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Original Article

Lateral tarsal flap with a reverse dorsalis pedis artery pedicle: an approach in repair and reconstructive surgery

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Abstract: Aim and objective: The aim of the study was to analyze weather the Lateral Tarsal Flap with a Reverse Dorsalis Pedis Artery Pedicle can be used for repair of Forefoot Skin and Soft Tissue Defects. Material and method: The total sample size was comprised of 20 subjects reported to the Dept of hand and foot Surgery. The sample size comprised of 14 males and 6 females with the age of 10 to 70 years. The injury on first metatarsophalangeal joint injury were comprised of 6 patients, the injury on toes injury were comprised of 8 patients and the injury on distal metatatarsal injury were comprised of 6 patients. The skin and soft tissue injuries were evaluated using the modified Oestern-Tscherne classification and all patients were followed up for at least 8 months. Results: Results concluded that all the 20 flaps were successfully implicated, in almost 18 patients the healing was done primary intension and only in 2 patients it was by secondary intention. There was no wound infections reported in any patient. In all the patients, donor site successfully accepted grafts and all wounds healed with minimal scarring. No patient reported any kind of problem or pain on standing or walking. Maximum no of patients reported with no activity limitation with the reconstructed foot, however in some patients they experienced occasional restrictions in recreational activities. Conclusion: We concluded that LT flap with a reversed DPA pedicle is a very effective and reliable surgical technique in reconstruction of forefoot defects.

Keywords: Lateral tarsal flap, reverse dorsalis pedis artery pedicle, forefoot, soft tissue, reconstruction

Introduction

Many approaches are available to repair and revamp forefoot skin and soft tissue defects which include skin grafts, orthotopic flaps, and heterotopic tissue transfer [1, 2]. The approach for full- or split-thickness skin graft can be done for repair of simple forefoot. Complex soft tissue defects around the ankle and foot represent a difficult reconstructive problem due to exposure of the bones, joints and tendons [1].

The forefoot considered to be the primary weight bearing portion. Therefore, a thick skin flap that is able to withstand pressure from standing and walking is required for repair of forefoot skin and soft tissue defects with a condition such as exposure of tendons and bones. Local flaps in the foot have limitations of reach and reduced amount of soft tissue that can be elated at the cost of unacceptable donor site morbidity [1].

Balakrishnan C et al used the reverse dorsal metatarsal artery flap has been for reconstruction of the distal foot, including the great toe [3]. However, this technique is at threat for flap failure in covering the forefoot defect as the first dorsal metatarsal artery frequently was injured in these patients [4].

Chengyuan Wang et al introduced the novel application of Lateral Tarsal Artery flap in hypopharyngeal reconstruction resulting from head and neck ablative surgery. They concluded that The LTA flap has unique features such as large size, thin, hairless and easy to harvest. It has effectively avoided distal stenosis or pharyngo-

cutaneous fistula and improved the postoperative life quality of advanced HypSCC patients [5].

Some researchers introduced distally based medial plantar flap with a lateral plantar artery pedicle. This Flap can also be used to cover the submetatarsal weight bearing zone, but due its small coverage size and probability of injury to inter-metacarpal plantar vascular network, its use has been limited [6, 7]. Cross-leg flap transfers with microsurgical vascular anastomoses can provide coverage of large defects, but these flaps require immobilization of the lower limbs and impair the patients quality of life [8, 9].

Microvascular tissue transfers provide a large amount of soft tissue at the most desired places, and are quiet reliable in experienced hands [10]. But, non-availability of microsurgical expertise and facility at peripheral centres, the cost and, sometimes, the patient-related factors may preclude the option of free flap [10]. Although free-tissue transfer plays an important role in limb salvage, better understanding and applications of regional flap designs have sometimes provided easier and more cost-effective alternatives for soft tissue coverage of the injured lower extremity. A free flap, combined with vascular anastomosis, has an overstuffed appearance and impaired sensory return, and requires repeated secondary interventions to restore normal gait [11].

Fu D et al in 2013 suggest that LT flap with a reversed DPA pedicle is a reasonable option for repair of traumatic forefoot skin and soft tissue defects with exposure of tendon and/or bone but a well-preserved LT donor site and is associated with minimal morbidity [12].

