

Original Article

Post-traumatic wounds over the dorsum of the foot - our experience

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Abstract: Post-traumatic wounds over the dorsum of the foot are commonly seen in our practice. Road traffic accidents, crush injuries due to the fall of heavy objects and burns are common causes of these injuries. The subcutaneous tissue in this region is very thin, and the tendons and bone are frequently exposed in these wounds. Since the skin is loosely attached to the underlying tendons, ligaments, and bones, the skin of the dorsum of the foot is also vulnerable to avulsion trauma. Added to this, there is a paucity of local tissues for coverage. Hence the management of these wounds is quite challenging. Through this article, we intend to describe our experience with traumatic dorsal foot wounds. A total of 33 patients were eligible according to the inclusion criteria and their details were included in the final analysis. There were 26 (78.79%) males and 7 (21.21%) females, with a male to female ratio of 3.71:1. The age of the study patients ranged from 8 to 62 years, with a mean age and standard deviation of 34.39 and 13.566 respectively. Majority of the study patients were in the 21-30 years age group (n=10, 30.3%). Road traffic accidents were the most common cause of traumatic dorsal foot wounds (n=20, 60.61%). Majority of the wounds showed features suggestive of infection (n=22, 66.67%) at presentation. Most of the patients in our study needed surgical intervention, in addition to medical management (n=28, 84.84%). Surgical procedures performed include split-thickness skin grafts, local flaps and free flaps. Early complications occurred in 5 (15.15%) patients and late complications in 2 (6.06%) patients. In conclusion, post-traumatic wounds of the dorsum of the foot are very common and pose a difficult reconstructive challenge. Skin grafts, local tissue flaps and free flap options are available for reconstruction; selection of the appropriate option should be individualized in a given patient. Local or distant flaps should be preferred in comparison to skin grafts, because of their long term durability and lesser chances of contractures. Reconstruction must consider form, function, and aesthetics.

Keywords: Foot, accidents, traffic, crush injuries, burns, skin transplantation

Introduction

The human foot plays an important role in the maintenance of bipedal form and function, serving as a dynamic platform on which we maintain our upright posture. Owing to its outward projection in relation to rest of the body and its vital role in locomotion, this region of the body is highly susceptible to various kinds of injury. Further, the majority of people in rural areas are habituated to barefoot walking or use such kinds of footwear that do not offer adequate protection to the entire foot. As such, traumatic wounds of the dorsum of the foot are commonly seen in our practice. Road traffic accidents, crush injuries due to the fall of heavy objects and burns are common causes of these injuries.

Accidents related to motor vehicles are reported to be the commonest cause of traumatic dorsal foot injuries. A specific type of pedestrian foot injury occurring due to motor vehicles is described as a car-tire injury [1, 2]. The victim, while trying to escape from the vehicle, gets his foot stuck under the car-tire. When the car-tire impacts on the foot, the driver is usually attempting to stop the car, resulting in an injury of variable severity depending on the amount of energy absorbed by the foot. The resultant injury is due to a varying combination of friction burn, crushing, shearing, and degloving. Al-Qattan described a series of children with car-tire friction injuries to the dorsum of the foot and classified these injuries into five grades basing on the severity of the injury. Grade I included superficial 2nd degree friction burn

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without skin loss, Grade II included deep 2nd degree friction burn with a small area of skin loss, Grade III included 3rd degree friction burn with or without a small area of skin loss, Grade IV included skin avulsion with tendon and/or bone exposure and Grade V consisted of severe soft tissue injury with significant bone loss [1].

Crush injuries of feet due to the fall of heavy objects are another common mode of injury reported to cause traumatic dorsal foot wounds. These can involve only soft tissues or bones or both, depending on the momentum of the falling object. Burn injuries to the feet usually occur in the extremes of age such as children and elderly and, in patients with diabetes and disability. Burns to children's feet are most often scalds due to hot water and, as an infant's skin is thinner, they are more susceptible to a full-thickness injury [3]. Hemington-Gorse et al found out in their study that scalds and chemical burns were equally common causes of foot burns in adults, followed by electrical and friction burns; whereas, scalds were the most common cause of foot burns in children [4].

