective variable of implantation success. Biopsy done: OR = 0.790 (95% CI: 0.5230.930) = Moderate protective factor. A short infertility (0-5 years): OR = 1.159 (95% CI: 0.7921.694) → It is not significant, but it indicates a minor benefit. Opposite to one: OR = 0.538 (95% CI: 0.1751.656), not significant.

Endometrium thickness that was less than 7 mm and poor-quality embryos were the primary risk factors of implantation failure.

The most applicable protective factors, on the other hand, were endometrium thickness more than 7 mm, high-quality embryos, biopsy conducted, and less than 5 years of infertility (05 years) and greater than one attempt.

## DISCUSSION

### Clinical and Demographic Characteristics of the Patients Undergoing In Vitro Fertilization

The population under analysis consisted mainly of women of advanced reproductive age, with the majority made of the age group 35 to 50 years (75.3%), which is indicated as a global trend of postponing motherhood to later stages. It has also been demonstrated that ovarian reserve and egg quality begin to drop dramatically at 35 years old and affect implantation and successful pregnancy rates (Li et al., 2021). This population profile will be representative of the population most likely to pursue in vitro fertilisation (IVF) procedures, as infertility rates have been rising with advanced maternal age.

Most of the participants were married (76.3%) and were well educated (67.7% university and 6.5% postgraduate), and 23.3% had a high school education. This implies an informed and financially able population with specialised medical services. The described trend aligns with the results of other studies across countries, where assisted reproductive treatments are most frequently demanded by women with a higher level of education and stable marriages, which also correlate with the voluntary postponements of having children because of academic or professional reasons (Leeners et al., 2023).

Also, 87.1 per cent of the patients had their home in urban areas, suggesting that more fertility centres are available in the urban regions and there is a definite disparity between accessing the services in rural regions. In terms of the aetiology of infertility, uterine causes were the most common (37.6%), then ovarian causes (19.4%), and tubal causes (18.3%). Such findings are consistent with the findings by Shen et al. (2022), who found uterine and ovarian abnormalities as common causes of female infertility. In addition, over 55.9% of the women were infertile for a secondary reason, which suggests that repeated reproductive failures are still a major problem, even in women with a history of previous pregnancies.

These are clinical and demographic features of an average patient type seeking assisted reproductive methods: women older than 35, with a good level of education, living in cities, and with a predominantly female aetiology of infertility. This background is also important in understanding other findings about the effects of embryo biopsy on implantation rates because such variables as age and infertility condition have a direct impact on reproductive response.

Risk and Protective Factors Associated with Embryo Implantation in IVF Patients with or without Embryo Biopsy for PGT-A

The outcome was that the primary risk factors of implantation failure were endometrial thickness less than 7 mm (OR = 29.04; 95% CI 3.89-216.74), low embryo quality (OR = 22.59; 95% CI 2.93-173.73), and no embryo biopsy (OR = 1.46; 95% CI 1.22-2.60). Comparatively, endometrial thickness 7 mm (OR = 0.59; 95% CI 0.42-0.84), high embryo quality (OR = 0.69; 95% CI 0.52-0.92), embryo biopsy (OR = 0.79; 95% CI 0.52-0.93), and short infertility duration (< 5 years) were the most relevant protective factors.

Such findings underscore the importance of morpho-functional aspects of the reproductive system, particularly endometrial thickness and embryo quality, as an important determinant of implantation, even more than age or cause of infertility. Diedrich et al. (2007) concur that thin endometrium (< 7 mm) correlates with decreased receptivity, inadequate uterine blood circulation and reduced implantation.

The strongest protective factor was the endometrial receptivity ($p < 0.001$). Ma et al. (2023) showed in their multicentre study result that endometrial thickness of 8 mm and a trilaminar pattern enhance the implantation rate of euploid blastocysts 3 times, which is in agreement with our results.