Chan Kwon et al concluded that reverse dorsalis pedis flap has not been commonly used due to the anatomical variation and uncertainty, which is different from the reverse radial forearm flap. However, when faced with the challenge of a moderate soft tissue defect of the distal forefoot, we believe that the reverse dorsalis pedis flap offers a good option with various advantages [13].

The perfect flap for repair and revamping of forefoot skin and soft tissue defects would provide the wound site with similar color, contour, and thickness. Furthermore, the transfer of such a flap would be less demanding than the other techniques and not require a secondary correction. With study of wide researches and literature [12], a lateral tarsal (LT) flap could be a good option for the revamping of forefoot skin and soft tissue defects because this flap has good contour, elasticity, and durability similar to the recipient site and thus is a reasonable option for treating traumatic forefoot skin and soft tissue defects or operative wounds [12]. In this study, we modified this technique by incorporating a reverse dorsalis pedis artery (DPA) pedicle instead of the previously reported reversed LT artery pedicle. This modification allowed for more flexible flap rotation for repair of the forefoot skin and soft tissue defects with exposure of tendon and/or bone.

Aim and objective

The aim of the study was to analyze weather the Lateral Tarsal Flap with a Reverse Dorsalis Pedis Artery Pedicle can be used for repair of Forefoot Skin and Soft Tissue Defects.

Material and method

Ethical approval had been taken from the ethical committee of the university regarding this study and written informed consent/assent form had been obtained from all the participants of the study. Not a single patient refuses to participate in the study.

The total sample size was comprised of 20 subjects reported to the Dept of hand and foot surgery. The sample size comprised of 14 males and 6 females with the age of 10 to 70 years.

Inclusion criteria

1. The patients that were undergone treatment for forefoot skin and soft tissues defects because of various causes like motor vehicle accidents, crushing by objects and any other related injuries. 2. The location of the wounds included the dorsal sides of the first metatarsophalangeal joint, the toes, and the distal metatarsal portions.

All the patients were divided according to the location of injury. The injury on first metatarsophalangeal joint injury were comprised of 6 patients, the injury on toes injury were comprised of 8 patients and the injury on distal

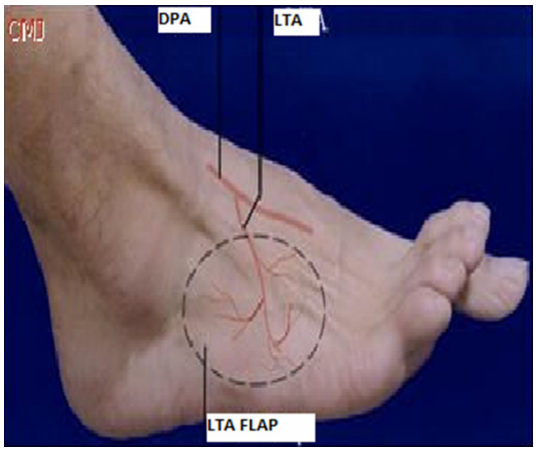

Figure 1. Schematic diagramme showing anatomical position of DPA, LTA and LTA flap.

metatatarsal injury were comprised of 6 patients. The wounds ranged in size from 5.0 × 7 cm to 8.0 × 6 cm and were complicated by the loss of forefoot skin and exposure of tendons and/or bones.

The skin and soft tissue injuries were evaluated using the modified Oestern-Tscherne classification [12, 14] and all patients were followed up for at least 8 months. These patients were followed every 4 months during the first postoperative year and every 8 months during the second postoperative year, respectively. Two of our best surgeons independently evaluate the full follow up process. They evaluate the lesion based upon the basis of physical appearance of the skin flap, standing and walking of the repaired foot, footwear requirements, two-point discrimination of the skin flap, and the hallux-metatarsophalangeal-interphalangeal scale, by the American Orthopaedic Foot and Ankle Society (AOFAS) [15].

