Evaluation of Longitudinal Slit Arteriotomy for End to Side Anastomosis in Free Tissue Transfer

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ABSTRACT:

BACKGROUND:
The choice of micro-anastomosis technique (end to end or end to side) in free flap surgeries is a critical step especially in single vessel extremity in which end to side is the preferable method. Which type of end to side (arteriotomy or arteriotomy) is another relevant point to be considered?

AIM:
This study aims to evaluate the reliability of end to side anastomosis using longitudinal slit arteriotomy.

METHODS:
(9) patients were managed with free tissue transfer using end to side anastomosis with longitudinal slit arteriotomy. (8) Patients with lower extremity defects and (1) patient with upper extremity defect. (6) Patients were managed with Latissimus dorsi flap and (3) patients were managed with ALT flap. In all cases end to side anastomosis is made using no. 11 blade to create a longitudinal slit in the recipient artery for micro-anastomosis

RESULTS:
All anastomosis remain patent and flaps survived without complications, neither re-anastomosis is required intra-operatively nor re-exploration is required post operatively

CONCLUSION:
longitudinal slit arteriotomy is easy to perform, reliable with high patency rate and can consistently be used in free tissue transfer with excellent results

KEY WORDS: Slit arteriotomy, Longitudinal slit aretriotomy, Microanastomosis, Free tissue transfer.

INTRODUCTION:

Since the introduction of the microvascular free tissue transfer in 1970 and with the improvement of experience, techniques, and instruments, the achieved success rate of free tissue transfer had been reaching up to 95%. A critical factor that determines successful free tissue transfer is choosing of adequate recipient vessels and perfect microvascular anastomosis where is either end to end or end to side anastomosis.[1,2]

End to end anastomosis remains the first option for most of the microvascular anastomosis, it needs less technical demand and also can be performed without the need of a surgical assistant. End-to-end anastomosis can be done in three different fashions; halving technique, back wall up technique and triangular technique.[3-5]

In 1978 Godine had described and popularized end to side anastomosis, especially for lower extremities free tissue transfer. End to side anastomosis is indicated for single vessel limbs, and for size discrepancy between donor and recipient vessels. End to side anastomosis is technically different but had to save patency rate in comparison with end to end anastomosis. [6-8]

Arteriotomy in end to side anastomosis is done either by using excision arteriotomies (arterioctomies) or by a single cut or slit arteriotomies. [9]

Tan et al had introduced a novel method of using slit arteriotomy which involved cutting of slit in the recipient artery rather than a hole that could be either longitudinal or transverse. Tan et al method of slit arteriotomy has not received acceptance among microvascular surgeons due to their concerns about the slit that may not sufficiently open which leads to thrombosis. [6,7,9]

In this study, the reliability of slit arteriotomy end to side microanastomosis had being evaluated in free tissue transfer for extremities reconstruction.

PATIENTS AND METHODS:

Between January 2018 and January 2019, (9) patients presented to Al-wasity teaching hospital with soft tissue defects in the lower extremity (7 cases), upper extremity (1 case) and foot equinus with unstable scar (1 case) of various causes. Patients' details and data are shown in table (1).

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All patients were subjected to complete physical examination including assessment of the size of the wound, the degree of wound contamination, status of vascularity of injured extremity and general assessment of patients' conditions
Ct angiography was done for the patients preoperatively to evaluate the vascular tree of the extremity and routine preoperative investigations were sent for all patients, all patients had preoperative informed consent, discussion with patient and\or their families the details and prognosis of the operation

Table 1: Patients' data.

No.	age	gender	Site of injury	Cause of injury	Free flap used
1	3 yrs.	Male	Exposed ankle joint	MVA	LD
2	17 yrs.	Male	Left hand first web space soft tissue loss	Shot gun bullet injury	ALT
3	5 yrs.	Male	Exposed lower tibia	MVA	ALT
4	28 yrs.	Male	Amputation of mid foot	Crush injury	LD
5	52 yrs.	Male	Exposed lower tibia	High voltage electrical injury	LD
6	28 yrs.	Male	Exposed Achilles tendon	Blast injury	ALT
7	35 yrs.	Male	Exposed lower tibia	MVA	LD
8	9 yrs.	Male	Exposed lower tibia	MVA	LD
9	10 yrs.	Male	Foot equinus	MVA	LD