The use of endometrial thickness as a predictor is a subject of much controversy. Mathyk et al. (2023) conducted a review of clinical thresholds and concluded that 7-14 mm would be the best clinical threshold, with less than 6 mm leading to poor

clinical outcomes, which agrees with our reference point of 7 mm. Xu et al. (2022) reviewed over 42,000 IVF cycles and applied an endometrial thickness of 1 mm, which demonstrated an increment in clinical pregnancy probability by 5 per cent. The size of the risk was higher in our cohort (OR = 29), hence emphasising the value of assessing and maximising endometrial preparation prior to embryo transfer.

Low embryo quality was the second risk factor. We also find a similar result (OR = 22.6) as Kelly et al. (2021) and Sun et al. (2023), who established that embryos with poor morphology have an implantation rate that is decreased by 60-percent and that such embryos are more likely to prematurely cease their development before attaching to the endometrium. Further, embryo quality also cooperates with embryonic genetics. According to Montag et al. (2013), morphological analysis used together with PGT-A yields more clinical pregnancy rates (more than 65% versus 45% when used alone). This supports our finding that embryo biopsy is a complementary protective factor.

Embryo biopsy was emphasised as a way to decrease the risk of non-implantation (OR < 1). Karavani et al. (2022) validated the results of a previous study that blastocyst biopsy has no impact on spontaneous embryo viability or infant outcomes, ultimately confirming the safety of applying it in a specialised centre.

The formulated objectives of the ASRM (2024) practice committee included the statement that not all clinical contexts have shown improved cumulative live birth rates with the use of PGT-A and that selective use is advised based on clinical circumstances, particularly in patients with prior failures, elderly age, and mixed aetiology. This is consistent with our research in which biopsy did not exhibit any significant relationship with implantation but did exhibit a moderate protective effect (OR = 0.79), which implies that there is a small clinical benefit in particular aetiological subgroups.

In our study, non-performance of embryo biopsy was related to a greater risk of implantation failure. Such an outcome is parallel to the meta-analysis by Cheng et al. (2022), which comprised 42 trials and revealed the substantial rise in the rates of implantation (RR 1.32; $p < 0.01$) in women receiving implantation embryos after PGT-A, especially their older counterparts (older than 38 years old).

These results are consistent with the findings of the current study, during which the biopsy did not have a significant impact on the success of implantation, indicating that the very procedure does not disrupt the implantation potential of an embryo.

In terms of the duration of infertility, in this study, women who had a short-term infertility (0-5 years) obtained more implantations (39 cases) compared to women who had a long-term infertility (>5 years, 32 cases), but the difference was not significant ($p > 0.05$). This result is consistent with more recent evidence indicating that infertility duration is a significant clinical prognostic factor, but not necessarily independent, in IVF success.

Zhang et al. (2022) assessed more than 6,000 IVF/ICSI cycles in the couples who had non-male infertility and have shown that the further infertility duration of more than 4.8 years was related to a lower fertilisation and clinical pregnancy rate. Likewise, in an examination of 3,475 patients, Huang et al. (2021) found that infertility 5 years was linked to a significant decrease in clinical pregnancy rates (aOR = 0.78; 95% CI 0.64-0.95), which once again confirms that long-term infertility is a reproductive risk factor. These findings are in line with those achieved in our cohort, where the favourable trend was in patients with shorter infertility, albeit with no statistically significant difference.

The study by Wang et al. (2024) has shown that the infertility caused by a long-term period influences the implantation rates because the endometrial environment becomes damaged over time. Conversely, Romanski and Kang (2021) revealed that 6 months of delay in treatment initiation does not significantly affect the outcome of live birth and can suggest that not all delays are associated with clinical consequences, but the effect becomes evident after multiple years of infertility.

The findings of the current research indicate that shorter infertility periods, less than five years, are more reproductively effective, and longer infertility duration is more related to the aetiological diagnosis being more complex and less successful. But this was not found to be significantly different, which means that its effect is associated with other variables, including embryo quality and endometrial thickness. The duration of infertility is one of the elements used in clinical practice to determine the effectiveness of IVF and the personalisation of treatment methods.

Uterine (37.6%), which is connected with the rise of implantation failures, was the primary cause of infertility found and reported by Shen et al. (2022) and Viotti (2020). The most common causes of early losses are uterine structural anomalies and embryonic aneuploidies.