According to Dehao Fu et al [12], AOFAS scale assessed pain components (40 points), functional components (45 points), and alignment components (15 points), for a total of 100 points. The potential complications were assessed using the Clavien-Dindo classification of surgical complications [12, 16] Dindo D et al defined complications as any deviation from the normal postoperative course and graded the severity of a complication from Grade I to Grade IV based on the impact on patients and the requirement of therapeutic intervention [16].

Procedure

Before, starting the procedure the inclusion criteria was standardized.

• First of all the Lateral Tarsal donor site remained preserved, the forefoot defect area should be less than 10 cm × 10 cm.

• Ultrosonography was done preoperatively to identify the normal LT artery and DPA.

The Exclusion criteria will be any history of diabetes mellitus or any type of vasculopathy and donor site was damaged or injured.

After evaluating the inclusion the criteria, First of all the tissue debridement was done and patient was put on spinal anesthesia combined with continuous epidural anesthesia. Tendon grafts were used to revamp the injured tendons. Doppler ultrasonography was performed before the procedure. The lateral tarsal artery and the anterior & posterior tibial arteries were orientated. The Lateral Tarsal flap was outlined centering on the perforating point of the LT artery cutaneous branch, namely, the midpoint between the lateral ankle and the fibular side of the fifth metatarsal head (**Figure 1**). The length (5-8 cm) and width (4.5-7.5 cm) of the flaps had 0.5- to 1.0-cm margins beyond those of the wound.

Aproper incision was made along the direction of the DPA to identify the starting point of the LT artery. The extensor digitorum brevis (EDB) was further mobilized to expose the lateral tarsal artery (**Figure 2**). The lateral tarsal flap was dissected along the medial margin outward to the lateral margin of the EDB. The EDB subsequently was retracted upward and medially to expose the underlying LT artery and its cutaneous branches using a microscopic hemostat (**Figure 2**). The musculocutaneous and periosteal branches of the LT artery underlying the EDB were ligated to allow dissection of the LT artery up to its originating point from the DPA, with 0.5-cm tissue margins or the underlying periosteum, distally to proximally and vice versa. The flap was further dissected along the lateral, anterior, and posterior margins successively toward the perforating point of the LT artery cutaneous branch (**Figure 2**).

While performing the surgery the step by step procedure had been followed (**Figure 3**):