*MVA: motor vehicle accident, LD: latissimus dorsi, ALT: anterolateral thigh flap

Operative technique

All operations are done under general anesthesia, after preparation of the wound bed and determining the site of the recipient vessels, the recipient vessel is prepared. The flaps are elevated and transferred to cover the wound and primary setting is done. The recipient artery is cleaned from perivascular adventitia using blunt microscissors and ligation of side branches of a segment of approximately 3 cm is done. Setting the slit in the recipient artery is determined by the orientation of the ETS anastomosis with regard to the setting of the flap and anatomic considerations of the wound.
A double micro-clamp is applied to the recipient artery, first the distal part then the proximal part of the clamp, utilizing the benefit of arterial pressure to dilate the vessel so decrease the risk of injury to the posterior wall during slitting. With no.11 blade a longitudinal slit is made in the recipient artery,
figure (1-A).
The length of the slit is about the diameter of the donor artery that is already beveled 30-40 degrees with micro-scissors. If the slit is short it can be lengthen using sharp end straight micro-scissors, we always try to avoid long slit that's need shortening with simple interrupted suture, figure (1-B). After releasing of the proximal clamp to check for arterial spurt, the double clamp is approximated slightly to allow pouching of the slit therefore facilitating the repair and reduce the risk of back walling, figure (1-C).

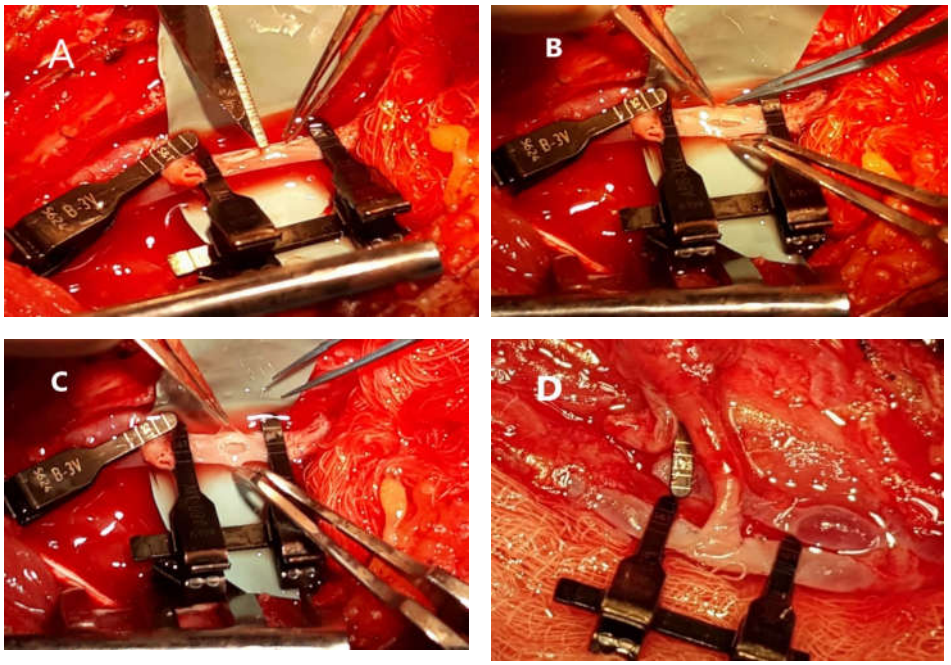


Figure 1: A- creation of slit arteriotomy using n.11 blade. B-slit is created. C- approximation of clamps cause pouching of the slit. D- final result after anastomosis

After irrigation of the lumen with heparinized saline and checking if there is any injury to the posterior wall, anastomosis is begin using 8.0 proline suture with suturing the heel site of the donor artery then the toe site. Posterior wall is repaired with setting of untied notes that is secured after checking there is no back walling to the anterior wall. The anterior wall is repaired also by untying the stitches until all stitching are done to prevent back waling. To keep the edges of the repair well everted the needle bite the donor artery then the recipient, the needle passed perpendicular to the arterial wall to tag the intima with repair and prevent its separation. Care is taken when placing the corner stitches as this is the most difficult part of the repair. Continuous irrigation with heparinized saline and lidocaine 2% throughout the anastomosis to prevent clotting and spasm respectively is done. The end result will be a well dilated vessel which is cupped over the slit arteriotomy, figure (1-D). Then Flap insetting is completed and multiple corrugate drains are placed under the flap.

