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Tightening Continuous Suture Loops in Microvascular Anastomosis with a Microneedle

Zongyu XIAO[1,2]

[1]Dushu Lake Hospital Affiliated to Soochow University, Department of Neurosurgery, Suzhou, China
[2]Affiliated Hospital of Qinghai University, Department of Neurosurgery, Xining, China

Corresponding author: Zongyu XIAO ✉ xiaozongyu@hotmail.com

To watch the surgical videoclip, please visit http://turkishneurosurgery.org.tr/uploads//jtn-37621-video.mp4; http://turkishneurosurgery.org.tr/uploads/jtn-37621-video2.mp4

ABSTRACT

AIM: To present a technique for tightening continuous suture loops in microvascular side-to-side anastomosis with a microneedle.

MATERIAL and METHODS: The technique for tightening continuous suture loops with a microneedle was presented in side-to-side microvascular anastomosis in chicken thighs arteries and rat common carotid arteries. After all the spiral continuous suture loops were loosely placed, the tip of the microneedle was used to precisely and gently tighten the second suture loop, then microforceps was used to pick this loop up and gently tighten it, while the body of the microneedle was gently applied to create a counterforce on the inner or outer surface of the vessel to help tighten the first loop under appropriate tension and place it in an appropriate position.

RESULTS: With this technique the author described, there is no need to change to any other surgical instruments during anastomosis, and these continuous suture loops in continuous microvascular anastomosis could be effectively tightened with a microneedle. And the technique was successfully applied in side-to-side microvascular anastomosis in chicken thighs arteries and rat common carotid arteries.

CONCLUSION: Microneedle could be safely and effectively used as a microretractor to tighten the continuous suture loops in continuous microvascular anastomosis. The judicious and discreet use of a microneedle as a multifunctional instrument for functions other than suturing could minimize the exchange of instruments and improve operative efficiency.

KEYWORDS: Tighten, Microneedle, Microvascular anastomosis, Continuous, Suture

INTRODUCTION

Generally, microforceps, angled ball-tipped probes or nerve hooks are used to tighten continuous suture loops in microvascular anastomosis (1,2,5). However, the procedure may occasionally be difficult and troublesome when the loops are incorrectly tightened or entangled with each other, and the vascular endothelium may be injured by inadvertently grasping the lumen of the vessel with microforceps when tightening the intraluminal continuous suture loops. Here, the author presents a technique for tightening continuous suture loops with a microneedle in microvascular side-to-side anastomosis. This technique was successfully applied in side-to-side microvascular anastomosis in chicken thigh arteries and rat common carotid arteries (CCAs).

MATERIAL and METHODS

The study was approved by the Institutional Review Board, and the animal care was performed in accordance with the Guide for the Care and Use of Laboratory Animals. All

Zongyu XIAO : 0000-0002-3678-1086

procedures were performed by the first author under 10× or 16× magnification under a microscope (Zeiss, OPMI Pico). Twenty chicken thighs were obtained from a grocery store without consideration of the age of the chicken or the size or weight of the individual thighs. Twenty male Sprague–Dawley (SD) rats weighing 200-250 g were used. Monofilament nylon sutures (10-0) were used for suturing.

Side-to-Side Microvascular Anastomosis Between Two Chicken Thigh Arteries

Side-to-side microvascular anastomosis between two chicken thigh arteries with a diameter of 1 mm was performed with 10-0 sutures as previously described (3,6). After all the intraluminal spiral continuous suture loops were placed loosely in the posterior wall of the anastomosis site (Figure 1A), the tip of the microneedle was used to precisely and gently elevate the second suture loop (Figure 1B). Then, a microforceps with a 0.15-mm tip was used to pick this loop up and gently tighten it, while the body of the microneedle was gently applied to create a counterforce on the inner surface of the vessel to help tighten the first loop under appropriate tension and place it in an appropriate position (Figure 1C). If the loop was tightened with too much tension or in the wrong place, it could be easily untied with the tip of the microneedle and adjusted accordingly. Then, the following suture loops were sequentially tightened with the same technique. Finally, the anterior wall was closed with an extraluminal continuous suturing technique, and the same tightening technique was used to complete the anastomosis (see video, supplementary digital content 1).

