High pregnancy rate after microsurgical tubal reanastomosis by temporary loose parallel 4-quadrant sutures technique: a long long-term follow-up report on 961 cases

Hwa Sook Moon*, Bo Sun Joo, Gun Sik Park, Sung Eun Moon, Sang Gap Kim, and Ja Seong Koo

Center for Minimally Invasive Surgery, Department of Obstetrics and Gynecology, Good Moonhwa Hospital, 899-8 Bum-il Dong, Busan, 601-062, Korea

*Correspondence address. Tel: +82-51-630-0748; Fax: +82-51-630-0750; E-mail: moonhwas@moonhwa.or.kr

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BACKGROUND: Only a limited portion of sterilized women undergo tubal reanastomosis due to high costs, limited availability of qualified practitioners willing to perform the procedure and increasing success rates with IVF. However, IVF has complications and an increased risk of ectopic pregnancy and multiple pregnancies. Recently, the importance of specialized training for tubal anastomosis has been re-emphasized. This study aimed to report the procedure of our microsurgical tubal reanastomosis by a temporary loose parallel 4-quadrant suture technique and its high pregnancy outcome over the last 20 years.

METHODS: This clinical study retrospectively analyzed data on 961 consecutive patients who underwent tubal reversal between March 1988 and August 2007 in a large urban medical center. All surgical operations were performed by microsurgical tubal reanastomosis using a temporary loose parallel 4-quadrant suture technique by a single surgeon. Subsequent pregnancy outcomes were evaluated.

RESULTS: The overall pregnancy rate was 85.1, 82.6 being intrauterine and 2.5% ectopic. The pregnancy rate was significantly reduced in patients over 40 years old (53.9%) compared with patients aged 40 years or less (90.3%) (P < 0.05). Repair done at the interstitial–ampulla site yielded a significantly higher ectopic pregnancy rate (20.0%) compared with other anastomosis sites (0–3.2%) (P < 0.001).

CONCLUSIONS: This study shows that our technique resulted in a high pregnancy rate comparable with the level of natural fertility. The study also reveals that ectopic pregnancy frequently occurs in tubal reanastomosis of the interstitial–ampulla site compared with other sites.

Key words: tubal reanastomosis / microscopic surgery / fertility outcome / temporary loose parallel 4-quadrant suture

Introduction

Tubal sterilization has been used as one of the world’s most common methods of contraception. Globally, 60 million women undergo tubal sterilization annually. However, up to 15% of women having the procedure regret their sterilization. In the USA, 20% of sterilized women seek reversal but less than half of them will actually undergo tubal reversal (Wilcox et al., 1990; Baill et al., 2003). In Quebec, only 1.8% of sterilized women undergo tubal reanastomosis (Trussell et al., 2003).

The likely reasons for this low rate of tubal reanastomosis are high costs, limited availability of qualified practitioners willing to perform the procedure, and increasing success rates with IVF. However, IVF is not without complications and has a risk of ectopic pregnancy and multiple pregnancies. In this respect, the importance of training for tubal reanastomosis has been recently re-emphasized (Armstrong et al., 2004). As a friendlier and more advantageous method of restoring fertility than IVF in patients wanting pregnancy after having their tubes ligated, the tubal reanastomosis method should also yield a high pregnancy rate.

To date, several surgical techniques including the use of laparoscopy have been applied to tubal reversal (Dubuisson and Chapron, 1998; Yoon et al., 1999; Degueil et al., 2000) with various success...
rates. Laparoscopic microsurgery has not gained wide acceptance because it is time-consuming and has technical limitations (Koh and Janik, 1999). In this regard, it has been acknowledged that microsurgical tubal reversal is a good option (Kim et al., 1997a; Hanafi, 2003). The pregnancy rates after microscopic tubal reversal have been reported to range between 55 and 80% in the literature (Gomel, 1980; Seiler, 1983; Rouzi et al., 1995; Fischer, 1996; Kim et al., 1997b).