The skin of the dorsum of the foot is comparatively thin and loose. The loose skin accounts for the enormous amount of dorsal swelling that can occur after foot trauma. There is only one muscle in this area, the extensor digitorum brevis, which is thin and ends in 4 tendons. The subcutaneous tissue in this region is also very thin, and, thus, the tendons and bone are frequently exposed in traumatic wounds of the dorsum of the foot [5]. Since the skin is loosely attached to the underlying tendons, ligaments, and bones, it is vulnerable to avulsion trauma [6]. Added to this, there is a paucity of local tissues for coverage.

From a reconstruction perspective, the dorsum of the foot represents a specialized surface. The skin and soft tissues in this region are thin and pliable allowing for excursions during plantarflexion and dorsiflexion. The deep layer of dorsal soft tissues provides a gliding surface for the movement of the extensor tendon mechanism. These special properties of the dorsal soft tissues must be given adequate consideration when selecting an option for reconstruction. Reconstruction must also take into account the role of the normal contour of the dorsum of the foot in being able to use nor-

mal footwear. Reconstructions that change this contour would result in the requirement of specialized footwear [7]. As a whole, foot reconstruction must take into account tissue reconstruction, functional restoration, and cosmetic rehabilitation.

According to some studies, a partial-thickness skin graft can be used for reconstructing superficial wounds of the dorsum of the foot with preserved paratenon. Thicker skin grafts are advocated because of a decreased incidence of contracture and better durability. Late complications from grafting including contracture involving hyperextension of the toes and recurrent breakdown of the skin graft have been reported. For these reasons skin grafting is not usually preferred and local or distant tissue flaps are used for reconstruction in these wounds [7, 8].

It has been seen that in traumatic dorsal soft tissue wounds, the relations, attachments, and vascularity between the wound and the surrounding soft tissues are altered. Although a local soft tissue reconstruction may be available, further changes in local vascularity and further scarring incurred in the dissection of the flap may make a local choice suboptimal. In this scenario, a free flap has the advantage of not causing further derangement of any of the surrounding soft tissue attachments while adding increased vascularity to the wound site by way of the flap itself [7].

Extensive traumatic wounds may involve soft tissue, underlying tendons and bone. Free flap reconstructions have been widely performed in the last two decades, and have allowed us to cover composite tissue losses of the foot [9]. The advantages of free-tissue transfer for the reconstruction of traumatic dorsal foot wounds include a wide choice of donor tissues, including composite reconstructions; limitation of further dissection, soft tissue disruption and scarring around the wound; and increasing vascularity to the recipient site directly from the flap. The disadvantages of free-flap reconstructions include prolonged operative time with the potential for increased patient morbidity and mortality, functional and aesthetic effects at the donor site, and the technical requirements for micro vascular surgery. Options for free-flap dorsal reconstruction include free muscle flaps with a skin graft, fas-

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ciocutaneous flaps, and fascial flaps with a skin graft [7].

Local flaps can provide effective coverage of small to medium sized wounds on the dorsum of the foot. These can avoid a lengthy free flap procedure reducing potential patient morbidity and have minimal donor-site sequelae. These pedicled flaps depend on the local vascularity, which may sometimes be altered owing to trauma, hence there is a need for thorough evaluation when selecting a local flap option. Local flaps for dorsal foot wound reconstruction include extensor digitorum brevis muscle flap, first dorsal metatarsal artery perforator flap, retrograde dorsalis pedis flap, retrograde peroneal flap, lateral superior malleolar flap, and sural artery flap [7, 10].

The management of traumatic wounds of the dorsum of the foot is quite challenging and these are commonly referred to reconstructive surgeons. There is paucity of literature concerning the epidemiology, clinical presentation and management of these wounds. Through this study, we intend to present our experience with traumatic wounds of the dorsum of the foot.

