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Original Research Article

Evaluation of Ovarian Reserve and Pregnancy Outcomes Following Microsurgical Tuboplasty in Reproductive-Age Women: A Prospective Comparative Study

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Abstract

Background: Tubal factor infertility remains a major reproductive problem, and the effect of reconstructive tubal surgery on ovarian reserve and subsequent pregnancy requires careful clinical evaluation.

Method: This prospective comparative study evaluated 80 reproductive-age women with tubal-factor infertility who either underwent microsurgical tuboplasty (n = 40) or received standard non-reconstructive fertility management after diagnostic laparoscopy (n = 40). Serum anti-Mullerian hormone (AMH), antral follicle count (AFC), day-2 follicle-stimulating hormone (FSH), ovarian volume, postoperative tubal patency, time to conception, clinical pregnancy, ectopic pregnancy, miscarriage, and live-birth/ongoing pregnancy rates were assessed over 12 months.

Results: Baseline characteristics were comparable between groups, including age (31.4 +/- 4.2 vs 32.0 +/- 4.1 years, p = 0.518), infertility duration (4.1 +/- 1.8 vs 4.4 +/- 1.9 years, p = 0.472), AMH (2.74 +/- 0.86 vs 2.69 +/- 0.81 ng/mL, p = 0.789), and AFC (11.6 +/- 3.9 vs 11.2 +/- 3.5, p = 0.631). At 6 months, AMH showed no clinically meaningful decline after tuboplasty (2.74 +/- 0.86 to 2.61 +/- 0.83 ng/mL, p = 0.091), and AFC remained stable (11.6 +/- 3.9 to 11.1 +/- 3.7, p = 0.173). Tubal patency was achieved in 32/40 women (80.0%) after tuboplasty. Clinical pregnancy occurred more often after tuboplasty than in controls (55.0% vs 25.0%, p = 0.006), with higher intrauterine pregnancy (50.0% vs 22.5%, p = 0.010) and live-birth/ongoing pregnancy rates (42.5% vs 17.5%, p = 0.015).

Conclusion: Microsurgical tuboplasty preserved short-term ovarian reserve and significantly improved spontaneous pregnancy outcomes in carefully selected reproductive-age women.

Keywords: Microsurgical Tuboplasty; Tubal-Factor Infertility; Ovarian Reserve; Anti-Mullerian Hormone; Antral Follicle Count; Pregnancy Outcome; Reproductive Surgery.

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Introduction

Infertility is a disorder of the reproductive system affecting a significant number of couples globally and necessitating a review of female, male and couple factors. Tubal-factor infertility is a clinically significant condition that results in the failure of gamete transport, fertilization, and early embryo transfer in the absence of apparent abnormalities in ovulation and semen parameters [1]. The fallopian tube is not just a passive conduit but also serves as the microenvironment for capturing the oocyte, capacitating the sperm, fertilizing the egg, and early embryonic development. Thus, the reduction in fecundability may be significant even if the ovarian reserve is maintained, and may be caused by occlusion, peritubal adhesions, fimbrial agglutination or post-sterilization discontinuity. Assisted reproductive technology has decreased the need for tubal surgery in modern infertility treatment, but reconstructive tubal surgery is still applicable to some women who want to conceive naturally, have good tubal anatomy, and do not have significant male factor infertility or advanced ovarian reserve depletion. Treatment options for tubal repair and in vitro fertilization should be individualized based on age, semen quality, location and extent of tubal disease, previous tubal surgery, ovarian reserve, cost and reproductive preference, according to the American Society for Reproductive Medicine [2]. Surgical reconstruction also presents the opportunity for more than one

spontaneous conception following a single successful surgery, but this is highly dependent on the careful selection and technical precision of the surgery.

Surgical reviews indicate that tubal surgery may be useful in certain patients, such as those with mild distal disease, proximal tubal obstruction that can be corrected, and in patients who wish to reverse their tubal sterilization with sufficient tubal length remaining [3]. To reduce fibrosis and restenosis, microsurgical principles are applied, such as magnification, atraumatic handling of the tissue, careful hemostasis, limited electrocoagulation, careful mucosal approximation, fine delayed-absorbable or non-absorbable sutures, and continuous irrigation. However, there are concerns that the principles of adnexal dissection, thermal spread, devascularization, or periovarian adhesion may still impact the ovarian reserve.

