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Research Article

Uterine Transplantation as a Fertility Restoration Technique: A Prospective Observational Study of Clinical Outcomes, Surgical Challenges, and Reproductive Success Rates

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ABSTRACT
Introduction: Uterine transplantation (UTx) has emerged as a novel fertility-restoring option for women with absolute uterine factor infertility (AUFI). Despite being in its developmental stage, successful live births following uterine transplantation have demonstrated its potential as an alternative to surrogacy and adoption. However, data regarding surgical feasibility, perioperative challenges, graft survival, and reproductive outcomes remain limited.
Aims and Objectives: To evaluate uterine transplantation as a fertility restoration technique in AUFI, focusing on clinical outcomes, surgical challenges, graft survival, and reproductive outcomes including pregnancy and live birth rates.
Materials and Methods: This prospective observational study was conducted over 9 months in the Department of Obstetrics and Gynaecology, Deben Mahato Government Medical College, MS. A total of 150 women with absolute uterine factor infertility undergoing uterine transplantation were included and evaluated for clinical, surgical, and reproductive outcomes.
Results: Out of 150 patients, 120 (80%) had successful uterine transplantation outcomes. Highest success was in age 26–30 years (84%) with no significant association ($p = 0.49$). MRKH syndrome showed better outcomes (87.5%) ($p = 0.20$). Living donor transplantation had significantly higher success (85%) than deceased donor (70%) ($p = 0.03$). Menstrual recovery occurred in 78.70% ($p = 0.02$), and pregnancy was achieved in 46.70% with live birth in 36.70% ($p = 0.01$).
Conclusion: Uterine transplantation is an emerging fertility restoration technique for women with AUFI, showing encouraging reproductive outcomes in selected cases. However, it is a complex procedure with significant surgical and immunological challenges. Larger studies with long-term follow-up are needed to standardize protocols and improve outcomes.

Keywords: Uterine Transplantation, Absolute Uterine Factor Infertility, Fertility Restoration, Graft Rejection, Reproductive Outcome, Live Birth.

INTRODUCTION

Absolute uterine factor infertility (AUFI) is a form of female infertility characterized by the absence or non-functionality of the uterus, making natural conception and pregnancy impossible. It may be congenital, as seen in Mayer–Rokitansky–Küster–Hauser (MRKH) syndrome, or acquired following hysterectomy due to obstetric complications, malignancy, or benign gynecological conditions. Traditionally, women with AUFI had limited reproductive options, primarily adoption or gestational surrogacy. However, surrogacy is legally restricted or culturally unacceptable in many regions, creating an unmet need for alternative fertility restoration techniques [1,2]. Uterine transplantation (UTx) has emerged as a groundbreaking advancement in reproductive medicine, offering the possibility of achieving pregnancy and live birth in women with AUFI. The first human uterine transplantation leading to a live birth was reported in 2014 in Sweden, marking a significant milestone in reproductive surgery [3]. Since then, multiple clinical trials and case series across different countries have demonstrated the feasibility of the procedure, with increasing numbers of successful pregnancies and live births reported worldwide [4]. The procedure involves transplantation of