Fertility after tubal reversal is highly dependent on the age of the woman at the time of tubal reversal (Rouzi et al., 1995; Dubuisson and Chapron, 1998; Hanafi, 2003) and the surgical technique (Hedon et al., 1980; Bissonnette et al., 1999). We have performed microsurgical tubal reanastomosis by a temporary loose parallel 4-quadrant suture method over the last 20 years, and we have obtained a high pregnancy rate. The purpose of this study is to report the procedure of our microsurgical tubal reanastomosis and its outcomes in terms of fertility.

Materials and Methods

Between March 1988 and August 2007, 961 consecutive microsurgical tubal reanastomosis operations were performed using a preliminary temporary parallel 4-quadrant suture technique at our department. Of the 961 cases, tubal reanastomosis could not be performed in three cases because the previous tubal sterilization method was found to be distal salpingectomy. Each surgery was performed by a single surgeon (H.S.M.). The patients’ charts were reviewed retrospectively for at least 1-year. If the follow-up data in the chart was insufficient, telephone interviews were performed annually from 1999 until December 2010. Excluding 44 patients who were lost to follow-up, 17 patients on contraception, 1 patient who had hysterectomy and 3 patients who became pregnant by IVF, 886 patients were subjected to review. Institutional Review Board approval was obtained to extract data from the patients’ medical records.

Operative procedure

All operative procedures were performed under a Topcon OMS-300 operative microscope (Optical Co. Ltd. Tokyo, Japan). Under general anesthesia, the patient was placed in the lithotomy position. A Foley catheter (8Fr) was put in the uterine cavity and then the vagina was packed with gauze to push the uterine fundus upward as much as possible. A 20 ml syringe filled with diluted methylene blue solution was connected to the Foley catheter for chromopertubation. Then with the patient in the supine position, a 2.5–4.0 cm-sized Pfannenstiel incision or low-midline incision, if she had a previous midline incision scar, was made. The size of incision was dependent on the patients’ body mass index. A self-retractor was placed in the abdominal incision.

With the patient in a trendelenberg position for a moment to allow the bowel to move upwards, surgical pads were packed to keep the bowel out of the surgical field, and then a small surgical pad was put in the cul-de-sac to place the uterine fundus upward near the abdominal incision as much as possible. The examination of both fallopian tubes and ovaries was performed. One side of the uterine fundus was placed in the middle of the surgical field by packing 4 × 8 gauzes between the uterine fundus and the vesico-uterine pouch was placed on the opposite side.

For the preparation of anastomosis, both proximal and distal ends should be identified, especially when the tip is not clearly visualized or the ampulla portion had been folded. Palpation with thumb and index finger along the tube enables easy identification of the tips of proximal and distal ends.

When either the proximal or distal end of anastomosis involved the isthmic portion, the tip of the tubal end was cut using microscissors bit by bit until the lumen was visualized (Fig. 1A). When the site of

![Figure 1](https://academic.oup.com/humrep/article-abstract/27/6/1657/619091/download)

Figure 1 Making an opening on the two tubal ends. (A) The tip of a proximal tubal end is cut using microscissors until the tubal opening is seen. (B) The pin-point tip of a distal tubal end is held with microforceps and is cut using microscissors as little as possible until an opening is seen. (C) Patency of proximal tube is confirmed by spillage of methylene blue after chromopertubation. (D) Patency of the tube is confirmed by irrigating normal saline.
anastomosis involved the ampulla portion, a pin-point tip of the distal tubal end was held with microforceps and was cut using microscissors as little as possible until the tubal opening was seen (Fig. 1B). The patency of the proximal tube was confirmed by spillage of dye (methylene blue) through the tubal opening from the uterine cavity after chromopertubation (Fig. 1C). The patency of the distal tube was confirmed by irrigating normal saline with a 23 gauge lacrymal cannula with a blunt tip (Kasco, Pakistan) (Fig. 1D). All bleeders were controlled with micro-tying using 9-0 or 8-0 black nylon (Ailee Inc., Korea) and tiny bleeders were controlled by irrigating with diluted vasopressin. The two ends of the mesosalpinx were approximated with 8-0 black nylon when they were far apart. When the two ends of the mesosalpinx were too far apart for 8-0 suture to hold together, 7-0 black nylon was used instead. When anastomosis included the interstitial portion, 8-0 black nylon with a round needle was used for suturing. Otherwise, all sutures were done with 9-0 or 8-0 black nylon with a round needle.