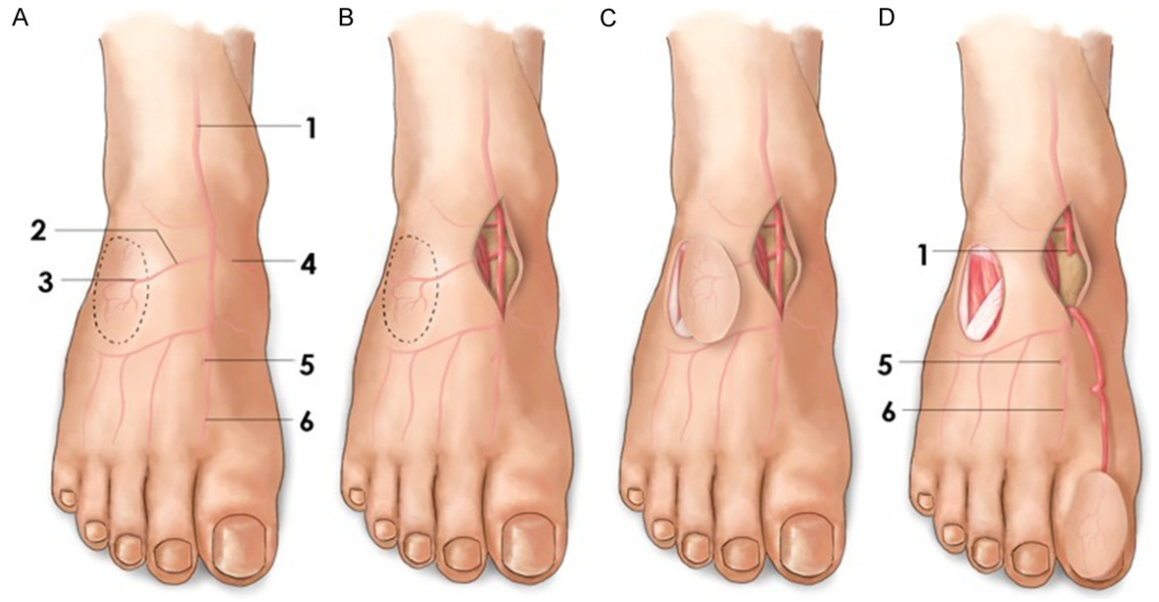

Figure 2. A. Schematic outline of the LT flap with a reversed DPA pedicle; B. Dissection of the lateral tarsal artery (LTA) up to its originating point from the DPA; C. Flap mobilization toward the perforating point of the LTA cutaneous branch; D. Reverse rotation of the flap to cover the forefoot wound are shown. The anatomic landmarks include: 1 = DPA; 2 = LT artery; 3 = cutaneous branch of LT artery; 4 = medial tarsal artery; 5 = deep plantar artery; and 6 = first dorsal metatarsal artery.

1. The incision to be extended proximally to a donor nerve of appropriate length.

2. The Lateral Tarsal flap was mobilized from the periosteum at the starting point of the Lateral Tarsal artery cutaneous branch (**Figure 3**).

3. The DPA was ligated at the point distal to the LT artery starting point if the flap and toes showed good circulation.

4. The medial tarsal artery and the anterior lateral malleolar arteries were well protected in the ligation of the DPA to minimize interruption of the EDB blood supply.

5. The LT flap with a reverse DPA pedicle was created and rotated under the EDB and the extensor digitorum longus to cover the forefoot defect.

6. The main trunk of the lateral dorsal pedal cutaneous nerve was anastomosed with the stump of the first or second plantar digital nerve at the recipient site.

7. The donor site was covered with an inguinal full-thickness skin graft and compressed with punctured pressure dressing (**Figure 3**).

Results

Results concluded that all the 20 flaps were successfully implicated, in almost 18 patients the healing was done primary intension and only in 2 patients it was by secondary intention (**Table 1**).

There was no wound infections reported in any patient. In all the patients, donor site successfully accepted grafts and all wounds healed with minimal scarring. The color was appeared similar to the surrounding skin at follow-ups. All patients were satisfied with the reconstruction outcome for the donor site and recipient site.

Not a single patient reported any kind of problem or pain on standing or walking. Maximum number of patients reported with no activity limitation with the reconstructed foot, however, in some patients they experienced occasional restrictions in recreational activities.

The metatarsophalangeal joints and interphalangeal joints were in normal motion. The joints had good stability in all directions. The reconstructed forefoot showed good alignment in all patients. Overall, the AOFAS scores for the hallux metatarsophalangeal-interphalangeal scale were 93 to 98 points (**Table 1**).

Figure 3. A 38-year-old man lost his left great toe after his foot was crushed. The photographs show (A) the preoperative appearance, (B) outlining of the skin flap, (C) donor sites 3 month after surgery, (D) Receipent site 36 months after surgery.

Discussion

Historically, options such as toe amputations, fillet flaps, cross leg flaps, reverse anterior artery flaps, and free autogenous and allogenic tissue transfers have been used. But despite their successes, each of these is associated with significant difficulties. For example, the use of the fillet flap precludes toe salvage [17]. The cross leg flap requires two operative stages, causing discomfort and stiffness to immobile joints. The reverse anterior tibial flap provides excess tissue bulk for small defects of the great toe, and free tissue transfers are time consuming and may be associated with higher failure and reoperative rates in patients with comorbities such as diabetes or aging [17].