Materials and methods

Study design

We have performed a prospective observational study of patients presenting with traumatic wounds over the dorsum of the foot over a period of one year, from October 2018 to September 2019. The study was conducted at the Department of Burns and Plastic Surgery of a tertiary care institute in a non-metropolitan city in Central India.

Inclusion criteria

Patients who presented to us with post-traumatic wounds over the dorsum of the foot and were willing to participate in the study.

Exclusion criteria

None.

Method

Permission for conducting the study was obtained from the Institutional Human Ethics Committee (IHEC). The study protocol conformed to the ethical guidelines of the 1975

Declaration of Helsinki. Written informed consent was obtained from all the participants before their inclusion in the study. Data collected from the patients included demographic details, history, clinical features, relevant imaging and lab reports.

Treatment was instituted according to the clinical picture. This included conservative management alone or surgical management. Complications were noted. The progress was monitored until the wound healed. Patients were followed up for 6 months thereafter.

Statistical analysis

All the patient and wound data collected were entered into a spreadsheet created in Microsoft Excel™ software 2013 version (©Microsoft Corporation, Redmond, Washington, United States). Data analysis was carried out using Epi Info software version 7.2 (Epi Info™, Centers for Disease Control and Prevention, Atlanta, Georgia). Summary statistics were derived. Nominal variables were statistically described with frequencies and percentages. Continuous variables were described with means and standard deviations. Ordinal variables were also presented in the form of frequencies and percentages.

Results

Patient characteristics

A total of 33 patients were eligible according to the inclusion criteria and their details were included in the final analysis (**Table 1**). There were 26 (78.79%) males and 7 (21.21%) females, with a male to female ratio of 3.71:1. The age of the study patients ranged from 8 to 62 years, with a mean age and standard deviation of 34.39 and 13.566 respectively. Majority of the study patients were in the 21-30 years age group (n=10, 30.3%). Most commonly, patients presented with traumatic wounds of three weeks duration or less (n=13, 39.39%). Road traffic accidents were the most common cause of traumatic dorsal foot wounds (n=20, 60.61%), followed by crush injuries due to the fall of heavy objects on the feet.

Wound characteristics

All of our study subjects had unilateral wounds at presentation (**Table 2**). The size of the wound

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Table 1. Patient characteristics

Characteristic	No. of patients n (%)
Sex	
Males	26 (78.79)
Females	7 (21.21)
Male:Female ratio	3.71:1
Age in years: mean (SD)*	34.39 (13.566); age range: 8-62
Age category	
≤10 years	1 (3.03)
11-20 years	4 (12.12)
21-30 years	10 (30.3)
31-40 years	9 (27.27)
41-50 years	3 (9.09)
51-60 years	5 (15.15)
61-70 years	1 (3.03)
Duration of wound	
3 weeks or less	13 (39.39)
>3 to 6 weeks	10 (30.3)
>6 to 12 weeks	7 (21.21)
>12 to 24 weeks	3 (9.09)
Mode of trauma	
road traffic accidents	20 (60.61)
crush injury due to fall of heavy object	7 (21.21)
burns	
scald	3 (9.09)
thermal	1 (3.03)
chemical	1 (3.03)
hit by a metal object	1 (3.03)

*SD: standard deviation.

varied from 7.5 cm² to 200 cm². Patients presented more commonly with isolated wounds of the dorsum of the foot (n=27, 81.82%), but in some subjects, traumatic wounds of the plantar aspect of the foot, medial and lateral aspects of ankle and leg were also present. Majority of the wounds showed features suggestive of infection (n=22, 66.67%) at presentation. Swabs were sent for cultures and antibiotic treatment was instituted according to the sensitivity of the isolates, basing on the clinical severity.