Postoperatively, patients are monitored to keep them warm, well hydrated, hemodynamically stable and pain free. Prophylactic heparin 5000 IU s\c is given every 8 hrs. for 5 days. Aspirin 100 mg is given once daily for 5 days. Limb elevation to avoid edema formation and enhance venous return. The free flaps are monitored clinically and with hand held Doppler hourly for the first 24 hrs. then every 2 hrs. for the next 48 hrs. then every 4 hrs. for the next 72 hrs. Patients discharged home after one week then regular follow up visit every 1 week for 1 month then a follow-up visit after three months.

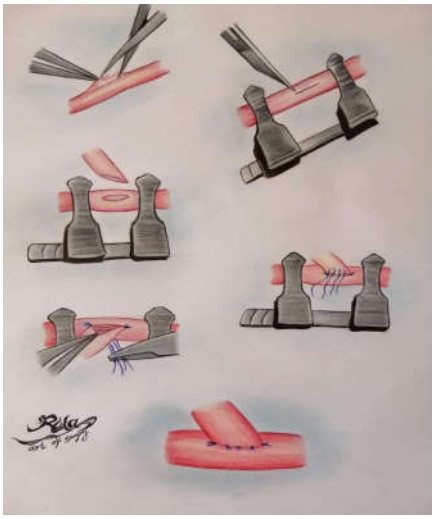


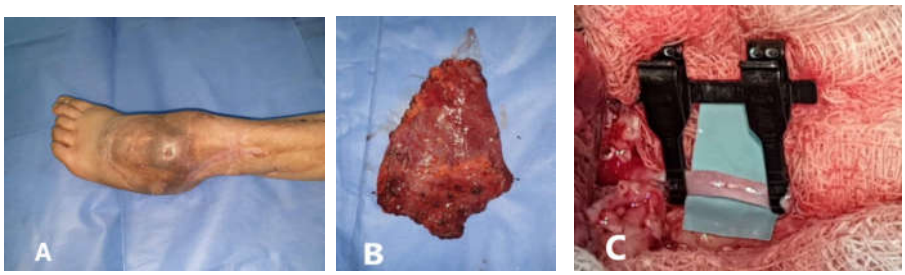
Figure 2: Sketching summarizes surgical technique of longitudinal skit arteriotomy in end to side anastomosis.

Figure (2) can summarize longitudinal slit arteriotomy in end to side anastomosis.

RESULTS:

Nine patients were successfully treated with free tissue transfer relying on the ETS anastomoisis using the longitudinal slit arteriotomy technique. (5) Patients had single vessel extremity according to the trauma zone and confirmed with CT angiography. For all patients with lower extremity defects, the posterior tibial artery was chosen as a recipient artery while the radial artery was chosen in upper extremity defect. Anterolateral thigh flap was used in upper extremity defect while lower extremity defects were managed as 2 cases with anterolateral thigh flap and 6 cases with latissimus dorsi mayocutaneous flap. The average time of anastomosis was 35 minutes

All flaps survived with no major complications. No flap required intra operative re-anastomosis. No flap required re-exploration for congestion or ischemia. No partial flap necrosis was encountered. No distal limb ischemia was encountered in any case.