The dorsalis pedis artery, which is an extension of the anterior tibial artery, supplies the flap. The anterior tibial artery lies lateral to the tibialis anterior tendon and medial to the extensor

Table 1. Demographic and clinical data of patients

Sr. No	Sex	Age (years)	Site of injury	Etiology of injury	Oestern-Tscherne classification	AOFAS score after repair	Healing
1	Female	25	Distal metatarsal injury	Car accident	Grade IV	97	Primary Intension
2	Male	35	Toes	Car accident	Grade IV	93	Primary Intension
3	Female	33	Toes	Crushed Injury	Grade IV	93	Primary Intension
4	Female	32	First metatarsophalangeal joint	Crushed by heavy object	Grade IV	96	Primary Intension
5	Male	21	First metatarsophalangeal joint	Motor vehicle accident	Grade IV	95	Primary Intension
6	Female	15	Toes	Crushed injury	Grade III	93	Primary Intension
7	Female	29	First metatarsophalangeal joint	Car Accident	Grade III	93	Primary Intension
8	Male	44	Distal metatarsal injury	Motor vehicle accident	Grade III	93	Primary Intension
9	Male	31	Toes	Crushed by heavy object	Grade IV	97	Secondary Intension
10	Female	33	Toes	Crushing injury	Grade III	93	Primary Intension
11	Male	39	First metatarsophalangeal joint	Motor Vehicle accident	Grade IV	94	Primary Intension
12	Female	29	First metatarsophalangeal joint	Motor vehicle accident	Grade IV	96	Secondary Intension
13	Male	19	Toes	Crushed injury	Grade III	93	Primary Intension
14	Female	29	First metatarsophalangeal joint	Car Accident	Grade III	93	Primary Intension
15	Female	30	Distal metatarsal injury	Car Accident	Grade IV	93	Primary Intension
16	Female	32	Toes	Motor Vehicle accident	Grade III	93	Primary Intension
17	Male	23	First metatarsophalangeal joint	Motor vehicle accident	Grade IV	96	Primary Intension
18	Female	29	Toes	Car Accident	Grade III	93	Primary Intension
19	Male	31	First metatarsophalangeal joint	Car Accident	Grade III	93	Primary Intension
20	Female	25	Distal metatarsal injury	Car accident	Grade IV	94	Primary Intension

hallucis longus tendon at the entrance of the extensor retinaculum or the ankle [18]. It courses under the retinaculum and emerges medial to the extensor hallucis longus tendon as the dorsalis pedis artery. The dorsalis pedis artery branches to form the arcuate artery, lateral and medial tarsal arteries, which supply structures beneath the extensor tendons and are not harvested as part of the flap [18].

Nodobut the repair of forefoot defects remain a major challenge in surgical practice, especially in terms of reconstructing forefoot appearance and function. Forefoot defects ideally are covered using pedicle flaps, and multiple flap designs have been described [19]. With this in mind we have designed a new pedicled fasciocutaneous flap, namely, the LT flap incorporated with a reversed DPA pedicle. We have analyzed that whether this technique is clinically feasible, effective, and safe for reconstruction of forefoot skin and soft tissue defects with tendon and/or bone exposure.

The results showed that a LT flap with a reversed DPA pedicle is a very effective and reliable surgical technique in reconstruction of forefoot defects. As we have stated above that the flap acceptability and reliability is very good. Medial plantar flaps reportedly are used to reconstruct the weight bearing forefoot [20], but are less suitable for repair of traumatic injuries attributable to the frequent concomitant damage to the plantar artery in complex cases [20].

According to recent studies, some authors have concluded that this flap has a restricted rotation range and frequently requires delayed transfer or secondary revision [20]. Therefore, this flap is less suitable for coverage of forefoot defects with complicating conditions. Otherwise this technique is subject to a high risk of flap failure or other complications [20]. But in our-study, no complication had been reported.

The results of our study showed that injured side has been revamped fully in all aspects and comparable to that of the contralateral side. As given in the literature, the lateral dorsalis pedis cutaneous nerve contained in the Lateral Tarsal flap is anastomosed with the stump of the first or second plantar digital nerve to reconstruct the sensation in the recipient site. So with this anatomoses it is showing a good two-point discrimination.

As compared to dorsal pedal neurocutaneous flap, donor site in Lateral Tarsal flap is located

in the hidden part of the body and bears no weight. The reconstructed forefoot is tough to footwear and no impairment has been seen when standing or walking.

Limitations

1. Sample size too small. 2. To compare the results no control subjects were enrolled to undergo comparable repair using other techniques.

Disclosure of conflict of interest

None.

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