Treatments given and complications

Table 3 presents the various modalities of treatments used in the study subjects. Most of the patients (n=28, 84.84%) in our study needed surgical intervention, in addition to medical management. Surgical procedures performed include split-thickness skin grafts, pedicled flaps and free flap reconstructions. Conserva-

tive management alone was instituted in 15.15% (n=5) cases. This included regular cleaning and dressing of the wounds with appropriate agents, oral or parenteral antibiotics, and debridements as needed. Additionally, limb elevation and splintage were added, when needed.

Early complications occurred in 5 (15.15%) patients. In a patient who underwent free ALT flap (anterolateral thigh flap) for a dorsal wound on the right foot, there was total flap loss. After debridement, the defect was resurfaced with a split-thickness skin graft. Two patients who underwent split-thickness skin grafting had partial graft loss and were managed successfully with dressings. In another patient, who underwent an islanded sural artery flap for a dorsal foot wound on right side, venous congestion developed in the flap in the post-operative period. There was marginal necrosis of the distal margin of the flap;

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Table 2. Wound characteristics

Characteristic	No. of patients n (%)
Laterality	
Right	17 (51.52)
Left	16 (48.48)
Wound size categories in cm ²	
1-10	3 (9.09)
10.1-20	4 (12.12)
20.1-50	9 (27.27)
50.1-100	13 (39.39)
100.1-200	4 (12.12)
Clinical features of infection	
Present	22 (66.67)
Absent	11 (33.33)
Involvement of surrounding regions	
not involved	27 (81.82)
involved (medial and lateral aspects of foot, medial and lateral aspects of ankle, lateral aspect of lower leg)	6 (18.18)

Table 3. Treatments given and complications

Treatment modality	No. of patients n (%)
Conservative Management	5 (15.15)
Dressings + Antibiotic treatment ± Debridements	
Surgical intervention in addition to conservative management	28 (84.84)
Split thickness skin grafting (STSG)	13 (39.39)
Negative pressure wound dressings followed by STSG	2 (6.06)
Pedicled flaps	
Sural artery flap	8 (24.24)
Posterior tibial artery perforator based fascio-cutaneous peninsular flap	2 (6.06)
First dorsal metatarsal artery perforator flap	1 (3.03)
Free flaps	
Anterolateral thigh free flap	2 (6.06)
Early complications	5 (15.15)
partial skin graft loss	2 (6.06)
venous congestion in sural artery flap	1 (3.03)
epidermal necrosis in distal part of FDMA flap*	1 (3.03)
total flap loss in free ALT flap [#]	1 (3.03)
Long term complications	
ulceration in skin graft	2 (6.06)

FDMA flap*: first dorsal metatarsal artery perforator based flap. ALT flap[#]: anterolateral thigh flap.

wound healing followed debridement of the necrotic tissue and dressings. In another patient who underwent FDMA (first dorsal metatarsal artery) perforator flap, there was a small area of epidermal necrosis in the distal part of the flap which healed with conservative management.

Below, we present some of the study cases in which surgical reconstruction was performed.

Case 1 (Figure 1)

A 30 year old male presented with a post chemical burn wound over dorsum of the left foot and ankle sustained 3 months before (Figure 1A). The ulcer and surrounding scarred skin were excised, which resulted in a defect with exposed tendons (Figure 1B). An islanded sural artery flap of dimensions 13 cm × 6 cm was elevated and used for reconstruction (Figure

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Figure 1. Case 1. A. post chemical burn wound in a 30-year old patient. B. Defect following excision of the wound and surrounding scarred skin. C. Islanded Sural artery flap after elevation. D. Long term result after healing of the wound.

1C). Flap healed well without any problems and patient was able to use his usual foot wear (**Figure 1D**).

Case 2 (**Figure 2**)

A 35 year old male presented with a post-traumatic wound over dorsum of right foot sustained 3 weeks before in a road traffic accident. Skeletal fixation for multiple metatarsal shaft fractures was already performed. The wound showed exposed metatarsal bones (**Figure 2A**). Free ALT flap was used for reconstruction of the wound (**Figure 2B**). The dorsalis pedis artery and vena comitans were used as recipient vessels. Flap survived completely and wound healed without any significant problems (**Figure 2C**). The flap settled down very well in the long term, except for some bulkiness (**Figure 2D**).