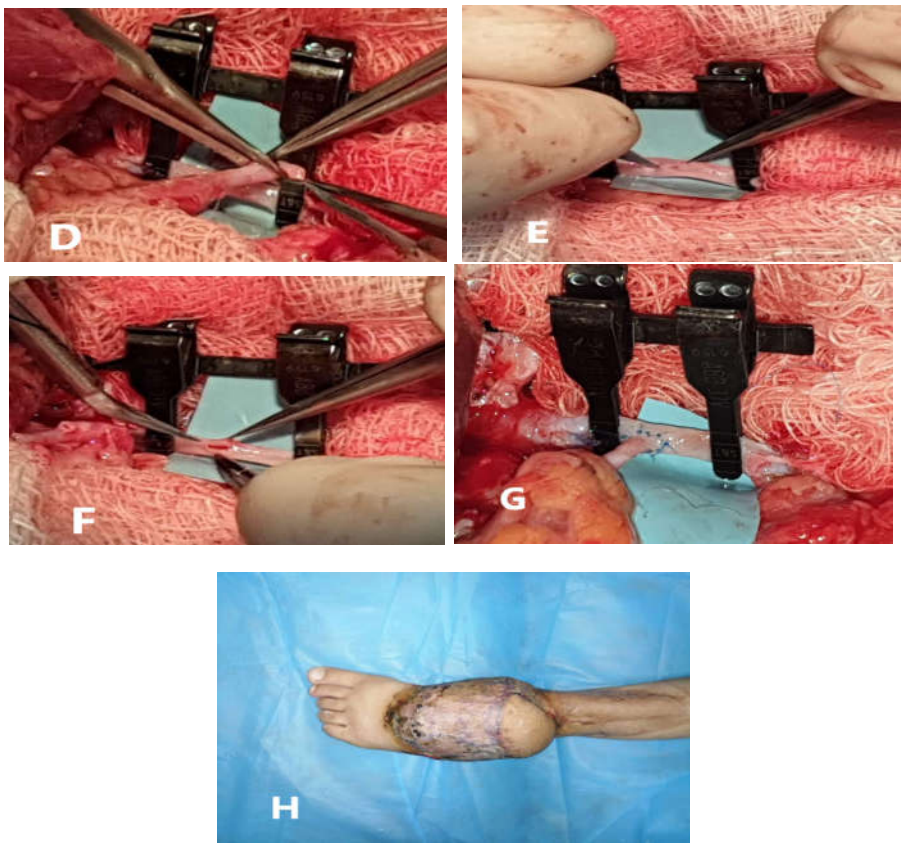


Figure 3: Case no.1, A: patient with traumatic equinus of left foot with unstable scar. B: LD flap. C: clamping the recipient artery. D: beveling of the donor artery. E: using no. 11 blade to create a slit. F: the slit is created. G: anastomosis is completed. H: final result.

DISCUSSION:

In general end to end anastomosis is regarded the most widely and accepted first option that had being used for microvascular anastomosis. This technique is less assistant dependent and less demanding. It is the standard technique for microvascular anastomosis in the early beginning of microvascular free tissue transfer. End to end anastomosis seems to be most effective to offer hemodynamic blood perfusion from one vessel to another [1,3,10,11].

However, in those cases that had single vessel extremity, end to side anastomosis is preferable, since this will maintain distal blood flow to the extremity. Single vessel extremity is commonly encountered problem in many conditions that required free soft tissue coverage in extremities. Maintenance of sufficient blood supply is crucially important for flap perfusion while preservation of adequate distal blood perfusion to the extremity. End to side anastomosis helps the surgeon to work outside the zone of injury by selecting the appropriate recipient vessel. More over end to side anastomosis can overcome size discrepancies between both donor and recipient vessels especially if discrepancy is more than 3:1 when gentle dilatation of the vessel and end to end anastomosis is not applicable. End o side anastomosis allows high blood flow which can wash away any potential thrombi that can occur at the anastomosis site based on fact that the recipient artery is not retracted so spasm is avoided [1,8,12].

High blood flow occur in end to side anastomosis since the recipient vessel maintain its original length and it's not retracted and thus spasm is avoided while when end to end anastomosis is done both ends are completely divided so they retracted longitudinally and this lead to spasm. Longitudinal retraction occur due to the effect of releasing the natural arterial wall resting tension which lead to thickening of the arterial wall [11].

End to side anastomosis has excellent healing

process of endothelium which reduces incidence of thrombus formation as it reported by Bas et al who conducted comparable study between end to end and end to side anastomosis by using rat models. Their results showed that end to side arterial anastomosis had excellent endothelial healing over end to end anastomosis which was confirmed histologically and electro microscopically. Of course better healing of the endothelium reduces the incidence of thrombus formation by decreasing platelet aggregation [3].

