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Use of Open-Loop Technique in Microsurgery: A Comparative Study between Conventional and Open-Loop Techniques on Rats

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ABSTRACT

Background: Many researches discussed different techniques for end-to-end anastomosis trying to minimize the anastomosis time to re-establish blood flow as early as possible. They used variety of techniques as interrupted continuous suture technique, continuous horizontal mattress technique and many other techniques.

Objectives: The aim of this study is to compare the conventional interrupted technique with open loop technique to distinguish which technique consume less time and has better patency rates and less anastomotic leakage.

Material and Methods: In our Comparative Study, we performed 40 anastomosis on 20 rats; they underwent bilateral femoral artery anastomosis using the conventional and the open-loop techniques one on each side, and then a comparison regarding time and patency rates as well as the anastomosis leakage was done between the 2 techniques.

Results: Regarding the anastomosis time, Open-Loop Technique consumed less time than the Conventional Interrupted Suture, although the time difference was minimal yet statistically significant (*p*-value 0.008). In terms of patency rates, there was no significant difference in patency at 5 minutes nor at 15 minutes post anastomosis in open-loop technique. Regarding the anastomotic leakage, 19 anastomosis done by conventional interrupted technique were evaluated as Grade II and only 1 anastomosis was evaluated as Grade III; while in open-loop technique, 3 anastomosis were evaluated as Grade I, 16 anastomosis Grade II and only 1 was evaluated as Grade III.

Conclusion: Open loop technique led to significant decrease in anastomosis time (*p*-value 0.008), however there was no significant difference in patency rate or anastomotic leakage between the 2 techniques.

Key Words: *Open-loop technique – Anastomosis – Microsurgery.*

INTRODUCTION

The most crucial step in any microsurgical procedure is microvascular anastomosis. Although the conventional interrupted suture technique remains the standard among all microvascular anastomosis techniques, it is time consuming and dependent on the surgeon's skill. It also places a significant load on surgeons when they are required to perform multiple and/or extremely small diameter anastomosis **[1,2]**.

After that, the continuous suture technique was introduced in an attempt to reduce anastomosis time compared to the conventional method and while it accomplished this goal, it also had a number of drawbacks, including a high probability of thrombus formation. Many more techniques were introduced afterwards with the same purpose of decreasing anastomosis time, the majority of which were the result of modifications to those two basic techniques, such as interrupted-continuous technique, continuous horizontal mattress technique, and others **[3]**.

However, these various techniques have a number of downsides, such as vasoconstriction, formation of thrombus, malalignment of the vessel intima, high costs, or demands significant surgical training **[4,5]**.

In order to minimize the risks associated with the previously mentioned techniques while maintaining the benefit of reducing anastomosis time, we made a comparison between the traditional interrupted suture technique and the open-loop technique in terms of time and patency in our study. Sun Lee et al., were the first to introduce the open loop technique back in 1984; this method can speed up vascular anastomosis while also ensuring that the contrary vessel wall isn't accidentally snatched by the needle (Back wall Stitch) **[6]**.

MATERIAL AND METHODS

This study was done on 20 rats; each rat underwent bilateral femoral artery anastomosis by the

conventional and the open-loop techniques one on each side making a total of 20 anastomosis by each technique.

Ethical consideration:

Permission to use laboratory animals for this research was obtained; animal care was complied with the guidelines of the care and use of laboratory animals with abundant food and water.

Surgical procedure:

All the procedures were performed under the effect of general anesthesia, we used a combination of ketamine (80mg/kg) and xylazine (10mg/kg) injected intraperitoneal.

On a dissecting board, the rat was placed in the supine position. The inguinal and abdominal regions were shaved. An oblique incision was made close to the inguinal ligament, and fat from the inguinal area was dissected; the inferior epigastric artery was left intact and retained laterally. The muscles of the abdomen were moved medially, uncovering the femoral artery. The femoral artery was dissected bluntly until it was exposed and free of the surrounding tissue. All the branches of the femoral artery were ligated or cauterized and irrigation with 2% Lidocaine HCL was performed to relieve any arterial spasm. (Fig. 1).

To distinguish the artery from surrounding tissues, a background was placed beneath the section of the artery where the anastomosis was performed. Microvascular clamps were applied and the femoral artery was cut.

Preparation of the vessel for the anastomosis was done by irrigation with 2% Lidocaine HCL and heparinized saline, removing any excess adventitia, and the vessel ends were dilated using microsurgical forceps.

Two stay sutures opposite to each other were done, apart 180 degrees from each other, using 10-0 Nylon monofilament sutures as shown in (Fig. 2) and the anastomosis time was recorded from the start of the first stay suture.

