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Precision in Perforator Based Anterior Tibial Artery Adipofacial Flap by the Use of Color Duplex

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ABSTRACT

Anterior tibial artery adipofacial flap is a pedicled perforator flap raised from the dorsum of the foot which enables reconstruction of a variety of local defects around the ankle without microvascular anastomosis and with minimal donor-site morbidity. The problem with this flap is that it is technically demanding as extreme care should be taken while dissecting and locating the perforator(s) needed for survival of flap. The possibility to miss or injure such perforator(s) specially being one or two in number is high. In an attempt for decreasing this possibility the color Doppler ultrasound was used as a method of identification preoperatively where the possible site of perforator(s) was compared with actual site intraoperatively. Ten patients (8 males, 2 females) suffering from soft tissue defect either on the medial or lateral malleolar region were included in the study. The study was carried out between August 2005 and August 2008. All patients had preoperative color Doppler ultrasound with marking of possible site of perforators in an area about 4x5cm in the lower anteromedial part of leg. All patients had anterior tibial artery adipofacial flap and STSG for coverage of defect. Intraoperative location of perforator(s) needed for flap was identified and compared with preoperative marking. All flaps survived completely except one where there was loss of distal 1/3 of it. The accuracy of color Doppler ultrasound in detecting exact site of perforator was 80%. The color Doppler ultrasound can accurately identify the perforator(s) and help in increase success rate of this flap and in addition can provide three dimensional information about perforators in this area which may be of great value in supermicrosurgery.

INTRODUCTION

Repair of ankle defects is a very difficult procedure for reconstructive surgeons, soft tissue defects of these regions are often accompanied by exposure of tendons or bones. Even a small defect in this region may justify the need for a microvascular tissue transfer to achieve coverage, because bone and extrinsic foot tendons are exposed easily **[1]**. In search for alternatives for free tissue transfer random flaps, dorsalis pedis artery flap, medial plantar island flaps, extensor digitorum brevis muscle flap, reversed soleus muscle flap have been all described with their advantages and disadvantages **[2-6]**. This was followed by the description of fasciocutaneous flaps based on sparing local perforators and perforator based adipofascial flaps **[7,8]**. The anterior tibial artery perforator based adipofascial flap represents a very good alternative with avoiding most drawbacks of such flaps **[9,10,11]**. Perforator based flaps can be harvested without sacrifying an important artery. Adipofascial flaps are thin, pliable, can be easily brought to the defect and the donor area is closed primarily. Locating the perforator in which the anterior tibial artery Adipofascial flap will be based upon may be technically demanding. Noninvasive vascular imaging techniques have made a very rapid progress, one of its current clinical applications is imaging of peripheral vessels **[12]**. Preoperative acoustic Doppler examination has been applied widely; however, this examination is considered to be unreliable in evaluating the small perforators. In contrast color Doppler ultrasonography has been improved dramatically and can now enable recognition of very small vessels **[13]**. For more precision in this flap, the color Doppler ultrasonography was used preoperatively to identify the possible location of perforators from the anterior tibial artery that the flap can be based on and compare these locations with surgical identification of these perforators. This study aims at decreasing the possibility of missing the perforators during elevation of the flap and measuring the reliability of color duplex as a tool that help in precision in this flap.

MATERIAL AND METHODS

This study was done on ten patients (eight males, two females) presented with soft tissue defect of the medial and lateral malleolar region

due to trauma with intact dorsal aspect of foot which needed flap coverage. The study was carried out between August 2005 and August 2008 in Ain Shams University Hospital. The patients age ranged from 12 years up to 40 years old (Table 1). All patients underwent coverage with anterior tibial artery perforator adipofascial flap followed by STSG in the same setting. All patients had a color Doppler ultrasongraphy (GE logic 7) using linear probe with frequency 5-12MHz at the medial malleolar area to locate the possible perforators at this area. This was done by a specialized radiologist where first the probe was used to locate the anterior tibial artery at the lower 1/3 of leg above the ankle joint (Fig. 1) then it was moved medially to inspect an area about 4x5 cm between the anterior tibial artery laterally and medial malleolus medially. Any possible perforators were noted, marked and traced to source artery. In some instances the perforators were difficult to find so we switch to the power Doppler mode which has a higher sensitivity for blood flow (Fig. 2).