Side-to-Side Microvascular Anastomosis Between Rat Common Carotid Arteries

Side-to-side microvascular anastomosis between bilateral CCAs in SD rats was performed with 10-0 sutures as we previously described (7). The animals were anesthetized intraperitoneally with pentobarbital (50 mg/kg). After the bilateral CCAs were fully dissected, they were temporarily occluded with two temporary aneurysm clips (Figure 2A). Arteriotomies of approximately 3 times the diameter of the CCA were made on the anterior walls of the bilateral CCAs; next, the lumens of the vessels were cleaned with heparinized saline (100 units/mL), and blue dye was used to enhance the visualization of the edges of the arteriotomies (Figure 2B). Then, a side-to-side microvascular anastomosis was performed. The depth of the sutures was 1-2 times the thickness of the CCA wall, and the spacing was approximately 3-5 sutures per millimeter. After these continuous suture loops were loosely placed intraluminally or extraluminally, the loose continuous suture loops were sequentially tightened with the tip of the microneedle using the tightening technique described in this study (Figure 2C-E). After the completion of the anastomosis, the temporary clips were removed to restore blood flow (Figure 2F). Generally, anastomotic bleeding is expected even with the most perfectly suturing, because it is a sign that blood is flowing through the patent anastomosis. In most cases, anastomotic bleeding stops with gentle pressure using cottonoid in 2 minutes after the removal of temporary clips (4). If obvious anastomotic leakage occurred, several interrupted sutures could be added to stop the bleeding with or without temporary clips. The patency of the side-to-side anastomosis was evaluated by "milking" the recipient artery with microforceps to empty it and refill it with bypass flow while one of the donor arteries was temporarily clipped. Patency was assessed immediately and 30 min after the procedure (see video, supplementary digital content 2). Finally, the animals were euthanized by intraperitoneal injection of pentobarbital (200 mg/kg).

RESULTS

With the technique described here, there is no need to change to any other surgical instruments during anastomosis, and these continuous suture loops in continuous microvascular anastomosis can be effectively tightened with a microneedle. In side-to-side anastomosis between the bilateral CCAs of rats, with an average CCA diameter of 1 mm, all the continuous suture loops were tightened with the tip of the microneedle either intraluminally or extraluminally, and 100% patency rates were achieved both immediately and 30 min after anastomosis. No additional sutures were added after the

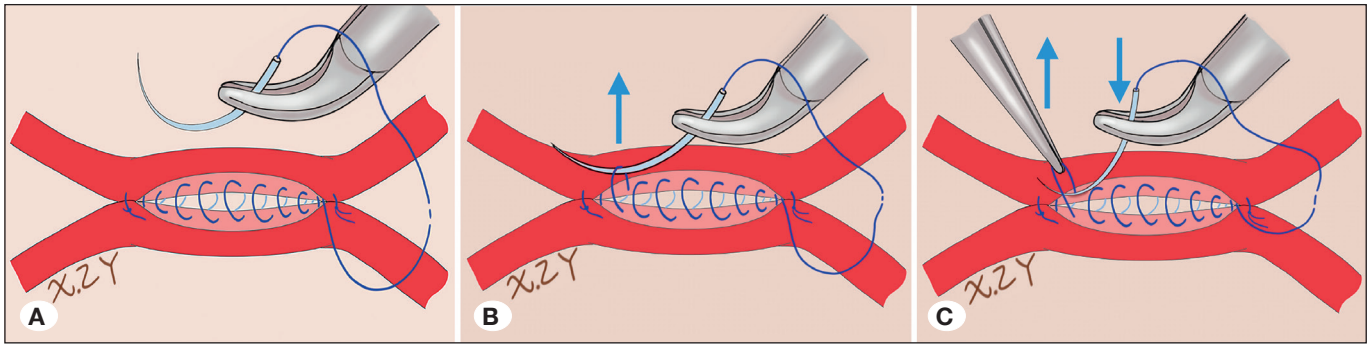

Figure 1: Schematic illustrations of the tightening the continuous suture loops in side-to-side microvascular anastomosis with a microneedle. After all the spiral intraluminal continuous suture loops were placed loosely in the posterior wall of the anastomosis site **(A)**, the tip of the microneedle was used to precisely and gently elevate the second suture loop **(B)**. Then, microforceps was used to pick this loop up and gently tighten it, while the body of the microneedle was gently applied to create a counterforce on the inner surface of the vessel to help tighten the first loop under appropriate tension and place it in an appropriate position **(C)**. Arrows indicate the motions needed to move the surgical instruments.