Mumusoglu et al. (2024) conducted a review of the recent evidence and concluded that PGT-A is beneficial, but only in a small number of patients with a good prognosis or mild causes of infertility; the rate of spontaneous abortion is reduced, and the efficiency of embryo transfer increases. This might be the reason the female and non-female differences did not become statistically significant in our study: perhaps most cases in females were of mild or even good ovarian reserve.

By meta-analysis, Rubio et al. (2019) revealed that PGT-A can decrease the rates of gestational losses and increase the pregnancy rates in patients with a history of repeated failure or female infertility causes, but it has less significant effects on unexplained infertility or severe male factors, where the quality of embryos may be more impaired.

Our results coupled with current evidence suggest that the effects of embryo biopsy in PGT-A depend on whether infertility is caused by a specific condition. The procedure can have benefits in female or combined aetiology as embryo selection is

maximised, but in male aetiology or idiopathy, the effect is less clearly seen. Thus, selective and personal application of embryo biopsy, based on aetiology, embryo quality, and endometrial receptivity as the primary determinants of reproductive success, is suggested.

The results of the analysis of the number of attempts showed that the highest number of implantations was achieved in the first cycle (77.4%). This finding was not statistically significant, but it aligns with the one in the review by Leeners et al. (2023), in which it is mentioned that protocol individualisation and team experience can also raise the rate of success in early cycles.

Other studies, however, have cautioned that repeated or poorly standardised procedures can reduce the rates of implantation. Guarneri et al. (2024) have demonstrated that clinical pregnancy rates in embryos that underwent a second biopsy (30% vs. 52% after having only one biopsy) were significantly lower because of inconclusive results, and thus technical accuracy is important.

Among the non-significant factors, maternal age was not directly related to implantation ($p = 0.75$). Nevertheless, such works as the one by Ni et al. (2022) point at the fact that the occurrence of aneuploidies is exponentially correlated with advanced age, which is partly addressed by imposing PGT-A to screen euploid embryos. Indeed, as Romanski and Kang (2021) noted, the implantation disparity between younger and older women settled when the transferred embryos were of genetically normal quality only, which is the compensatory effect of PGT-A.

Combining the data, we realise that the factors that have the most significant statistical weight (endometrial thickness, embryo quality, and biopsy) have a hierarchical nature: first of all, uterine receptivity; followed by the genetic and morphological viability of the embryo; and, last of all, the personal conditions of the clinic (age, infertility).

The primary risk and protective factors of implantation failure (endometrial thickness < 7 mm, low embryo quality, and lack of biopsy) and protection (embryo biopsy, endometrial thickness [> 7 mm], high-quality embryos, and reduced infertility duration) are also clear in this study. Such results are in agreement with the literature around the world and evidence embryo biopsy to be used as an average protection tool in clinical IVF practice.

Relationship Between Embryo Biopsy and Embryo Implantation Success

The results of the investigation reveal that embryo biopsy before transfer had a higher rate of implantation (80.3 of 68.8), but it was not statistically significant ($p = 0.212$). Nonetheless, the risk analysis (OR = 0.79; 95% CI 0.52-0.93) indicates the moderate level of protective effect, i.e., the fact that the biopsy procedure might decrease the risk of implantation failure. This finding is in line with the trend as reported by Cheng et al. (2022), who showed that Preimplantation Genetic Testing of Aneuploidy (PGT-A) with whole chromosome sequencing enhances the cumulative implantation rate in women who underwent in vitro fertilisation (IVF).

This benefit is proposed to be offered by the selectivity process of euploid embryos. PGT-A enables the detection of chromosomal anomalies which often cause implantation failure or premature miscarriage. In a meta-analysis of more than 25,000 cycles, Hou et al. (2021) reported that the clinical pregnancy rates were significantly high and the rate of gestational loss was lower in the case of the transfer of chromosomally normal embryos. Despite the fact that not every series becomes statistically significant per cycle, the cumulative data is in favour of the hypothesis that a long-lasting protective effect is present.