Conventional interrupted technique:

Within the area between the stay sutures, three sutures with equal spacing were done, then the artery was turned upside down and the posterior edges were sutured as well.

Open-loop technique:

Three continuous open-loops with equal distances between them were done on the anterior edges with the end of the needle used to make the stay suture, after which a stay suture was cut and the first open-loop done was transected and tied. The subsequent loop was cut and tied with the prior short suture tail, and the third loop was cut and tied in the same manner as shown in (Fig. 2). The vessel was then flipped over and three equally spaced loops were done, which were then cut and tied using the same technique as the anterior wall. After the anastomosis was completed, time was recorded, the clamps were released and then the patency rate and anastomotic leakage were assessed.

Anastomosis time:

The anastomosis time was recorded from the start of the first stay suture till the end of the last interrupted suture done in the conventional technique, and till the tying of the third loop in the open- loop technique.

Patency rates:

Evaluation of patency rate in all of the anastomosis was done at 5 minutes and 15 minutes after the anastomosis through utilizing ultrasonic Doppler hearing the blood flow distal to the anastomosis site as shown in (Fig. 3) and through the milking test. After obstructing the anastomosed artery far from the anastomosis with a microsurgery forceps, a small part of the artery distal to the first forceps was emptied with another forceps. The proximal forceps was released the second forceps was held closed, and refill time of the blood flow was recorded. Rapid refilling indicated anastomosis patency, slow refilling could indicate a vasoconstriction, thrombus formation, or surgical error, while no refilling suggested thrombus formation or a huge surgical error. According to the refill time the anastomosis was graded as good, fair, or poor **[4]**.

Anastomotic leakage:

After the releasing of the approximating clamps the anastomotic leakage was assessed and graded as follows **[4]**.

- Grade I: Minimal amount of bleeding that was stopped with no interference.
- Grade II: Moderate amount of bleeding that could be stopped by pressure with surgical gauze.
- Grade III: Extensive bleeding that may require clamping of the artery and revision with more sutures.

Fig. (1): Dissection of the rat's femoral artery.

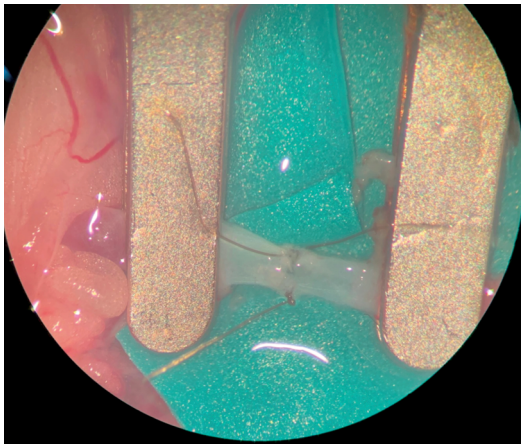

Fig. (2A): Two stay sutures opposite to each other were done, 180 degrees apart.

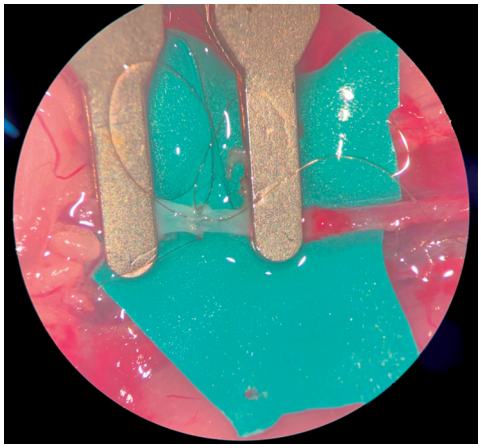

Fig. (2B): The start of the open-loops.

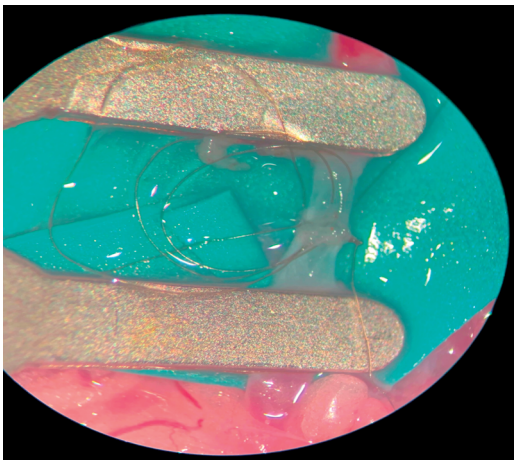

Fig. (2C): Three continuous open-loops with equal distances between them.