Godina in 1979, showed higher flap failure rate reach up to 38% with end to end anastomosis. However there are many confounding factors that may lead to misinterpretation of these finding. Later on experimental studies showed no difference in flap failure, blood flow and peripheral resistance when comparing end to end and end to side microvascular anastomosis. Samaha et al showed equal patency in long term period for both types of anastomosis. Cho et al compared end to end with end to side anastomosis for lower leg reconstruction using free flaps and no difference in the outcome was found. However end to side anastomosis is crucial technique in cases with single vessel extremity and those with large vessel discrepancy between the recipient and the donor vessels [1,13].

Sacrificing major artery in extremities reconstruction is inevitable with end to end anastomosis. Jones and o'brien in 1989 reported a patient who had acute hand ischemia after harvesting radial forearm flap, though this patient had preoperative satisfactory Allen's test. Heller et al also demonstrated necrosis of fingertip which occurs due to insufficiency of blood supply after 1 year of radial forearm flap elevation [10]. Therefore, even in double vessels extremity preservation of blood vessels continuity is preferable.

End to side arterial anastomosis using slit arteriotomy for free tissue transfer was used successfully in extremities reconstruction by Bien-keem Tan et al in 2008. They used this technique in sixty free flaps of both upper and lower extremities reconstruction with 95% overall success rate. Their study shows four cases had no flow that occurred immediately after revascularization. In two cases the flow resumed after topical application of papaverine and warming. The other two cases no flow was due to white thrombus formation, in one case the thrombus spontaneously washed out after intravenous heparin injection while in the other case opening the anastomosis and evacuation of the thrombus was required [6]. In our study we did 9 cases with no flap failure or re-exploration neither intra nor post-operative.

No venous flap congestion was noticed in all our cases, this attributed to the fact that the blood flow matches the physiological need of the flap, since not all recipient blood flow directed to the flap so that venous drainage of the flap is coping to the recipient vein of the flap [6].

No posterior wall injury was encountered during slitting the vessel wall and this is may be due to meticulous technique and clamping the distal part of the recipient artery before the proximal part thereby utilizing the effect of blood pressure dilating the vessel.

No back walling was encountered during this procedure we attributed to the using pouching effect on blood vessels during repair which was done by approximating the double clamp after creation of the slit in the arterial wall thus facilitating end to side suturing away from the posterior wall.

Slit aretiotomy has many advantages, its easily performed procedure by 30^{o} or 150^{o} micro-knife although in our study we did it by using no. 11 blade with excellent result. Also it's a dynamic procedure in term that the slit can be extended when larger opening is required or shortened if it's too long. Furthermore, since no portion of the vessel is removed (as in cases of arterioctomies) we expected that the lumen of the recipient vessel is not narrowed but rather it is enlarged. Finally, if the flap failure happened or if we needed to change the site of the slit for any given reason, simple interrupted suturing to the slit can retain the original lumen diameter of the recipient vessel.

The factors that maintain the recipient vessel patency after slit arteriotomy are residual stress, coupling effect of both donor and recipient artery and blood pressure. According to Fung [7] there are compressive and tensile residual stresses that act on inner and outer region of the arterial wall respectively. After longitudinal slit is done, circular contraction of smooth muscles in arterial wall tend to open the space and prevent it from spasm, this account for 20% of slit opening. Coupling effect of the donor and recipient vessels accounts for 40% contribution for maintenance of slit opening. During stitching of the donor vessel to the recipient vessel, the slit is widened, since the surgeon is matching the recipient vessel (initially narrow) to the donor vessel (initially wide) which will reach in balanced forces to open the slit. In another words, elastic recoil of the donor vessel in longitudinal axis will keep opening the slit and with constant factors the thicker the donor artery the wider the slit.

Finally, blood pressure contributes to 40% of slit

opening. When the donor vessel thickens and stiffens, it will initially increase the width of the slit after stitching, but at the end of operation decreases width of the slit, since contribution of blood pressure to slit opening becomes relatively minor in thickened and stiffened donor vessel [6,7,14].

Another important point to be mentioned is that according to Poiseuille's low, diameter is inversely proportional to resistance and stenosis or spasm increases resistance to flow greatly but in contrary to common thinking, slit aretiotomy is beneficial to flow because of anastomotic site dilatation [6].

In general, the main disadvantages of arterioctomies are irregular margins because more than one cut is required, risk of laceration to the posterior wall, risk of vascular thrombosis, difficult to adequately control the size of the arterioctomy, time consuming and sometimes the need of instruments that are especially designed to perform arterioctomy which may be expensive and not always available [9,15].