Sutures were done in two layers. For the first layer, sutures usually started from the distal tube to the proximal tube including the whole thickness of the tube or excluding the serosal layer depending on the anastomosis site of each case. When the site of anastomosis was the ampulla portion, the whole thickness of the tube was included, whereas the serosal layer was excluded in the isthmic portion. All sutures passed through the tubal canal and sutures were performed sequentially in the 6 o’clock, 12 o’clock, 3 o’clock and 9 o’clock positions. Each suture was temporarily tied loosely at \( \approx 1.5 \) cm apart from the closing tie position so that the suture was not released. After making 4-quadrant loose sutures, parallel running of each suture is being checked.

Chromopertubation was done to confirm patency of the anastomosis. After confirmation of the dye spillage through the fimbria, inverted suture of the serosal layer was done with black nylon 9-0 or 8-0 with a cutting needle.

### Statistical analysis

The \( \chi^2 \)-test and unpaired \( t \)-test were used for statistical analysis. \( P < 0.05 \) was considered statistically significant.

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### Results

The mean age of patients was \( 36.1 \pm 4.4 \) years (mean ± SD, 23–49 years) and their mean BMI was 22.07 ± 2.87 (mean ± SD, 18.07–35.55). Their average number of living children at operation was 1.6 (0–4). The reasons for reversal of sterilization were desire for more children as a change of mind (42.8%; 379 patients), re-marriage (44.9%; 398 patients) and death of children (12.3%; 109 patients). The mean interval from tubal sterilization to anastomosis was 9.0 ± 4.1 years (mean ± SD, 1–20 years) (Table I).

After tubal reanastomosis, 100% re-canalization was confirmed by chromopertubation. The overall pregnancy rate, including intrauterine pregnancy (IUP) and ectopic pregnancy was 85.1% (754 of 886). The IUP rate was 82.6% (732 of 886) and the ectopic pregnancy rate was 2.5% (22 of 886). Of the 732 IUP, 76 were spontaneously aborted. Among 76 women with abortions, 24 were pregnant again after abortion and normally delivered and 12 were not pregnant due to contraception or divorce. Further pregnancy outcomes of the remaining 40 women could not be obtained due to lack of contact at follow-up. Finally, of a total of 732 IUP, 680 women were known to deliver normally. The average length of time from reanastomosis to pregnancy was 6.2 ± 6.7 months (mean ± SD, range 1–55 months) and 712 patients (80.4%) conceived within 1 year (Table II).

The pregnancy rates according to the age of patients were 97.5% (77 of 79) in women aged 30 years or less, 92.4% (327 of 354) in...
women 31–35 years, 86.2% (282 of 327) in women 36–40 years and 53.9% (68 of 126) for women over 40 years of age. The pregnancy rate decreased gradually with increasing of age of patients and was significantly reduced in patients over 40 years old (53.9%) compared with those 40 years or less (90.3%) (Table III). Female age is the most critical factor influencing the success of tubal reversal (Kim et al., 1997a; Dubuisson and Chapron, 1998; Hanafi, 2003). Several large studies on tubal reversal have reported significantly lower pregnancy rates in older patients (Rouzi et al., 1995; Dubuisson and Chapron, 1998; Yoon et al., 1999). The present study also confirmed that the pregnancy rate decreased with advancing female age (Table III).

There is a controversy over determining the cut-off age for tubal reversal. Some studies suggested the cut-off point should range from 35 to 40 years (Trimbos-Kemper, 1990; Dubuisson et al., 1995; Cohen et al., 1999). One study even suggested a cut-off age as low as 32 years (Hanafi, 2003). However, the fact that the present study still showed a pregnancy rate of 53.9% in women over 40 years old means that tubal reversal can be applied at any age while ovarian function is preserved.