Case 3 (**Figure 3**)

A 24 year old male presented with a post-traumatic wound over the distal part of the dorsum of the right foot, sustained in a road traffic accident. Examination of the wound showed exposed bone (**Figure 3A**). The integrity of the first dorsal metatarsal artery perforator was confirmed with a hand-held doppler. A distally based peninsular flap was elevated based on this perforator (**Figure 3B**) and utilized to cover the exposed bone. Split-thickness skin graft was applied over the rest of the wound and the donor site of the flap. In the post-operative period, flap survived completely except for a small

area of epidermal necrosis in the distal part of the flap, which healed with conservative management. Flap healed well and covered the problem area (**Figure 3C**). Skin graft also healed satisfactorily (**Figure 3D**).

Discussion

Dorsum of the foot is a frequently injured area [11]. The unique architecture of the dorsum of the foot consists of a thin, loose and pliable surface that allows wide excursion and tendon gliding. Any plan of reconstruction must preserve

these important functions and allow the patient to use normal footwear. There is a paucity of local flap options and free flap reconstruction is frequently indicated [12]. The need for a durable cover over contaminated wounds, exposed bones, joints or hardware makes the free flap an ideal choice for reconstruction in traumatic wounds [13].

Literature shows that road traffic accidents and crush injuries are the most frequent causes of extensive foot trauma in children [14-16]. Our study revealed similar findings in our patient group which consisted predominantly of adults. Road traffic accidents were the cause of traumatic dorsal foot wounds in 60.61% cases, followed by crush injuries, which were the cause in 21.21% cases. These findings are further supported by the fact that majority of the patients (57.57%) were in the productive age group of 21-40 years, which is more susceptible to accidental or occupational trauma.

Some studies [12, 17] have shown that post-traumatic lower extremity reconstruction may be safely and reliably performed when the wound is adequately debrided and other injuries have been stabilized, and the final results obtained after delayed soft tissue reconstruction compared favorably with the results of early closure within 7 days of trauma [18]. Most of our study subjects presented to us around 3 weeks or later after initial trauma, as they were referred to us after being initially treated elsewhere. This also probably was

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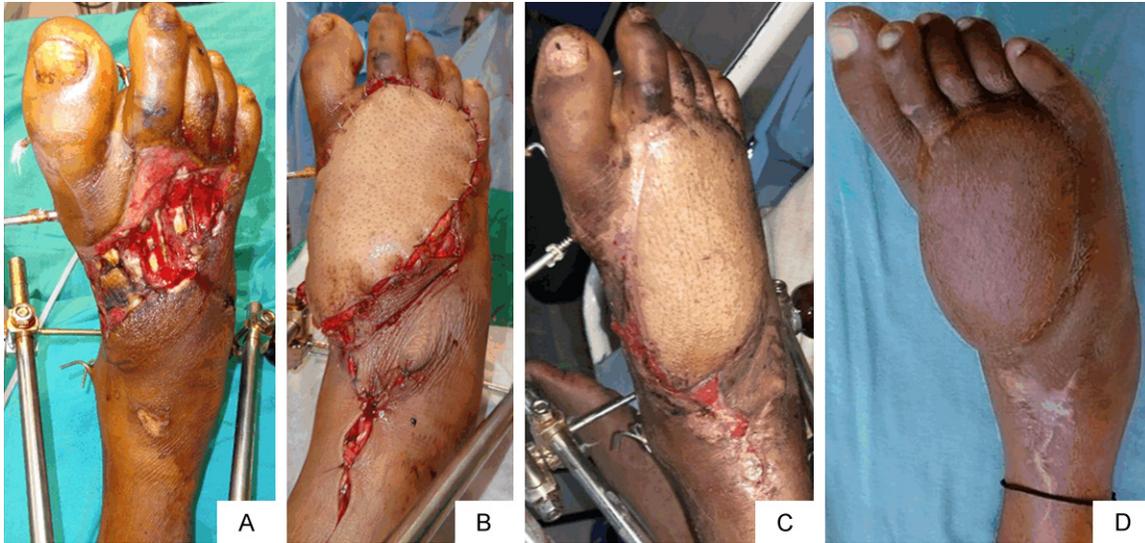