Ovarian reserve testing is a key component of reproductive counseling. AMH and AFC are some of the most useful quantitative markers of remaining follicular pool and expected ovarian response, but they are not very accurate on their own to predict natural conception [4]. AMH is secreted by granulosa cells of small growing follicles and is related to the number of recruitable follicles, and therefore a useful biomarker for assessing potential iatrogenic effects of pelvic surgery [5]. The clinical importance of documenting postoperative stability of AMH, AFC and basal FSH is given, as tuboplasty is performed close to the ovarian blood supply and tubo-ovarian relationship.

The previous reports on tubal anastomosis and reconstructive tubal surgery have focused primarily on the patency, pregnancy, ectopic pregnancy, and live birth [6,7]. There are relatively few prospective comparative studies that evaluate the ovarian reserve markers before and after tuboplasty and also monitor spontaneous reproductive outcomes. This gap is important in reproductive age women where a surgically reconstructed tube may be of value only if there is adequate ovarian function. Furthermore, the outcomes of distal tubal disease and reconstructive surgery are variable and the criteria for selection could significantly affect pregnancy and safety outcomes [8]. The purpose of the present study was to compare ovarian reserve and pregnancy rates after microsurgical tuboplasty with matched women who were not treated with reconstructive tubal surgery in reproductive-age women with tubal-factor infertility.

Materials and Methods

Research design and setting: This was a prospective comparative study carried out in the department of obstetrics and gynecology and reproductive medicine, tertiary care teaching hospital over a period of 24 months. Women were enrolled following evaluation and counseling on surgical and non-surgical options for women who were eligible.

Study Population: Eighty women, aged between 21 and 40 years, who had tubal-factor infertility were included. A total of 40 women were included in the tuboplasty group, which included those with microsurgical tuboplasty for reconstructable unilateral or bilateral tubal occlusion, fimbrial phimosis, mild hydrosalpinx (without gross destruction of the mucosa), and post-sterilization tubal discontinuity. The comparison group consisted of 40 women with tubal-factor infertility who had diagnostic laparoscopy and chromopertubation but were not treated with reconstructive tuboplasty due to either a lack of desire for surgery or awaiting assisted reproduction.

Inclusion and Exclusion Criteria: Women aged 22-38 years, married or in a stable reproductive relationship, with a duration of infertility of at least 1 year, ovulatory cycles, normal uterine cavity, at least one potentially functional ovary and normal or corrected male partner semen parameters were included. Tubal disease was documented by hysterosalpingography and confirmed by laparoscopy. Severe male factor infertility, AMH <1.0 ng/mL, AFC <5, severe endometriosis, active pelvic inflammatory disease, large hydrosalpinx requiring salpingectomy, endocrine disease not treated, polycystic ovary syndrome with marked anovulation, previous ovarian surgery, ovarian endometrioma, and refusal of follow-up were exclusion criteria.

Preoperative Assessment: All participants had detailed history, general examination, gynecological examination, body mass index measurement, semen analysis of the partner, transvaginal sonography, day-2 serum FSH, estradiol, AMH, AFC and ovarian volume assessment. A standard chemiluminescent immunoassay was used to measure AMH. AFC was determined by the sum of the number of follicles 2-10 mm in size in both ovaries on transvaginal ultrasonography performed during early follicular phase. Hysterosalpingography and chromopertubation were used to evaluate tubal status and confirmed intraoperatively.

Surgical Procedure: Tubal access was achieved by microsurgical tuboplasty under general anesthesia either via minilaparotomy or laparoscopic-assisted microsurgical access, depending on the tubal site and surgeon's judgment. Cold scissors were used to perform adhesiolysis when possible. The affected part was removed conservatively and healthy mucosal ends were found. Tubotubal anastomosis, fimbrioplasty, terminal salpingostomy or adhesiolysis with

fimbrial reconstruction was performed with 6-0 or 7-0 monofilament sutures under loupe or operating microscope magnification. Minimization of thermal coagulation. Prior to closure, patency was tested by methylene blue chromopertubation.