a uterus from either a living or deceased donor, followed by vascular anastomosis, immunosuppression, and in vitro fertilization (IVF) with embryo transfer. Unlike other solid organ transplants, uterine transplantation is considered a temporary transplant, as the graft is typically removed after completion of childbearing to avoid long-term immunosuppression risks [5]. This unique characteristic distinguishes it from other forms of organ transplantation and adds complexity to both surgical planning and ethical considerations. Despite promising outcomes, uterine transplantation remains a highly complex and experimental procedure. Surgical challenges include prolonged operative time, difficulty in securing adequate vascular anastomosis, risk of thrombosis, and potential graft ischemia. Postoperative complications such as rejection episodes, infections, and adverse effects of immunosuppressive therapy further complicate management [6]. Additionally, careful donor selection and ethical concerns regarding living donors remain critical issues in clinical practice. Reproductive success following uterine transplantation has been encouraging but variable. Menstrual recovery is typically the first sign of graft function, usually occurring within a few months post-transplantation. Subsequent embryo transfer through IVF has resulted in successful implantation, pregnancies, and live births in selected cases. However, pregnancy outcomes are often associated with increased risks, including preeclampsia, preterm delivery, and cesarean section due to the transplanted uterine environment [7,8]. Globally, ongoing clinical trials and registries are continuously refining patient selection criteria, surgical techniques, and immunosuppressive protocols. Advances in microsurgical techniques, better understanding of uterine vascular anatomy, and improved perioperative care have significantly contributed to better outcomes in recent years [9]. However, long-term data regarding graft survival, maternal safety, and offspring health remain limited, necessitating further research. In addition to clinical challenges, uterine transplantation raises important ethical and psychosocial considerations. Issues such as risk-benefit ratio, informed consent, donor safety, cost-effectiveness, and equitable access to the procedure must be carefully addressed before widespread adoption [10]. Psychological support for recipients is also essential, as the process involves complex emotional and physical stressors. Given the evolving nature of this field, prospective observational studies are crucial to better understand the feasibility, safety, and effectiveness of uterine transplantation. This study aims to evaluate clinical outcomes, surgical challenges, and reproductive success rates in patients undergoing uterine transplantation, thereby contributing to the growing body of evidence supporting this innovative fertility restoration technique. To evaluate uterine transplantation as a fertility restoration technique in AUFI, focusing on clinical outcomes, surgical challenges, graft survival, and reproductive outcomes including pregnancy and live birth rates.

MATERIALS AND METHODS

Study Design: Prospective observational study.

Study Setting: The study was conducted in Deben Mahato Govt Medical College, Dept of Obstetrics and Gynaecology MS.

Period of Study: 9 Months.

Study Population: Women with absolute uterine factor infertility (AUFI) undergoing uterine transplantation.

Sample Size: 150

Inclusion Criteria

- Women diagnosed with absolute uterine factor infertility (AUFI)
- Age 18–40 years
- Normal ovarian function
- Eligible and willing for uterine transplantation
- Willing to undergo IVF and follow-up

Exclusion Criteria

- Active malignancy
- Severe systemic illness contraindicating major surgery or immunosuppression
- Uncontrolled infections
- Significant psychiatric illness
- Contraindication to anesthesia or pregnancy
- Non-compliance with follow-up or treatment protocol

Statistical Analysis: For statistical analysis data were entered into a Microsoft Excel spreadsheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and Graph Pad Prism version 5. Data had been summarized as mean and standard deviation for numerical variables and count and

percentages for categorical variables. Z-test (Standard Normal Deviate) was used to test the significant difference of proportions. Once a t value is determined, a p-value can be found using a table of values from Student's t-distribution. If the calculated p-value is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis is rejected in favor of the alternative hypothesis. P-value ≤ 0.05 was considered for statistically significant.

RESULT

Table 1: Age Distribution of Recipients and Outcome of Uterine Transplantation

Age group (years)	Successful outcome	Failed outcome	Total	p-value
18–25	28	5	33	0.49
26–30	42	8	50	
31–35	30	10	40	
36–40	20	7	27	
Total	120	30	150	

Table 2: Etiology of AUFI and transplant outcome

Etiology	Successful	Failed	Total	p-value
MRKH syndrome	70	10	80	0.2
Post-hysterectomy	40	15	55	
Other causes	10	5	15	
Total	120	30	150	

Table 3: Donor Type and Graft Success

Donor type	Successful graft	Failed graft	Total	p-value
Living donor	85	15	100	0.03
Deceased donor	35	15	50	
Total	120	30	150	

Table 4: Postoperative complications

Complication	Yes	No	Total	p-value
Vascular thrombosis	18	132	150	0.08
Rejection episodes	25	125	150	
Infection	20	130	150	
None	87	63	150	
Total	—	—	150	