Recent sources support the use of PGT-A as an embryo selection tool. One of the review articles has mentioned that PGT-A should be used at a higher rate of implantation and reduced rates of miscarriages as an intervention in selected patients (women of advanced maternal age) (ASRM, 2024). Also, PGT-A with chromosomal screening techniques (CCS) was reported in a meta-analysis by Kasaven et al. (2023) to lower embryo transfer miscarriage rates.

According to a recent review by Petch and Crosby (2024), PGT decreases the likelihood of implantation failure and maximises embryo selection but stresses that the advantage of this technique relies on the laboratory protocol, the quality of the biopsy, and technical experience. This technical dependency can be the reason why the direct association was not significant in this study, though the ORs support biopsy.

In addition, in its statement on PGT-A, the ASRM Practice Committee (2024) stated that the 2019 SART data demonstrates that the use of PGT-A is associated with the increased implantation rates and reduced miscarriage rates, but the evidence does not support the universal use of this technique in all patients.

The findings are also in line with the findings that show the effect of PGT-A is multifactorial. Reshef et al. (2022) have shown that implantation necessitates the coordination of a genetically fit embryo with a receptive endometrium; hence, the favourable impact of biopsy will be achieved only in case the uterine environment is favourable. This is consistent with our result that endometrial thickness (> 7 mm) was the most significant protective factor ($p < 0.001$) that boosted the benefit of PGT-A.

Actually, a lot of the benefits of PGT-A have been blamed on the fact that it tends to group out chromosomally abnormal embryos, which otherwise would not implant or result in miscarriage, and do not necessarily increase the number of embryos which implant. In this regard, PGT-A is considered a filter of genetic quality, and therefore, it increases in its effect once a

euploid embryo has been transferred in a suitable environment.

To sum up, there are two pieces of evidence in the last five years which help direct to the fact that embryo biopsy PGT-A is a protective factor in enhancing implantation success by enhancing embryo selection and decreasing aneuploid embryo transfers. Nevertheless, its absolute effectiveness is determined by the age of the mother, the quality of the embryo and endometrial receptivity. The positive trend with an OR of less than 1 in the results of the present study meets the international literature and makes it clear that PGT-A is a helpful tool in the situation when the research is conducted in well-controlled conditions and in the group of patients who are correctly selected.

Clinical Recommendations Based on the Evidence to Optimize Patient Selection for Embryo Biopsy for PGT-A in IVF Treatments

The results of this research proved that embryo biopsy PGT-A may be evaluated as a valuable clinical method, if it is utilised in clear-cut situations and targets well-chosen patients. In the analysed cohort, there was no significant relationship, but the risk analysis (OR = 0.79; 95% CI: 0.52-0.93) indicates a moderate protective effect, which agrees with international data indicating that it is valuable to increase implantation rates and prevent spontaneous abortions (Cheng et al., 2022).

According to the received evidence, it should be emphasised that PGT-A should be used in patients with high genetic or reproductive risks, including those with maternal age. 38 years, repeated implantation failures, repeated unexplained miscarriages, or severe male factors. The rates of embryonic aneuploidy are much more prevalent in these groups, and genetic screening may enhance clinical pregnancy and reduce the rate of use (Kasaven et al., 2023).

Nevertheless, it has also been demonstrated that the PGT-A can indiscriminately be used in younger women with low genetic risk without offering possible equal benefits and even raising the costs of treatment without any significant effect on live birth rates (New et al., 2023). Thus, individualising the indication of embryo biopsy according to the reproductive profile and history of the individual patient, not routinely, is the first of the clinical suggestions that should be made.

The most predictive variables in this study were the endometrial thickness of 7 mm and high embryo quality ($p < 0.001$). Therefore, prior to deciding on a biopsy, one has to make sure that the uterine environment and embryo competence are at their best. According to Reshef et al. (2022) and Ma et al. (2023), PGT-A does not address the problems of endometrial receptivity and does not enhance the morphology of the embryo; its advantage is maximised only in cases where the above variables are appropriate.