Operative technique:

The preoperative marking done using color Doppler ultrasound were confirmed by palpation except for possible site of perforator. In mid-dorsum of the foot a lazy s incision extending from the metatarsophalyngeal joint to inferior extensor retinaculum was done, skin flaps were elevated above the level of superficial veins, adipofascial flap was raised from distal to proximal above the level of paratenon up to the proximal edge of extensor retinaculum then dissection using high magnification was done for search of perforators guided by external mark. This mark was compared to actual identification of the perforators intraoperatively and whether it was a match or not. If the perforator was identified correctly this was defined as positive result, when the perforator existed but had not been marked preoperatively this was defined as a negative result. The flap was transferred to cover the defect and a STSG was applied, cutting the extensor retinaculum is used often to transpose the flap and locate the perforators. In such cases the retinaculum is sutured after insetting the flap. The donor site is closed primarily using the elevated skin flaps (Fig. 3).

RESULTS

All flaps survived completely with good take of the overlying STSG except in one case where there was loss of the distal 1/3 of flap. Dressing was done until granulation tissue developed and STSG was applied. All donor areas healed with no problems except in one case the distal 2cm of skin flaps healed like a graft with development of hypertrophic scar. In comparing the site of the perforator(s) marked using color duplex before operation with actual site of of perforator(s) located under vision intraoperatively 8 cases were positive (good match) (Figs. 4-6) and 2 cases were negative (Table 2). In these 2 cases the perforators were identified more proximally. The percentage of accuracy of using colour duplex in locating the perforators was 80%. The perforator(s) needed for raising this flap lies in an area about 4x5cm in lower part of leg between anterior tibial artery before becoming dorsalis pedis artery and medial malleolus.

Table (1): Clinical characteristics of patients.

Case no.	Age	Sex	Defect	Flap size
1	7	F	Medial malleolaus	4x8
2	40	F	Medial mallelous	4x11
3	35	M	Medial malleolus	3x10
4	36	M	Medial malleolus	3x11
5	38	M	Lateral malleolus	3.5x10
6	32	M	Medial malloelus	3x10
7	22	M	Medial malleolus	3x11
8	26	M	Lateral malleolus	4x10
9	12	M	Medial malleolus	4x10
10	30	M	Medial malleolus	3x10

Table (2): Comparison between sites of perforators located by dissection versus preoperative color duplex.

Case no.	Number of perforators detected by color duplex	Perforators detected by dissection (Intraoperative match)
1	1	+ve
2	2	+ve
3	1	-ve
4	1	+ve
5	1	+ve
6	2	+ve
7	1	-ve
8	2	+ve
9	1	+ve
10	1	+ve

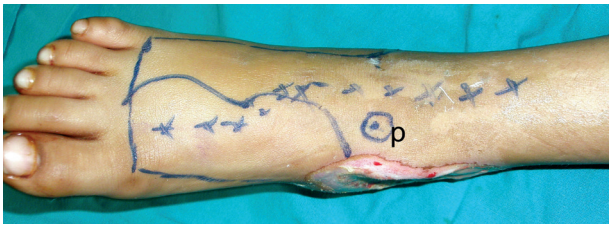

Fig. (1-A): Location of anterior tibial artery and possible site of perforator arising from it.

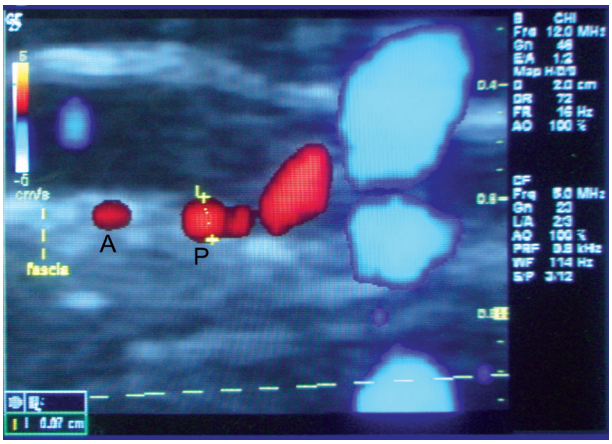

Fig. (1-B): Color duplex showing anterior tibial artery (A) and possible site of perforator arising from it (p) with the possibility of measuring its diameter.