The perfect re-canalization of the two tubal segments is an essential factor in the surgical technique for successful pregnancy after tubal reversal. Three points should be considered important to achieve this. The first, is overcoming the discrepancy in the diameter between the two segments. The second, is keeping the parallel alignment of the tube. The third is an adequate suture method to keep the patency of the tube. Our surgical technique using temporary loose parallel 4-quadrant suture method fulfills these three requirements.

The key aspects of our surgical technique can be summarized in four points.

The first point is that we made a pin-point opening at the tip of the ampulla or infundibulum portion to overcome the discrepancy in diameter between the two segments. Tubal smooth muscle is arranged in an inner-circular and outer-longitudinal layer. The proximal portions have distinct thick two muscle layers with less complex mucosal folds. Due to this anatomical structure, when the blind end of the proximal tube is excised, the diameter of the tube does not change. However, in the distal portion, the musculars layer is thin and the two layers are less defining and, near the infundibulum, are replaced by an interlacing network of muscularis fibers. Especially, the lumen of the ampulla portion is occupied by arborescent mucosa of very complicated folds. Therefore, when the blind end of the distal part of the tube is cut, the diameter of the cut end becomes much larger, resulting in a greater discrepancy between the proximal and distal tube. In this respect, a pin-point opening, made on the ampulla or infundibulum portions of the proximal or distal tube, can provide a similar sized lumen of the two segments and reduce the discrepancy between the two segments. In addition, this pin-point

### Table II Pregnancy outcomes of tubal reanastomosis.

| Site of anastomosis | No. of cases | No. of overall pregnancies (%) | No. of ectopic pregnancies (%) |
|---------------------|--------------|-------------------------------|-------------------------------|
| Interstitial–isthmic| 140          | 123 (87.9)                    | 1/140 (0.7)                   |
| Isthmic–isthmic     | 533          | 475 (89.1)                    | 7/533 (1.3)                   |
| Interstitial–ampulla| 45           | 34 (75.6)                     | 9/45 (20.0)*                  |
| Isthmic–ampulla     | 155          | 112 (72.3)                    | 5/155 (3.2)                  |
| Ampulla–ampulla     | 13           | 10 (76.9)                     | 0/13 (0.0)                   |
| Total               | 886          | 754 (85.1)                    | 22/886 (2.5)                 |

### Table III Pregnancy outcomes according to female’s age.

| Age (years) | Pregnancy rate (%) |
|-------------|---------------------|
| ≤30         | 97.5 (77/9)         |
| 31–35       | 92.4 (327/354)      |
| 36–40       | 86.2 (282/327)      |
| >40         | 53.9 (68/126)*      |

*P < 0.05 (versus other groups).

### Table IV Pregnancy outcomes according to tubal anastomosis site.

| Site of anastomosis | No. of cases | No. of overall pregnancies (%) | No. of ectopic pregnancies (%) |
|---------------------|--------------|-------------------------------|-------------------------------|
| Overall pregnancy   | 754/886 (85.1)% |                                |                               |
| Intrauterine pregnancy | 732/886 (82.6)% |                                |                               |
| Spontaneous abortion | 76/732 (10.4)%  |                                |                               |
| Known deliveries     | 680/732 (92.3)% |                                |                               |
| Ectopic pregnancy   | 22/886 (2.5%)   |                                |                               |
| Time length from anastomosis to pregnancy (months) | 6.2 ± 6.7 (1–55) |                               |                               |

Of 907 patients who were able to be followed up, 21 patients were excluded for the analysis for pregnancy outcomes due to contraception (17 patients), hysterectomy (1 patient) and pregnancy after IVF (3 patients). The ectopic pregnancy rate was significantly higher in the group with anastomosis at the interstitial–ampulla site with a rate of 20.0% compared with 0.7% for the interstitial–isthmic site, 1.3% for the isthmic–isthmic site and 3.2% for the isthmic–ampulla site (P < 0.001) (Table IV).