Practically, in this regard, it is suggested to take some integrated pre-biopsy assessment procedures, including (a) ultrasonographic analysis of the endometrium and uterine Doppler; (b) morphological classification of the embryo by using standardised criteria (modified Gardner and Schoolcraft); (c) basal hormonal assessment and ovarian reserve; and (d) genetic and obstetric assessment. This multidimensional procedure minimises the possibility of biopsying poorly developing embryos or placing high-quality embryos in non-receptive uterine conditions (Petch & Crosby, 2024; Viotti, 2020).

It is further noted that the biopsy must be conducted at the blastocyst phase (days 5-6) as in this study since it is less risky in terms of embryonic damage and has encouraging clinical results. The researchers confirmed that blastocyst biopsies in no way affected the rate of implantation or neonatal outcomes, as opposed to day 3 (blastomere) biopsies, which would affect the integrity of the embryo (Hou et al., 2021; Karavani et al., 2022).

The other important suggestion is an enhancement of the communication between gynaecologists, embryologists and geneticists due to the need to process the PGT-A results correctly. Research by Kasaven et al. (2023) emphasises that the clinical efficacy of PGT-A requires a combination of the quality of genetic analysis and proper choice and counselling of the candidate patients. The findings of this research and current literature presuppose a key suggestion: embryo biopsy of PGT-A must be used on the basis of individualised and evidence-based medicine. Its careful spreading among women at high risk of aneuploidies, recurrent implantation failures, or recurrent miscarriages gives a chance to optimise the results, minimise the unnecessary risks, and encourage ethical, safe, and cost-effective reproductive practice.

## CONCLUSION

This research established that preimplantation genetic testing (PGT-A) embryo biopsy is an effective approach to in vitro fertilisation clinical interventions and that it shows a medium protective role (OR = 0.79; 95% CI 0.52-0.93), but the statistical correlation was non-significant ($p = 0.212$).

Endometrial thickness less than 7 mm thick (OR = 29.04) and low quality of the embryo (OR = 22.59) were determined to be the primary risk factors in relation to implantation failure. Conversely, endometrial thickness 7 mm, high embryo quality and embryo biopsy were the most significant safeguarding factors and were linked to increased implantation rates.

The age of the mother, length of infertility and attempts were not statistically significantly associated with implantation, but there was a positive clinical response in women with infertility under 5 years of age and in early IVF attempt cycles.

Embryo biopsy exhibited clinical safety, reflecting no evidence of negative outcomes on implantation rate and embryo quality, which is consistent with other studies favouring the procedure when done at the blastocyst stage.

Interplay between three major factors that include embryogenetic viability, endometrial receptivity, and individual clinical

profile determines overall efficacy of PGT-A. As such, it should be used toward personalised reproductive medicine with preference to patients at an increased genetic or reproductive risk.

RECOMMENDATIONS

Indicate selective embryo biopsy, particularly in women. The procedure is recommended for women who are 38 years of age, have repeated implantation failures, repeated miscarriages, or a history of aneuploidies, but it is not regularly used in young patients with a good prognosis.

Maximise endometrial receptivity prior to embryo transfer by means of ultrasonographic regulation, hormonal regulation, and Doppler assessment so as to have an endometrial thickness. 7 mm to maximise the probability of implantation.

Biopsy during the blastocyst phase (days 5-6) and in the laboratories with the specific personnel is recommended because this period decreases the chances of embryonic injuries and enhances the clinical results.

Enhance interdisciplinary liaison among gynaecologists, embryologists and geneticists in order to understand PGT-A results appropriately and inform patients on the advantages, constraints and expenses in a proper manner.

Institutional pre-biopsy evaluation protocols should be instituted, such as ovarian reserve, hormonal analysis, preceding genetic evaluation, and reproductive medical history to depict appropriate indication and safety of the procedure.

Advance the concept of multicentre prospective studies that compare the outcomes of PGT-A in other etiological subgroups and various clinical conditions to reinforce the evidence on its actual effect on the rates of live birth and the overall effectiveness of the IVF procedures

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