Studies on rat show that there is no difference in patency between excisional and incisional methods. Also, Nam, Robaerts and Acland showed no difference in flow when compared between slit longitudinal arteriotomy and excised ellipse. However, Adams et al demonstrated that most surgeons prefer to use longitudinal slit over excisional method because, it is easy to done. Also, when we compared longitudinal slit with transverse slit arteriotomy, the longitudinal slit is more superior to the transverse slit, since the later does not increase the diameter of anastomosis site and also it has the potential of posterior vessel wall damage [9,11].

The main disadvantage of slit arteriotomy that it has less exposure to the vessel opening edges compares with excision method. However, with approximation of the clamps end to pouch the vessel and with help of well-trained assistance this problem can be overcome. Also, it spends more time to perform end to side anastomosis than to spend with end to end.

CONCLUSION AND RECOMMENDATIONS:

Longitudinal slit arteriotomy provides simple and easy technique for end to side anastomosis with high patency rate. It requires no excision of the arterial wall, it's a dynamic procedure in which the slit can be elongated or shortened easily and it has the advantage of keeping the original diameter of the recipient artery if we had to close the slit. We recommend using this technique especially in cases of single vessel extremity

REFERENCES:

1. Heidekrueger PI, Ninkovic M, Heine-Geldern A, Herter F, Broer PN. End-to-end versus end-to-side anastomoses in free flap reconstruction: single centre experiences. Journal of plastic surgery and hand surgery. 2017 ;51: 362-65.
2. Barros RS, Leal RA, Teixeira RK, Yamaki VN, Feijó DH, Gouveia EH, Valente AL, Silva Feitosa-Junior DJ, Carvalho LT. Continuous versus interrupted suture technique in microvascular anastomosis in rats. Acta cirurgica brasileira. 2017;32:691-96.
3. Hsieh YH, Lee CH, Kwon SH, Chang TN. Chang's Technique of Sequential End-to-Side Microvascular Anastomosis. International Microsurgery Journal (IMJ). 2017.
4. Mania Z Siemionow, Manta Eisen man-klein. Plastic and reconstructive surgery, 1st ed, springer-relog London limited, 2010:94.
5. Jeffrey E Janes. Essential of plastic surgery, 2nd ed, DMP CRC, New York, 2014:75,80,81.
6. Tan BK, Wong CH, Chew W, Hong SW. Use of the slit arteriotomy for end-to-side arterial anastomosis in free-tissue transfers to the extremities. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2009;62:1519-23.
7. Gu H, Chua A, Tan BK, Hung KC. Nonlinear finite element simulation to elucidate the efficacy of slit arteriotomy for end-to-side arterial anastomosis in microsurgery. Journal of biomechanics. 2006;39:435-43.
8. Hallock GG, Rice DC. Use of a micropunch for arteriotomy in end-to-side anastomosis. Journal of reconstructive microsurgery. 1996;12:59-64.
9. El Rifaï S, Boudard J, Haïun M, Obert L, Pauchot J. Tips and tricks for end-to-side anastomosis arteriotomies. Hand surgery and rehabilitation. 2016;35:85-94.
10. Tsai YT, Lin TS. The suitability of end-to-side microvascular anastomosis in free flap transfer for limb reconstruction. Annals of plastic surgery. 2012 ;68:171-4.
11. Godina M. Preferential use of end-to-side arterial anastomoses in free flap transfers. Plastic and reconstructive surgery. 1979;64:673-82.
12. Fu-Chan wei, Samir Mardini. Flaps and reconstrctvesurgery, 1st ed, Saurters Elsenier, 2009:59, 64, 121.

13. Pafitanis G, Veljanoski D, Ghanem AM, Myers S. Intimal surface suture line (end-product) assessment of end-to-side microvascular anastomosis. Plastic and Reconstructive Surgery Global Open. 2017;5.
14. Diego Marre. Fndemental topics in plastic surgery, 1st ed, Thieme, New York, 2018;347
15. Dash H, Kononov A, Maloney J, Browne E. A simple arteriotomy method for microsurgical end-to-side anastomoses: technical aspects of use in training and laboratory applications. Journal of reconstructive microsurgery. 1993;9:381-4.