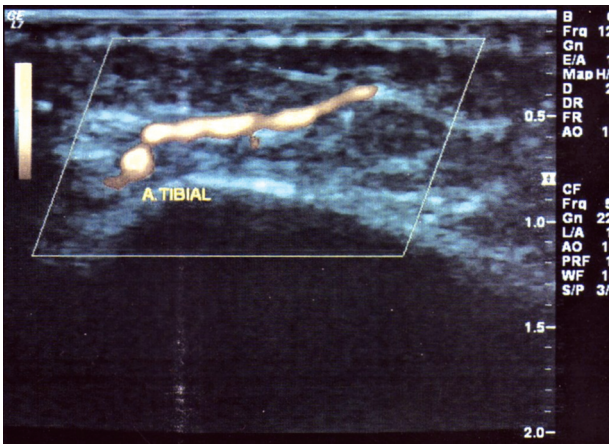

Fig. (2): Location of anterior tibial artery and the perforator arising from it using power Doppler mode.

Fig. (3-A): A patient with right medial malleolar defects with exposed tendons.

Fig. (3-B): Design of flap from dorsum of foot with possible site of perforator (p).

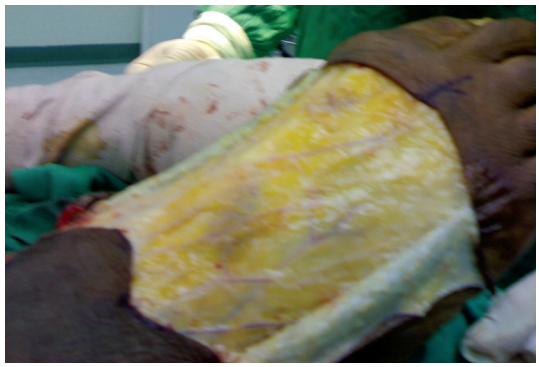

Fig. (3-C): Elevated skin (dermal) flaps showing intact superficial veins.

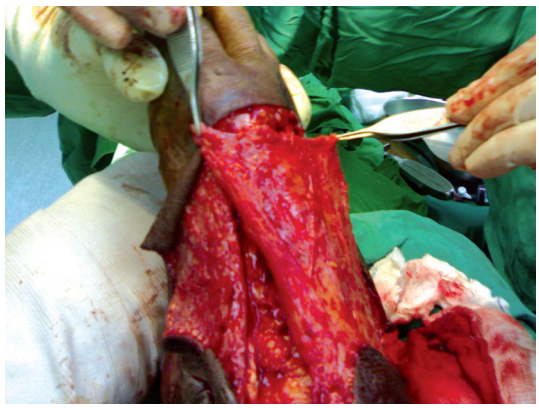

Fig. (3-D): Elevated adipofacial flap from dorsum of foot.

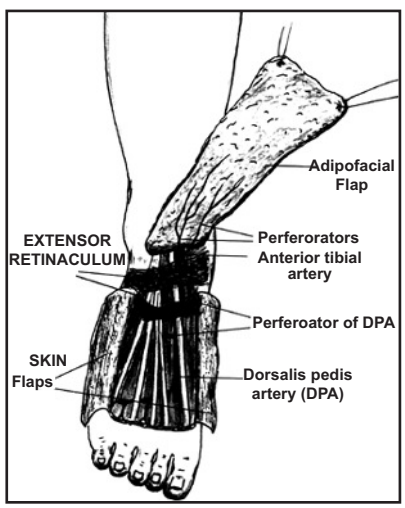

Fig. (3-E): Diagram showing elevated adipofacial flap with perforators in its base.

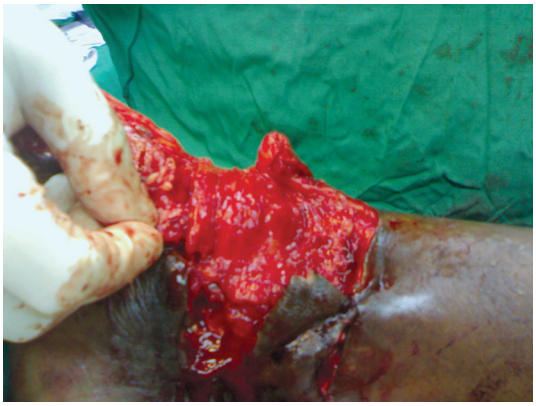

Fig. (3-F): Insetting of flap in medial malleolar defect.