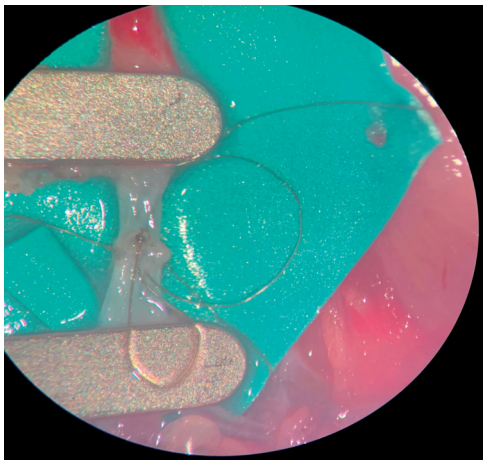

Fig. (2D): The first loop was tied and cut.

Fig. (3): Assessing patency rate using ultrasound doppler.

RESULTS

Anastomosis time:

The mean of the anastomosis time for the 2 studied groups was 24.95 with standard deviation ±3.78 ranging from 19 to 37 minutes. The Conventional Interrupted Suture (Group I) mean time is 24.50±2.04 minutes, while the Open-Loop Technique's (Group II) time is 22.40±4.48 minutes, although the time difference is minimal still statistically highly significant (*p*-value 0.008). Thus, the open-loop technique can save anastomosis time over the conventional technique (Table 1).

Table (1): Comparison of anastomosis time among the studied groups.

	Anastomosis type		Test value	*p*-value	Sig.
	Conventional Interrupted Suture No.=20	Open-Loop Technique No.=20			
Anastomosis Time (in Minutes):					
Mean± SD	24.50±2.04	22.40±4.48	2.817•	0.008	HS

Patency rate:

The overall patency rate for all studied groups measured 5 minutes after the anastomosis was (95%) good and only (5%) was poor patency. The patency rate measured 15 minutes after the anastomosis was (82.5%) good, (10%) fair and (7.5%) poor. When comparing the two investigated groups in terms of Patency, there was no significant difference between them (Figs. 4,5).

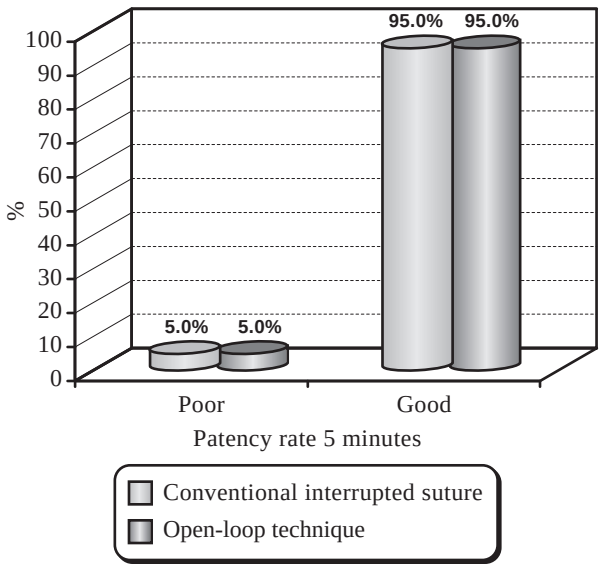

Fig. (4): Comparison of Patency rate after 5 minutes among studied groups.

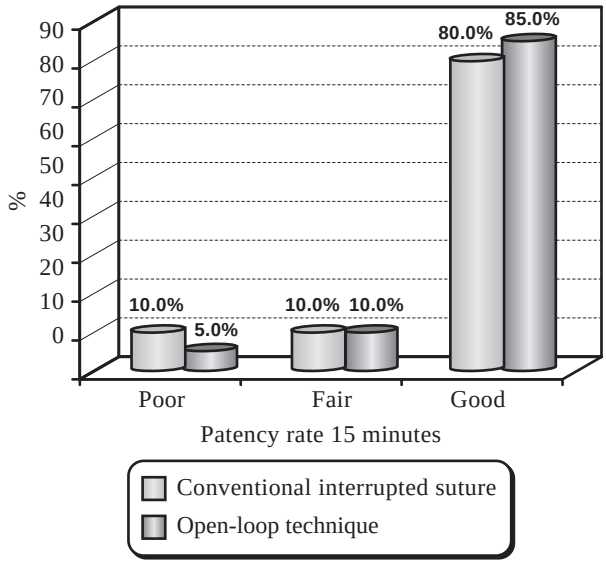

Fig. (5): Comparison of Patency rate after 15 minutes among studied groups.