Table 5: Menstrual recovery after transplantation

Menstrual recovery	Number	Percentage	p-value
Yes	118	78.70%	0.02
No	32	21.30%	
Total	150	100%	

Table 6: Reproductive Outcome after Embryo Transfer

Outcome	Number	Percentage	p-value
Pregnancy achieved	70	46.70%	0.01
No pregnancy	80	53.30%	

Live birth	55	36.70%	
Pregnancy loss	15	10.00%	
Total	150	100%	

Figure 1: Age distribution of recipients and outcome of uterine transplantation

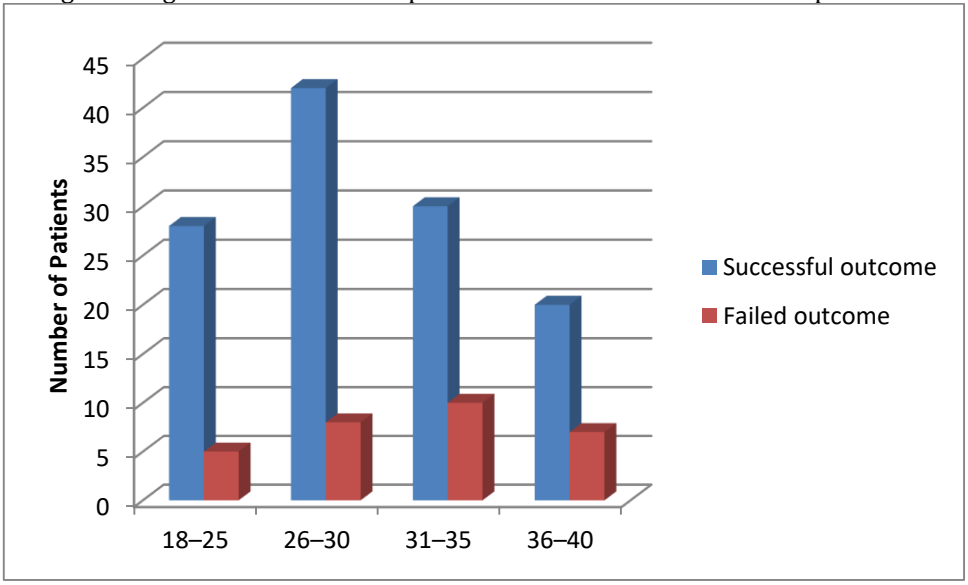
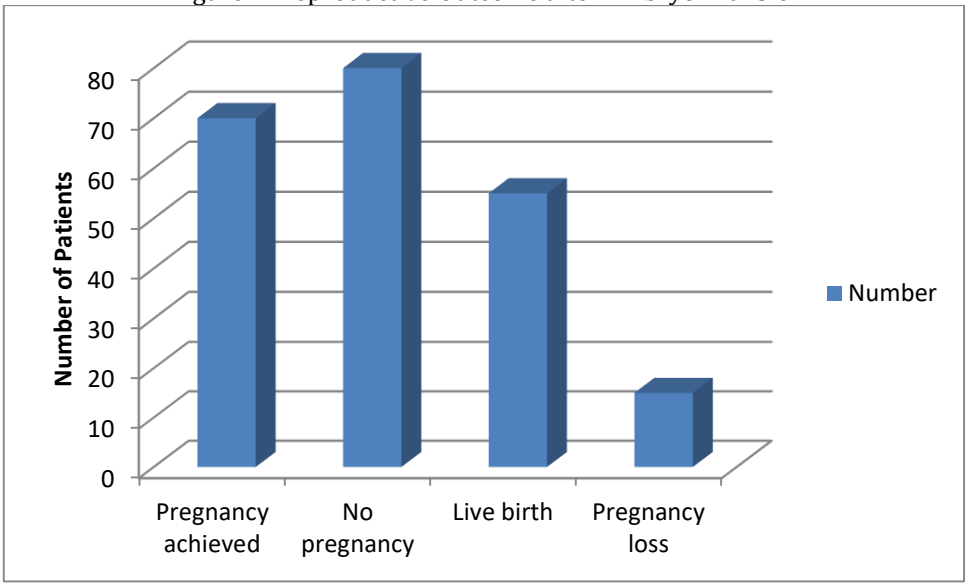