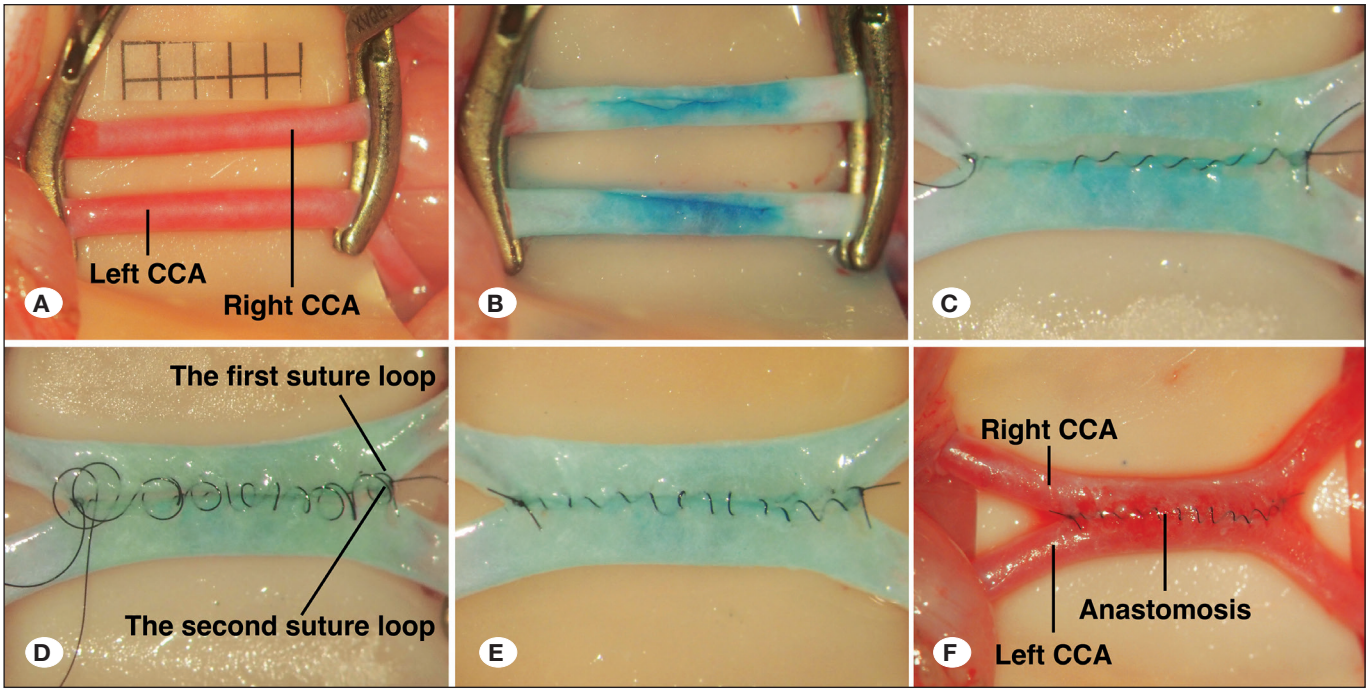

Figure 2: Side-to-side microvascular anastomosis between rat common carotid arteries. After the bilateral common carotid arteries were fully dissected, they were temporarily occluded **(A)**, arteriotomies were made on the anterior walls of the bilateral CCAs **(B)**. The posterior wall was closed intraluminally in a continuous suturing technique and these sutures loops were tightened **(C)**. Then the anterior wall of the side-to-side anastomosis was closed extraluminally in a loose continuous suturing technique **(D)**, and the loose continuous suture loops were tightened sequentially with the tip of the microneedle using the tightening technique described in this study **(E)**. After the completion of the anastomosis, temporary clips were removed to restore the blood flow **(F)**. (Scale bar = 1 mm). CCA = common carotid artery.

removal of the temporary clips. At the site of the side-to-side anastomosis, we found no obvious anastomotic leakage, no anastomotic aneurysms, and no thrombosis.

DISCUSSION

The microneedle has a very fine tip and could be safely used as the finest microretractor or microdissector if applied appropriately; otherwise, the sharp tip of the microneedle may place the vessel at risk of injury, but dexterity can be achieved through sufficient microsurgical training.

In this study, the author presents a tightening technique using the tip of a microneedle for side-to-side microvascular anastomosis. First, the author demonstrated this technique in chicken thigh arteries. Then, the technique was successfully applied for side-to-side anastomosis between the bilateral CCAs of rats. No obvious anastomotic leakage was found, and a 100% patency rate was achieved. Generally, loose continuous suture loops are tightened with microforceps, angled ball-tipped probes or nerve hooks in microvascular anastomosis (1,2,5). Regardless of the instruments used to tighten the suture loops, these suture loops must be gently tightened under appropriate tension and placed in an appropriate position. Loose suture loops leave gaps between the edges of the anastomosis, whereas overtightened suture loops may distort tissues. Through sufficient training in the microsurgical laboratory, a surgeon can learn to use the tip of a microneedle as effectively as other instruments to tighten the suture loops. Due to the small size and extremely fine tip, a microneedle is more effective for this purpose when the anastomotic field is deep and narrow. Moreover, if the suture loops are tightened incorrectly or placed in the wrong location, these loops can be easily untied with the fine tip of the microneedle and adjusted accordingly.

With this technique, there is no need to change to any other surgical instruments during anastomosis, therefore enhancing surgical efficiency. In addition to the technique described above, the microneedle tip could also be used as a microhook to retract the adventitia of the vessel or could be applied directly but gently and atraumatically on the inner surface of the vessel to elevate the edge of the anterior wall and expose the lumen clearly.

Therefore, the technique described in the study could be used as an alternative technique to tighten suture loops. However, the choice of technique for tightening these suture loops should be based on the surgeon's comfort and experience because any microsurgical technical modification should be fully mastered in the laboratory so that it can be safely and effectively applied in the operating room.

CONCLUSION

A microneedle can be safely and effectively used as a microretractor to tighten the continuous suture loops in

continuous microvascular anastomosis. The judicious and discreet use of a microneedle as a multifunctional instrument for functions other than suturing could minimize the exchange of instruments and improve operative efficiency.

AUTHORSHIP CONTRIBUTION

The author (ZX) confirm responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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