Follow-up and outcomes: Follow-up visits were planned at 1, 3, 6, 9 and 12 months. Ovarian reserve markers were re-evaluated at 3 and 6 months. A tuboplasty group had hysterosalpingography at 3 months unless they became pregnant. Timed intercourse was recommended for 6 months after patency was documented; ovulation induction or intrauterine insemination was only performed when clinically indicated. The main ovarian reserve outcome was the difference in AMH between baseline and 6 months. The primary reproductive outcome was clinical pregnancy within 12 months. Secondary outcomes included AFC, FSH, ovarian volume, patent rate, intrauterine pregnancy, ectopic pregnancy, miscarriage, live birth or continuing pregnancy past 28 weeks, and time to conception.

Statistical Analysis: The data were analyzed with SPSS version 26.0. Continuous variables were presented as mean +/- standard deviation, and categorical variables as frequency and percentage. Independent-samples t-test or Mann-Whitney U test was used for between-group comparisons.

Changes in markers of ovarian reserve over time were evaluated using repeated-measures ANOVA. Categorical outcomes were compared using chi-square or Fisher exact test. Multivariable logistic regression was used to determine the predictors of clinical pregnancy following tuboplasty. A p value of <0.05 was deemed to be statistically significant.

Results

A total of 92 women were screened, of whom 80 met the eligibility criteria and completed baseline assessment. Forty women underwent microsurgical tuboplasty and 40 were included in the comparison group. Follow-up at 12 months was complete for 76 women; two participants from each group were contacted telephonically for pregnancy status after missing one interim visit. There were no major intraoperative complications, ovarian injuries, or conversions to emergency laparotomy.

Baseline demographic and infertility characteristics were comparable between the two groups (Table 1). The mean age was 31.4 +/- 4.2 years in the tuboplasty group and 32.0 +/- 4.1 years in the comparison group (p = 0.518). Primary infertility was present in 16 (40.0%) and 18 (45.0%) women, respectively. The most common tubal abnormality in the tuboplasty group was distal fimbrial disease or fimbrial phimosis (37.5%), followed by post-sterilization discontinuity (27.5%), proximal occlusion (22.5%), and mixed disease (12.5%).

Ovarian reserve markers are shown in Table 2. Baseline AMH, AFC, FSH, and ovarian volume were statistically similar between groups. In the tuboplasty group, AMH changed from 2.74 +/- 0.86 ng/mL at baseline to 2.66 +/- 0.84 ng/mL at 3 months and 2.61 +/- 0.83 ng/mL at 6 months; this small decline was not statistically significant (p = 0.091). AFC also remained stable (11.6 +/- 3.9 at baseline and 11.1 +/- 3.7 at 6 months, p = 0.173). Between-group differences in AMH and AFC at 6 months were not significant. Day-2 FSH showed no meaningful postoperative rise.

Pregnancy outcomes favored microsurgical tuboplasty (Table 3). Tubal patency was documented in 32 of 40 women (80.0%) after tuboplasty, including bilateral patency in 18 women and unilateral patency in 14 women. Clinical pregnancy occurred in 22 women (55.0%) in the tuboplasty group compared with 10 women (25.0%) in the comparison group (p = 0.006). Intrauterine pregnancy was higher after tuboplasty (50.0% vs 22.5%, p = 0.010). Ectopic pregnancy occurred in two women after tuboplasty and one woman in the comparison group. Live birth or ongoing pregnancy beyond 28 weeks was achieved in 17 women (42.5%) after tuboplasty versus 7 women (17.5%) in controls (p = 0.015). Among tuboplasty patients, age <35 years, postoperative patency, AMH >=2.0 ng/mL, and final tubal length >=4 cm were associated with higher clinical pregnancy rates.

Table 1: Baseline demographic and clinical characteristics of study participants.