Fig. (3-G): Medial malleolar area with healed split thickness graft.

Fig. (4-A): Medial malleolar defect with exposed bone.

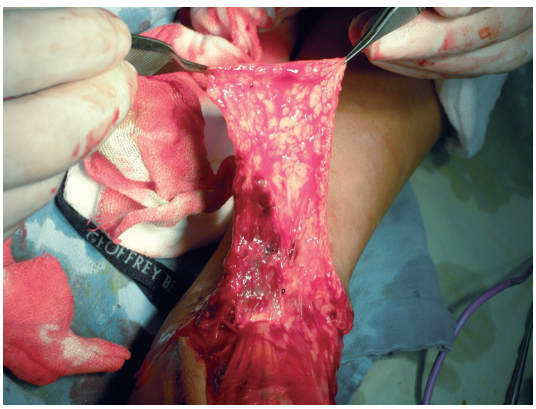

Fig. (4-B): Elevated adipofacial flap with surgical identification of perforator (p).

Fig. (4-C): Undersurface of flap with intact paratenon on underlying tendons.

Fig. (4-D): Insetting of flap in medial malleolar defect.

Fig. (4-E): Good healing at lower leg and medial malleolar area with no bulk, scarring of dorsum of foot due to healing of distal 2cm of flaps like a graft.

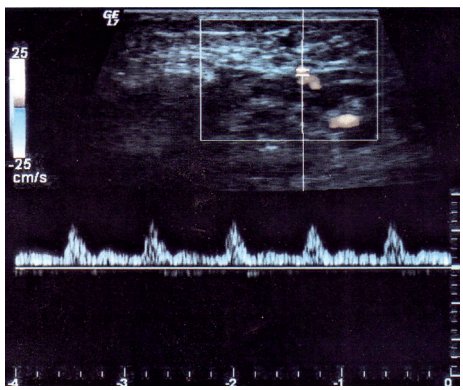

Fig. (5): Color duplex showing waves denoting flow in perforator arising from anterior tibial artery.

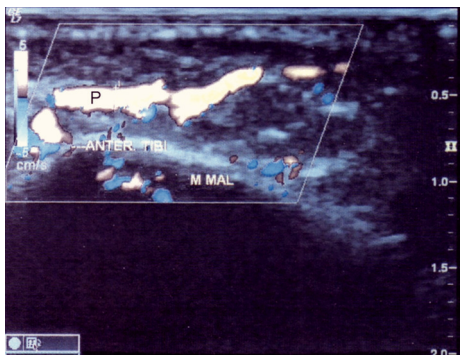

Fig. (6): Color duplex showing medial malleolus (MMAL), anterior tibial artery (ANTER.TIB.) and oblique course of perforator (P).