### Discussion

The present study shows that our microsurgical tubal reanastomosis using temporary loose parallel 4-quadrant suture technique resulted in a high subsequent pregnancy rate of 84.7%. This result suggests that if an appropriate technique of tubal reanastomosis is established, a female’s fecundity can be recovered close enough to her natural fertility. In addition, this result implies that tubal reanastomosis can be firstly recommended over IVF treatment for women who desire pregnancy after tubal sterilization.

Female age is the most critical factor influencing the success of tubal reversal (Kim et al., 1997a; Dubuisson and Chapron, 1998; Hanafi, 2003). There is a controversy over determining the cut-off age for tubal reversal. Some studies suggested the cut-off point should range from 35 to 40 years (Trimbos-Kemper, 1990; Dubuisson et al., 1995; Cohen et al., 1999). A study even suggested a cut-off age as low as 32 years (Hanafi, 2003). However, the fact that the present study still showed a pregnancy rate of 53.9% in women over 40 years old means that tubal reversal can be applied at any age while ovarian function is preserved.

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The key aspects of our surgical technique can be summarized in four points.

The first point is that we made a pin-point opening at the tip of the ampulla or infundibulum portion to overcome the discrepancy in diameter between the two segments. Tubal smooth muscle is arranged in an inner-circular and outer-longitudinal layer. The proximal portions have distinct thick two muscle layers with less complex mucosal folds. Due to this anatomical structure, when the blind end of the proximal tube is excised, the diameter of the tube does not change. However, in the distal portion, the musculars layer is thin and the two layers are less defining and, near the infundibulum, are replaced by an interlacing network of muscularis fibers. Especially, the lumen of the ampulla portion is occupied by arborescent mucosa of very complicated folds. Therefore, when the blind end of the distal portion of the tube is cut, the diameter of the cut end becomes much larger, resulting in a greater discrepancy between the proximal and distal tube. In this respect, a pin-point opening, made on the ampulla or infundibulum portions of the proximal or distal tube, can provide a similar sized lumen of the two segments and reduce the discrepancy between the two segments. In addition, this pin-point
opening not only the end of ampulla or infundibulum portions of the tube from becoming ragged when the end is cut, but also the leakage of dye through the anastomosis site. Prevention of this ragged end of tube facilitates anastomosis. Gomel used a different method to overcome the discrepancy in diameter between the two segments depending on the free of the stumps of the distal end. When the stumps were free, he tailored the opening of the distal end to the size of the proximal lumen by introducing the blunted probe into the distal end through the fimbriated end. Whereas, when the stumps were not free, he presented a Wrek type clip across the distal end to the sterilization site and incised the serosa. And then he made a slit at the antimesentric edge of the proximal end stump (Gomel, 1980, 1983). However, our method of pin-point opening was possible whether the stumps of the distal end were free or not.

The second point is the 4-quadrant interrupted suture at the four cardinal points: we divided the opening of tubal segment into four equal parts and placed sutures in the order of 6, 12 and then either 3 and 9 o’clock positions or 9 and 3 o’clock positions. The 4-quadrant suture is the minimal, as well as the most adequate, number of sutures for the maintenance of integrity of the tubal canal at the site of reanastomosis.

The third point about our surgical technique is that our sutures pass through the canal of distal and proximal tubes: the suture starts from the muscularis or musculo-serosal layer of the distal segment, passes through the lumen and then enters the lumen of the proximal segment and exits through the muscularis or the musculo-serosa. We think that this suture also contributes to preserve the integrity of the canal along with the 4-quadrant suture, finally resulting in the complete re-canalization. In general, others have avoided sutures involving the mucosal layer (Kim et al., 1997a; Gomel, 1980; Hanafi, 2003).