Variable	Tuboplasty group (n=40)	Comparison group (n=40)	p-value
Age (years)	31.4 +/- 4.2	32.0 +/- 4.1	0.518
BMI (kg/m2)	24.8 +/- 3.1	25.2 +/- 3.3	0.579
Duration of infertility (years)	4.1 +/- 1.8	4.4 +/- 1.9	0.472
Primary infertility, n (%)	16 (40.0)	18 (45.0)	0.651
Secondary infertility, n (%)	24 (60.0)	22 (55.0)	0.651
Previous pelvic infection, n (%)	11 (27.5)	13 (32.5)	0.626
Previous tubal sterilization, n (%)	11 (27.5)	8 (20.0)	0.429
Unilateral tubal disease, n (%)	15 (37.5)	17 (42.5)	0.648
Bilateral tubal disease, n (%)	25 (62.5)	23 (57.5)	0.648
Baseline AMH (ng/mL)	2.74 +/- 0.86	2.69 +/- 0.81	0.789
Baseline AFC (total count)	11.6 +/- 3.9	11.2 +/- 3.5	0.631

Table 2: Ovarian reserve markers at baseline, 3 months, and 6 months.

Marker	Time point	Tuboplasty group (n=40)	Comparison group (n=40)	Between-group p-value
AMH (ng/mL)	Baseline	2.74 +/- 0.86	2.69 +/- 0.81	0.789
AMH (ng/mL)	3 months	2.66 +/- 0.84	2.67 +/- 0.82	0.957
AMH (ng/mL)	6 months	2.61 +/- 0.83	2.65 +/- 0.80	0.826
AFC (total count)	Baseline	11.6 +/- 3.9	11.2 +/- 3.5	0.631
AFC (total count)	3 months	11.3 +/- 3.8	11.1 +/- 3.4	0.804
AFC (total count)	6 months	11.1 +/- 3.7	10.9 +/- 3.5	0.804
Day-2 FSH (IU/L)	Baseline	6.8 +/- 1.9	6.9 +/- 1.8	0.811
Day-2 FSH (IU/L)	3 months	7.0 +/- 2.0	6.9 +/- 1.7	0.810
Day-2 FSH (IU/L)	6 months	7.1 +/- 2.1	7.0 +/- 1.9	0.824
Ovarian volume (mL)	Baseline	8.3 +/- 2.4	8.1 +/- 2.2	0.698
Ovarian volume (mL)	6 months	8.0 +/- 2.3	7.9 +/- 2.1	0.839

Table 3: Surgical and pregnancy outcomes during 12-month follow-up.

Outcome	Tuboplasty group (n=40)	Comparison group (n=40)	p-value
Documented tubal patency at 3 months	32 (80.0)	Not applicable	-
Bilateral patency after tuboplasty	18 (45.0)	Not applicable	-
Clinical pregnancy within 12 months	22 (55.0)	10 (25.0)	0.006
Intrauterine pregnancy	20 (50.0)	9 (22.5)	0.010
Ectopic pregnancy	2 (5.0)	1 (2.5)	0.556
Miscarriage among pregnancies	3/22 (13.6)	2/10 (20.0)	0.642
Live birth/ongoing pregnancy >28 weeks	17 (42.5)	7 (17.5)	0.015
Mean time to conception (months)	6.2 +/- 2.7	8.1 +/- 2.4	0.048
Pregnancy in women <35 years	17/27 (63.0)	7/25 (28.0)	0.011
Pregnancy with AMH >=2.0 ng/mL	19/31 (61.3)	8/30 (26.7)	0.008

Discussion

The present prospective comparative study demonstrated that 6-months after microsurgical tuboplasty, the ovarian reserve did not significantly decrease, whereas the clinical pregnancy and live-birth/ongoing pregnancy rates at 12 months were significantly increased. The significance of the ovarian reserve findings is that tubal surgery is done in close proximity to the tubo-ovarian vascular arcade. Careful adhesiolysis, minimal thermal energy, conservative excision and preservation of periovarian tissue were correlated with stable AMH, AFC, FSH and ovarian volume in this study.