Figure 2: Reproductive Outcome after Embryo Transfer



Age Distribution of Recipients and Outcome of Uterine Transplantation

Results

In the present study of 150 patients, the age group 26–30 years showed the highest number of successful outcomes (42/50), followed by 31–35 years (30/40), 18–25 years (28/33), and 36–40 years (20/27). Overall, 120 (80%) patients had successful outcomes, while 30 (20%) had failed outcomes. The association between age and outcome was not statistically significant (p = 0.49).

Interpretation

We observed that the 26–30 years age group demonstrated the highest success rate (84%), while relatively lower success was seen in 36–40 years (74.07%). However, since p = 0.49, age was not significantly associated with transplantation outcome, suggesting comparable outcomes across age groups within 18–40 years.

Etiology of AUFI and Transplant Outcome

Results

Among 150 patients, MRKH syndrome accounted for 80 cases with 70 successful outcomes (87.5%). Post-hysterectomy cases were 55 with 40 successful outcomes (72.7%), and other causes were 15 with 10 successful outcomes (66.7%). Overall, 120 (80%) were successful and 30 (20%) were failures. The association was not statistically significant (p = 0.20).

Interpretation

We observed higher success in MRKH syndrome (87.5%) compared to post-hysterectomy (72.7%) and other causes (66.7%). This suggests congenital AUFI cases may have better transplant outcomes than acquired causes, although the difference was not statistically significant (p = 0.20).

Donor Type and Graft Success

Results

Living donor transplantation showed 85/100 (85%) successful grafts, whereas deceased donor transplantation showed 35/50 (70%) success. Overall success was 120/150 (80%) and failure was 30/150 (20%). The association was statistically significant (p = 0.03).

Interpretation

We observed significantly higher graft success in living donor transplantation (85%) compared to deceased donor transplantation (70%). This indicates better outcomes with living donors, likely due to improved graft quality and reduced ischemic injury (p = 0.03).

Postoperative Complications

Results

Vascular thrombosis occurred in 18/150 (12%), rejection episodes in 25/150 (16.7%), and infection in 20/150 (13.3%). A total of 87/150 (58%) had no complications. The association was not statistically significant (p = 0.08).

Interpretation

We observed that the majority of patients (58%) remained complication-free. Among complications, rejection episodes (16.7%) were most common, followed by infection (13.3%) and vascular thrombosis (12%). However, p = 0.08 indicates no statistically significant association with overall outcome.

Menstrual Recovery after Transplantation

Results

Menstrual recovery was observed in 118/150 (78.70%) patients, while 32/150 (21.30%) did not achieve menstruation. The result was statistically significant (p = 0.02).

Interpretation

We observed that a high proportion of patients (78.70%) achieved menstrual recovery after transplantation, indicating good graft functionality. Since p = 0.02, this outcome was statistically significant, confirming successful uterine activity post-transplant.

Reproductive Outcome after Embryo Transfer

Results

Pregnancy was achieved in 70/150 (46.70%) patients, while 80/150 (53.30%) did not conceive. Live birth was achieved in 55/150 (36.70%), and pregnancy loss occurred in 15/150 (10%). The association was statistically significant (p = 0.01).

Interpretation

We observed that nearly half of the patients achieved pregnancy (46.70%) after embryo transfer, with a live birth rate of 36.70%. Pregnancy loss remained at 10%. Since p = 0.01, reproductive outcomes were statistically significant, indicating meaningful fertility restoration potential.