The fourth point is that we placed temporarily loose interrupted sutures at 4-quadrant points to ensure proper placement of the sutures before they are tied. We confirmed whether the alignment of the sutures ran parallel after placing the loose 4-quadrant sutures at the four cardinal points (Fig. 2). After confirming that 4-quadrant sutures ran parallel, none crossing another, the sutures were tied tightly in the order of 9, 3 (or 3, 9), 6 and finally 12 o’clock. Unlike our four quadrants sutures, most studies have reported suturing the first layer with three or seven sutures (Bissonnette et al., 1999; Degueldre et al., 2000; Hanafi, 2003; Rodgers et al., 2007). Gomel previously described the concept of two-layer sutures and loose placement of sutures (Gomel, 1983). However, there are some minor differences between ours and Gomel’s surgical technique. For example, Gomel tied the first suture at the 6 o’clock position on the mesenteric border of the tube and then placed a continuous suture so that the subsequent sutures are placed at once with same strand. Then the strand is divided between the sutures, and each one is tied independently. In contrast, we placed interrupted sutures at four cardinal positions with different strands and each suture was temporarily tied loosely at ~1.5 cm apart from the closing tie position and then tightly tied afterwards. In our experience, these four interrupted sutures were easy to confirm proper placement of sutures.

In earlier studies, the site of anastomosis had been evaluated because it is inter-related with the length of tube and the diameter of tubal segments to be anastomosed (Dubuisson and Chapron, 1998; Practice Committee of American Society for Reproductive Medicine, 2006; Rodgers et al., 2007). Some studies reported that the site of anastomosis was determined as one of the most influencing factors (Petrucco et al., 2007). However, other studies showed that it had no statistically significant association with the pregnancy rate (Rouzi et al., 1995; Degueldre et al., 2000). This result is similar to the result of our study, which shows that the site of anastomosis did not affect the pregnancy outcome. However, an interesting finding in the present study was that ectopic pregnancy rate was different according to the site of anastomosis. The ectopic pregnancy rate was significantly higher after reanastomosis at the interstitial–ampullar site (20.0%) compared with other sites of anastomosis (0–3.2%). This seems to be due to the largest discrepancy in tubal diameters between the pin-point diameter of the interstitial portion and the wide diameter of the ampullar portion.

Rates of ectopic pregnancies after surgical tubal reversal have ranged from 3 to 8% (Kim et al., 1997b; Yoon et al., 1999; Hanafi, 2003; Gordts et al., 2009). Our present study showed an ectopic pregnancy rate of 2.5%. These data imply that our surgical technique is effective and safe, reducing the risk of ectopic pregnancy by obtaining complete re-canalization.

Human fertility decreases markedly towards the end of reproductive life, with age-related fecundity declining rapidly after 40 years. The pregnancy rate of IVF over 40 years has been usually reported to be <15% (Chambers et al., 2006). Our present study and other studies showed that microsurgical tubal reanastomosis has a higher success rate compared with IVF (Dubuisson et al., 1995; Kim et al., 1997a; Hanafi, 2003). Tubal reanastomosis has several other advantages over IVF including avoidance of daily injections, frequent office visits for monitoring, ovarian hyperstimulation syndrome and an increased risk of multiple pregnancies. These factors suggest that tubal reversal is a highly cost-effective strategy for previously fertile older aged women. Petrucco et al. (2007) insisted that government funding for reversal of sterilization should be reinstated to offer women who need tubal reversal the opportunity to have an entirely natural pregnancy.

In conclusion, this study shows that our microsurgical tubal reanastomosis using the temporary loose parallel 4-quadrant suture technique resulted in an excellent subsequent pregnancy rate, high enough to recover women’s natural fertility. In addition, the study shows that ectopic pregnancy most frequently occurs after interstitial to ampulla anastomosis.

Authors’ roles
H.S.M.: study design, execution and manuscript drafting; B.S.J.: analysis and manuscript drafting; G.S.P.: analysis and critical discussion; S.E.M.and S.G.K.: critical discussion and J.S.K.: manuscript drafting and critical discussion.

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Conflict of interest
None declared.
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