The pregnancy rate following tuboplasty, 55.0%, is similar to previous series of tuboplasty performed laparoscopically and microsurgically. In a small group of selected women, Ribeiro et al. reported a 56.5% pregnancy rate following laparoscopic tubal anastomosis, and no ectopic pregnancies [9]. The overall pregnancy rate and intrauterine pregnancy rate following laparoscopic tubal reanastomosis were reported as 55.5% and 51.8% respectively by Karayalcin et al. [10] which is similar to the intrauterine pregnancy rate in the present study. Godin et al. also reported good pregnancy and delivery rates in expert hands after laparoscopic reversal, which was performed when anatomy and age were favorable, thus reinforcing the benefits of reconstructive surgery in appropriate hands [11].

The younger age associated with good pregnancy outcome in our study is biologically plausible and consistent with the literature on reconstructive surgery. High cumulative pregnancy rates were obtained in women under 35 years using reconstructive microsurgery and level of obstruction and reconstruction site were emphasized by Barac et al. [12]. In a large outpatient population, Berger et al. showed that bilateral tubotubal anastomosis was effective, and that age was a significant factor in success [13]. Likewise, Moon et al. reported high pregnancy rates following microsurgical tubal reanastomosis with meticulous temporary loose parallel suturing, which also emphasizes the importance of microsurgical technique [14].

The present study is an addition to the standard surgical endpoints, which includes monitoring of the ovarian reserve. Tuboplasty did not affect AMH, indicating that conservative tubal surgery is less likely to negatively impact AMH than more aggressive adnexal surgery. This is in keeping with the difference between tubal reconstruction and tubal procedures involving removal or occlusion of the tubal structures close to the blood supply of the ovary. In selected fertility-seeking women, tissue-preserving techniques may be preferable because salpingectomy has been shown to have a more short-term detrimental effect on ovarian reserve than proximal tubal occlusion [15].

The rate of ectopic pregnancy following tuboplasty was 5.0%, consistent with those following tubal reconstructive surgery. This risk is due to the potential for remaining mucosal damage, dysfunction of cilia or partial re-stenosis following restoration of tubal patency. The discussion of tubal reanastomosis in the IVF era has recently focused on the fact that conventional laparoscopy and microsurgical tubal repair are still viable options if the expertise is available, but that patients should be warned about the risk of ectopic pregnancy, delayed time to conception and the necessity of early pregnancy localization [16]. The 2024 study by Moon et al. also confirms that tubal reanastomosis continues to have a place in women with good prognosis, especially for those who wish to conceive naturally and have a desire for repeated pregnancies [17].

The pregnancy rate was lower in the comparison group as would be expected as mechanical tubal correction was not carried out. However, there were still some pregnancies, probably due to the presence of unilateral patency, partial obstruction, spontaneous recanalization, or adjunct ovulation induction. In recent years, comparative data between tubal reanastomosis and IVF has suggested that age should be used to guide counseling, with IVF being the preferred option for older women, and tubal reanastomosis may be useful for younger women with favorable anatomy [18]. Therefore, it should not be a surgery vs IVF choice for every patient, but rather a case-by-case basis depending on the patient's ovarian reserve, age, semen parameters, tubal anatomy and patient preference.

There are some limitations to this study. The number of subjects was small, follow-up was only 12 months for pregnancy outcomes and 6 months for ovarian reserve markers, and the allocation was non-randomized as the choice of treatment was based on counseling and patient preference. The conclusions should not be extrapolated to women with advanced hydrosalpinx or severe endometriosis, poor ovarian reserve or major male factor infertility. Advantages are prospective assessment, objective markers of ovarian reserve, uniform follow-up, and simultaneous patency, pregnancy, and safety assessment.

Conclusion

In carefully selected women of reproductive age with tubal-factor infertility, the microsurgical tuboplasty preserved ovarian reserve and resulted in better spontaneous clinical pregnancy rates. Basal FSH, AFC, AMH and ovarian volume did not change after surgery, indicating that careful reconstruction of the tube does not result in any measurable compromise of ovarian reserve. The best outcomes were seen in women under 35 years, with AMH >= 2.0 ng/mL, who had documented postoperative patency, and who had a final tubal length >= 4 cm. After individual counseling about the chances of pregnancy, the risk of ectopic pregnancy, the time to conception and other options like IVF, microsurgical tuboplasty should be considered a fertility-preserving procedure in appropriately selected women.

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