Anastomotic leakage:

Regarding the Anastomotic leakage, in our study, 19 anastomosis of which were done by conventional interrupted technique were evaluated as Grade II and only 1 anastomosis was evaluated as Grade III. While those done by open-loop technique, 3 anastomosis were evaluated as Grade I, 16 anastomosis as Grade II and only 1 as Grade III; indicating that in terms of anastomotic leakage there was no significant difference between the 2 techniques (Table 2).

Table (2): Comparison of anastomotic leakage among the studied groups.

	Anastomosis type		Test value	*p*-value	Sig.
	Conventional Interrupted Suture No.=20	Open-Loop Technique No.=20			
Anastomotic leakage:					
Grade I	0 (0.0%)	3 (15.0%)	3.243*	0.072	NS
Grade II	19 (95.0%)	16 (80.0%)			
Grade III	1 (5.0%)	1 (5.0%)			

DISCUSSION

Through our study, applying the open-loop technique showed several advantages; it integrates the convenience and speed of the continuous sutures with the safety of the simple ones. Other than saving time, it allows the surgeon to maintain precise visualization of the vessel lumen at all times, so that he will not blindly injure the vessel back wall with the needle during the anastomosis because he would be able to see every edge being

sutured. These observations are consistent with the study of Vila et al., **[7]**.

Therefore open-loop technique is indicated in procedures with multiple anastomosis and/or at the end of the anastomosis to avoid closure of the space on the last suture.

However, most surgeons are more familiar with and used to performing the conventional method, and if not properly trained, the open-loop technique might be too complex making the anastomosis more difficult for the surgeon due to the open loops present around the vessel, making it unclear over which loop should be cut and tied next. Lee et al., **[6]** and Hamdy Sakarya **[8]** stated that we can overcome this confusion by making the loops in different sizes, so that they can be identified with ease consecutively.

In terms of sample size, we applied our study on 40 rats' femoral arteries divided equally into two groups of 20 rats each, similar to Barros et al., **[3]** who made a comparison between the continuous technique and the interrupted suture technique performed on the femoral vessels of an equal number of rats. While Tetik et al., **[4]** who compared the continuous horizontal mattress technique to the continuous simple suture technique on 64 femoral arteries from 32 rats, dividing the rats into 4 groups with 16 anastomosis in each group.

Regarding the anastomosis time, the Conventional Interrupted Suture mean time in is 24.50± 2.04 minutes, while the Open-Loop Technique mean time is 22.40±4.48 minutes. This was in line with the findings of Lee et al., **[6]**, who found that the mean time of Conventional Interrupted Suture is 25 minutes and that of Open-Loop Technique is 19 minutes to complete an anastomosis.

While Barros et al., **[3]** found that the continuous suture technique required considerably less anastomosis time than the interrupted suture technique, with mean time of 12±0.7 minutes for the interrupted suture technique and 7.6±0.95 minutes for the continuous suture technique.

Furthermore, while Barros et al., **[3]** stated in the same study that the conventional interrupted suture technique has higher patency rate than new techniques, the results of our study showed no significant difference in patency at 5 minutes or 15 minutes post anastomosis in our open-loop technique, which is consistent with study of Tetik et al., **[4]**.

While regarding assessing the patency in our study, we employed the milking test and Doppler ultrasound same as Lee et al., **[6]** Chen et al., **[9]** and Yin et al., **[10]** while Barros et al., **[3]** used Acland test, which is less commonly used for assessing patency rates. Tetik et al., **[4]** used only milking test.

And finally, regarding the Anastomotic leakage in our study, we had 19 anastomosis done by conventional interrupted technique evaluated as Grade II and only 1 anastomosis evaluated as Grade III, while through the open-loop technique 3 anastomosis were evaluated as Grade I, 16 anastomosis Grade II and only 1 evaluated as Grade III, and this was consistent with the study of Tetik et al., **[4]**.

Limitations and Recommendations:

1- Assessing the patency rate 5 and 15 minutes after the anastomosis can give us a good idea about the patency after the anastomosis, however, may not be conclusive enough. We recommend that future studies should wake the rats up after the procedures and asses patency after several days and also do a histological examination for the rats' femoral vessels after being sacrificed to assess narrowing of the anastomosed segment, reendothelialization, hyperplasia of the vessel intima, aneurysm formation and the final structure of the anastomosed vessel after open-loop technique.

2- Most surgeons are more familiar with the conventional interrupted technique and are more used to it, and if not trained well, the open-loop technique might be too complex and might make the anastomosis more difficult for the surgeon, however it was evident during our study that the more we perform the open-loop technique the easier it gets.

Conclusion:

In Conclusion, open-loop technique reduces anastomosis time, while also increases the anastomosis safety by minimizing back wall stitches. And therefore, our recommendation is to use open-loop technique particularly in procedures with multiple anastomosis.

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