Figure 2. Case 2. A. Post-traumatic wound with exposed metatarsals in a 35-year old patient. B. Reconstruction performed with a free ALT (anterolateral thigh) flap. C. Flap in the healing phase with some residual raw areas. D. Long term result after flap has settled down.



Figure 3. Case 3. A. Post-traumatic wound with exposed bone in a 24-year old patient. B. Flap based on the first dorsal metatarsal artery perforator elevated. C. Flap healed and covered the exposed bone. D. Healed skin graft on the dorsum of the foot.

responsible for the large proportion (66.67%) of cases presenting with clinical features suggestive of infection.

Involvement of other areas such as medial or lateral aspects of foot, ankle and lower leg was present in 18.18% of our subjects. This significantly influences the plan of treatment as there may be further limitation of the local flap options for reconstruction.

In our study, 84.84% patients underwent some form of surgical intervention for management of the dorsal foot wound. This is in addition to the sharp debridements which were performed in almost all of the patients. Non-viable tissue in the form of slough or eschar is very commonly found in chronic wounds [19], and its presence will impede wound healing [20], and also increases the risk of infection. Therefore, debridement is required to remove the non-

viable tissue and constantly disrupt the bio-films. Timely debridement will help accelerate the wound healing process, by removing the barrier of devitalized tissue that is preventing wound healing [21]. Debridement also helps to break down the protective layer of microbes, exposing the microorganisms, enabling more effective action of topical antimicrobial agents [22].

Sural artery flap has been described in many studies as a good option for the cover of dorsal foot region [23, 24]. We performed Sural artery flaps in 8 patients who had post traumatic wounds over the dorsum of the foot. The ultimate outcome was satisfactory in all of the 8 cases. Although it has many advantages, this flap is risky in cases where there is evidence of trauma at the base of the pedicle.

Several studies describe free flaps as an ideal option for reconstruction of dorsal foot region in both pediatric and adults patients [7, 9, 12, 25]. We have performed two free anterolateral thigh flaps for dorsal foot region in this study. Other free flap options described for this region include free gracilis muscle flap with a skin graft, lateral arm flap and superficial circumflex iliac artery perforator (SCIP) flap [11].

We have not performed any pedicled or free muscle flaps in this study. Both pedicled and free flaps which survived had a very good long term outcome in terms of the durability of skin cover. There were some issues like the bulkiness of the flap in free ALT flap which would require additional debulking procedures.

We have performed reconstruction with split thickness skin graft in 45.45% of our patients. Although not an ideal option, there may be certain situations where skin grafting may be chosen as an option for reconstruction in dorsal foot wounds. In this subset of patients, 2 patients reported episodes of wounding in the skin grafts in the 6-month follow up period. These wounds responded to conservative management. None of the patients who underwent skin grafting developed any hyperextension toe contractures.

Our study had some limitations. The sample size in our study was small, hence it may not be justified to draw general conclusions that are applicable in different settings. Also, the follow

up period of 6 months in our study might not have been enough for all the secondary complications to supervene.

In conclusion, post-traumatic wounds of the dorsum of the foot are very common and pose a difficult reconstructive challenge. Skin grafts, local tissue flaps and free flap options are available for reconstruction; selection of the appropriate option should be individualized in a given patient. Local or distant flaps should be preferred in comparison to skin grafts. Reconstruction must consider form, function, and aesthetics.

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Disclosure of conflict of interest

None.

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