DISCUSSION

Reconstruction for defects around the ankle continues to be challenging. Repairs have been tried using the Dorsalis pedis flap but the sacrifice of Dorsalis pedis artery and the need for skin graft constitutes major disadvantages specially that the donor site of the flap tends to produce ugly scar **[14]**. In this flap the donor site is closed primarily avoiding such problem. The reversed soleus muscle flap had been used for coverage of defects in the ankle region yet recorded variations in number and locations of perforators from posterior tibial artery and the fact that the flap is narrow still makes this flap less popular **[15]**. The maximum size of the flap raised in this study was 4x11cm which in comparison constitutes a large surface area for coverage of medial or lateral malleolar defect. In addition the relatively increased arc of rotation being perforator base facilitates it's reach to defect. In one case we had loss of distal 1/3 of flap possibly due to non cutting of retinaculum which produced difficulty in transposition and so proper insetting of the flap. Cutting retinaculum is a point we should always consider provided repair is done after transposition. Reverse flow fasciocutaneous flaps including the anterior tibial, posterior tibial and peroneal flaps had been used for reconstruction of defects around the ankle **[16]** yet these flaps sacrifice an important artery of the leg and their donor area is usually closed by a graft which leads to contour deformity. One of the major advantages of the flap in this study is that it is perforator based and so does not scarify any major vessels which make it of utmost choice in patients having peripheral vascular impairment. The faciocutaenous flaps also are bulky **[10]** where this adipofacial flap is pliable and thin and all of our patients reported easiness of shoe wearing which is an additional advantage. In order to minimize donor site morbidity of fasciocutaneous flaps adipofacial flaps were introduced **[17]**. In this study the donor site of flap healed primarily except for one case where sloughing of distal 2cm occurred as the skin flap edges were too thin but spontaneous healing occurred. The posteriortibial and peroneal axial pattern distal based adipofascial flaps had been described **[18]**, still these flaps scarify major blood vessel. To avoid such problems the concept of perforator based adipofacial flaps had to arise. Dorsalis pedis perforator turn over adipofascial flaps were described. This flap was raised from the same area the flap in this study was raised from but it was distally based and used for treatment of forefoot defect **[19]**. In our opinion the only drawback of this flap is that The dissection of a single perforating vessel is technically very demanding and the irregular anatomical distribution of these vessels only adds to the difficulty. For this reason, precise localization and qualitative preoperative evaluation of the individual perforating vessels are highly desirable.

The concept of perforator based flaps invited a concomitant rapid progress in peripheral vascular imaging. Many diagnostic imaging methods are present today for peripheral vessels location and disease assessment **[20]**. Taylor et al. **[21]** reported the use of Doppler examination for planning of flap surgery mainly because it is noninvasive and simple. Recently introduction of magnetic resonance angiography helped in visualization of blood vessels yet small vessels less than 2mm cannot be visualized **[20]**. Multidetector row computed tomographic angiography allows evaluation of the vascular status of the lower extremity and detection of perforators **[22]**. Giunta et al. **[23]** applied preoperative acoustic Doppler examination in deep inferior epigastric perforators or gluteal artery perforator flaps where very high false positive results were achieved. Tsukino et al. **[24]** mentioned that color Doppler ultrasonography has been improved dramatically and can now enable recognition of very small vessels. He also concluded that color Doppler examination can accurately identify the perforators with a concordance rate 100% and is useful for planning in anterolateral thigh flap surgery, whereas acoustic Doppler examination is unreliable. In this study an accuracy rate of about 80% was achieved where we have eight positive match between perforator allocated by colour duplex and intraoperative dissection. In some cases there was difficulty in locating the perforator so we shift to power Doppler mode depending on detecting minimal motion in blood vessels. The colour Doppler ultrasound needs depth to detect any motion, since the area examined has a thin subcutaneous tissue; examination was more difficult than other areas with good subcutaneous tissue as gluteal region and abdomen. The need of an acquainted experienced radiologist with the procedure is essential for attaining accurate results. The color Doppler ultrasound has the advantage of delineating the course of the perforator which helps the surgeon intraoperatively by not missing it or injuring it especially if it has an oblique course. Extra information could be detected from the color duplex as the diameter of the perforator and the velocity of blood, this information until recently has not been appreciated but with the introduction of supermicrosurgery these data would be of utmost importance. Hong **[22]** explained that the use of super microsurgery in lower extremity reconstruction allows an increase in selection of recipient pedicles.

By using a perforator-to perforator anastomosis approach, less time is consumed in securing the recipient vessel and elevating the flap, the risk for major vessel injury is minimized and flap survival is acceptable. The use of super microsurgery in the lower extremity allows the recognition of "freestyle" flaps. The color Doppler ultrasonography is a very simple effective noninvasive tool that has proven accuracy that will help in perforator flap surgery and supermicrosurgery.

REFERENCES

1- Koshima I., Itoh S., Nanba Y., et al.: Medial and lateral malleolar perforator flaps for repair of defects around the ankle. Ann. Plast. Surg., 51: 579-583, 2003.

2- Wee J.T.: Reconstruction of the lower leg and foot with the reverse pedicled anterior tibial flap: Preliminary report of a new fasciocutaenous flap. Br. J. Plast. Surg., 39: 327-337, 1986.

3- Hong G., Steffens K. and Wang F.B.: Reconstruction of the lower leg and foot with the reversed pedicled posterior tibial fasciocutaenous flap. Br. J. Plast. Surg., 42: 512-516, 1989.