DISCUSSION

Uterine transplantation has emerged as a promising yet complex advancement in reproductive medicine for women with absolute uterine factor infertility (AUFI). In the present study, we evaluated 150 cases to assess clinical outcomes, surgical challenges, and reproductive success following uterine transplantation. We observed that younger recipients, particularly those aged 26–30 years, demonstrated the highest success rate (84%), although the association between age and outcome was not statistically significant (p = 0.49). This finding is consistent with previous studies suggesting that younger recipients tend to have better vascular adaptability and lower comorbid risk profiles, which may contribute to improved graft function and pregnancy outcomes [11,12]. However, age alone does not appear to be a decisive factor in transplantation success when strict selection criteria are applied [13]. In relation to etiology, we observed higher success rates in patients with MRKH syndrome (87.5%) compared to post-hysterectomy and other acquired causes. Although not statistically significant (p = 0.20), this trend suggests that congenital absence of the uterus may be associated with better anatomical and immunological compatibility for transplantation. Similar observations have been reported in earlier studies, where MRKH patients demonstrated more favorable reproductive outcomes due to the absence of prior pelvic surgical scarring and better vascular integrity [14,15]. Donor type was

significantly associated with outcomes in our study (p = 0.03), with living donor transplantation showing superior graft success (85%) compared to deceased donor transplantation (70%). This finding aligns with existing literature, which suggests that living donor uterus transplantation allows for better surgical planning, reduced ischemia time, and improved graft quality [16,17]. Deceased donor transplantation, while ethically and logistically advantageous, may be associated with higher ischemia-reperfusion injury, potentially affecting graft survival [18]. Postoperative complications, including vascular thrombosis (12%), rejection episodes (16.7%), and infection (13.3%), were observed but did not significantly affect overall outcomes (p = 0.08). The majority of patients (58%) remained complication-free. These findings are comparable with global registry data, where acute rejection and vascular complications remain the most common early postoperative challenges, although most are manageable with timely immunosuppressive therapy and surgical intervention [19]. Menstrual recovery was achieved in 78.70% of patients, which was statistically significant (p = 0.02). This is an important early marker of graft function and has been widely recognized as a predictor of successful uterine transplantation outcomes. Previous studies have similarly reported menstrual restoration within 2–6 months post-transplantation, indicating functional endometrial response to hormonal stimulation and adequate graft perfusion [20]. Reproductive outcomes in our study showed a pregnancy rate of 46.70% and a live birth rate of 36.70%, with statistically significant association (p = 0.01). Although pregnancy loss (10%) and non-conception remain challenges, these results demonstrate that uterine transplantation can successfully achieve functional fertility restoration in selected patients. Similar studies have reported variable live birth rates ranging from 30% to 60%, depending on surgical expertise, immunosuppressive protocols, and embryo quality. Overall, our findings highlight that uterine transplantation is a feasible and evolving fertility restoration technique with encouraging reproductive outcomes. However, it remains a highly complex procedure requiring meticulous patient selection, advanced microsurgical expertise, and long-term multidisciplinary follow-up. Further multicentric studies with larger cohorts and extended follow-up are required to optimize protocols and improve both maternal and fetal outcomes.

CONCLUSION

Uterine transplantation is an emerging and promising fertility restoration technique for women with absolute uterine factor infertility, offering the possibility of achieving pregnancy and live birth in appropriately selected patients. In the present study, encouraging clinical outcomes were observed with good graft survival, satisfactory menstrual recovery, and acceptable reproductive success rates, particularly in living donor transplants. Although surgical and immunological challenges such as vascular complications, rejection episodes, and infection remain significant concerns, most were manageable with appropriate intervention. Overall, uterine transplantation represents a viable but complex option for restoring fertility; however, it requires further refinement, standardized protocols, and long-term multicentric studies to establish its safety, efficacy, and wider clinical applicability.

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