4- Gahhos F.N., Jaquith M. and Hidalgo R.: The extended digitorum brevis muscle flap. Ann. Plast. Surg., 23: 255-262, 1989.

5- Carriquiry C., Aparecida C.M. and Vasconez L.O.: An anatomic study of the septocutaneous vessels of the leg. Plast. Reconstr. Surg., 76: 354-359, 1985.

6- Wright J.K. and Watkins R.P.: Use of the soleus muscle flap to cover part of the distal tibia. Plast. Reconstr. Surg., 68: 957-962, 1981.

7- Satoh K., Sakai M., Hiromatsu N. and Ohsumi N.: Heel and foot reconstruction using reverse-flow posterior tibial flap. Ann. Plast. Surg., 24: 318-324, 1990.

8- Liu K., Li Z., Lin Y., et al.: The reverse-flow posterior tibial artery island flap: Anatomic study and 72 clinical cases. Plast. Reconstr. Surg., 86: 312-316, 1990.

9- Lees V. and Townsend P.L.G.: Use of a pedicled fascial flap based on septocutaneous perforators of the posterior tibial artery for repair of distal lower limb defects. Br. J. Plast. Surg., 45: 141-148, 1992.

10- Lin S.D., Lai C.S., Chou C.K., et al.: Distally based posterior tibial adipofascial flap. Br. J. Plast. Surg., 45: 284-289, 1992.

11- Lin S.D., Chou C.K., Lin T.M., et al.: The distally based lateral adipofacial flap. Br. J. Plast. Surg., 51: 96-102, 1998.

12- Reimer P. and Landwehr P.: Non-invasive vascular imaging of peripheral vessel. European Journal of Radiology, 8 (6): 858-872, 1998.

13- Loh N., Ch'en I.Y., Olcott E., et al.: Power Doppler imaging in preoperative planning and postoperative monitoring of muscle flaps. J. Clin. Ultrasound, 25: 465- 471, 1997.

14- Samson M.C., Morris S.F. and Tweed A.E.J.: Dorsalis pedis flap donor site: Acceptable or not? Plast. Reconstr. Surg., 102: 1549-1555, 1998.

15- Hallock G.G.: Distal lower leg local random fasciocutaneous flap. Plast. Reconstr. Surg., 86: 304-309, 1990.

16- Touam C., Rostoucher P., Bhatia A., et al.: Comparative Study of Two Series of Distally Based Fasciocutaneous Flaps for Coverage of the Lower One-Fourth of the Leg, the Ankle and the Foot. Plast. Reconstr. Surg., 107: 383-392, 2001.

17- Sarhadi N.S. and Quaba A.A.: Experience with the adipofascial turn-over flap. Br. J. Plast. Surg., 46: 307-311, 1993.

18- Lin S.D., Lai C.S., Chou C.K., et al.: Distally based posterior tibial adipofascial flap. Br. J. Plast. Surg., 45: 284-287, 1992.

19- El-Khatib H.A.: Adipofascial Turn-over Flap Based on Perforators of the Dorsalis Pedis for Resurfacing Forefoot Defects: An Anatomic and Clinical Approach. Plast. reconstr. Surg., 102: 393-397, 1998.

20- Rankin S.C.: Spiral CT: Vascular applications. European Journal of Radiology, 28: 18-29, 1998.

21- Taylor G.I., Doyle M. and McCarten G.: The Doppler probe for planning flaps: Anatomical study and clinical applications. Br. J. Plast. Surg., 43: 1-16, 1990.

22- Hong J.P.: The Use of Supermicrosurgery in Lower Extremity Reconstruction: The Next Step in Evolution. Plast. Reconstr. Surg., 123: 230-235, 2009.

23- Giunta R.E., Geisweid A. and Feller A.M.: The value of preoperative Doppler sonography for planning free perforator flaps. Plast. Reconstr. Surg., 105: 2381-2386, 2000.

24- Tsukino A., Kuraachi K., Inamiya T., et al.: Preoperative Color Doppler Assessment in Planning of Anterolateral Thigh Flaps. Plast. Reconstr. Surg., 113: 241-246, 2004.