Distally Based Sural Fasciocutaneous Flap in the Management of Foot, Ankle, and Lower Third of the Leg Soft Tissue Defects: A Retrospective Study in the National Burn Center and Plastic Surgery of Morocco

Abstract:
Reconstruction of soft tissue defects in the lower extremities, especially in the regions of the foot, ankle, and lower third of the leg, presents significant challenges due to the complex vascular anatomy and limited tissue availability. The racket flap distally based sural fasciocutaneous flap has emerged as a valuable option for addressing these challenging defects. This retrospective study, conducted at the National Burn Center and Department of Plastic Surgery in Casablanca, Morocco, reports on the outcomes of 9 cases where this technique was utilized. We aim to share our experiences and assess the reliability and effectiveness of the distally based sural fasciocutaneous flap in the management of lower limb soft tissue defects.

Keywords : Neuro fasciocutaneous, sural flap, Reverse sural flap, Soft tissue defect, Foot defect, Ankle defect, leg defect.

Introduction:

The reconstruction of soft tissue defects in the lower extremities, particularly those involving the foot, ankle, and lower leg, poses a formidable clinical challenge. This challenge arises from the region's precarious vascularity, limited tissue availability, and the prevalence of underlying pathologies [1]. The sural fasciocutaneous flap has emerged as a versatile option for addressing these complex defects [2, 3].

Fasciocutaneous flaps, first described by Ponten in 1981 [4], paved the way for the development of the sural neurocutaneous flap, introduced by Donski and Fogdestam in 1983 [5]. In 1991, Masquelet's work provided a comprehensive anatomical and surgical description of this flap [2]. The sural nerve follows a distinct path, initially coursing between the gastrocnemius muscles before descending laterally to the lateral malleolar region [6]. Its vascularization relies on retrograde flow, with venous drainage facilitated by retrograde flow forcing the valves of the lateral saphenous vein [7].

The sural fasciocutaneous flap can be harvested in various configurations, including fasciocutaneously, fascio-subcutaneously, or even with a portion of the gastrocnemius muscles [8]. Although complications such as flap necrosis, aesthetic sequelae, and sensory disturbances have been reported [9], it remains an attractive option for covering substantial soft tissue defects in the lower limb.

The objective of this retrospective study is to share our institutional experience and evaluate the reliability and efficacy of the racket flap distally based sural

fasciocutaneous flap in addressing soft tissue defects involving the lower third of the leg, ankle, and foot.

Patients and Methods:

This retrospective study was conducted at the National Burn Center and Department of Plastic Surgery in Casablanca, Morocco. The study included 15 patients who presented with soft tissue defects involving the lower third of the leg, ankle, or foot and underwent reconstruction using the distally based sural fasciocutaneous flap. The study period spanned from March 2020 to March 2023.

Detailed epidemiological and pathological data were collected for each patient, including age, sex, etiology of the soft tissue loss, and defect location.

Surgical Technique:

The racket flap technique we are using was first described by Bich C.-S et al. [10] in 2020. The patient is positioned in a prone or lateral position, and the external saphenous axis is traced between the midpoint of the popliteal fold and the retro-malleolar external groove. Locating the external saphenous vein can be facilitated by applying a tourniquet to the leg. This landmark is crucial, as it forms the axis of the fascio-adipose pedicle of the flap around which the entire dissection will revolve. The flap's design represents a critical aspect of the procedure and should be tailored to the location of the tissue loss (Figure 1).

Figure 1: Flap's design, handheld vascular doppler help locate the fibular network perforator.

Regarding the pivot point during the harvesting of the posterior sural flap with a distal pedicle, it is important to maintain a minimum distance of 7 cm above the lateral malleolus to include a perforator from the fibular network within the flap's fascio-adipose pedicle for vascular reliability [6].

The procedure is performed under a tourniquet. Using the analogy of a tennis racket, the rotation arc determines the length of the pedicle (the racket's handle). The head of the racket covers the tissue loss. The handle aligns with the pedicle along its entire length to the pivot point. The resulting flap design takes the shape of a tennis racket. The flap is raised, encompassing the external saphenous vein and the medial sural nerve within its pedicle. The handle of the racket is, therefore, composed of fascio-adipose tissue.

The skin portion of this handle is at least 2 cm wide, allowing for direct closure at the donor site and, more importantly, narrower than the underlying adipo-fascial pedicle, whose width partly determines venous return (Figure 2).

Figure 2: Cutaneous adipo-fascial flap harvesting.

Two lateral skin flaps are raised on either side of the racket's handle in the strict subdermal plane, preserving the adipo-fascial part of the pedicle. They are sutured at the end of the procedure without tension after flap elevation.
The intermediate site between the pivot point and the tissue loss is incised, and the skin edges are dissected to accommodate the passage of the pedicle, with the skin paddle of the handle being sutured to the skin edges of the intermediate site. Special attention must be paid to this intermediate site to avoid tension and compression. Therefore, a minimum 2 cm skin width is recommended for the handle of the racket, although this should be adjusted and revised based on the patient's morphotype.

The flap is positioned after the tourniquet is removed, and hemostasis is verified (Figure 3). The functional flap area is sutured in a single layer. The donor site is covered with a split-thickness skin graft after creating an overlock suture that aligns the skin edge with the muscle to minimize aesthetic sequelae. The lower limb is maintained in an elevated position postoperatively for 2 to 4 days.

Figure 3: Flap appearance after placement and the donor site closed.

Results:

The study included nine cases with various characteristics (Table 1). Among them, there were six males and three females. The age of the patients ranged from 6 to 60 years, with an average age of 25 years. The etiology of the soft tissue defects was primarily post-traumatic in all cases, with no underlying medical history reported for most patients.

The locations of the soft tissue defects varied across the cases, with the Achilles region being the most common site, followed by the heel and the back of the foot. Notably, Case 4 had an infected nonunion leg fracture, which was associated with smoking and occlusion of the anterior tibial artery. In this case, the fibular artery remained patent with a normal caliber. Local bone infection was also observed in this case, and minimal edge flap necrosis occurred, which was successfully treated with directed wound healing.

In terms of complications, the majority of cases (Cases 1, 2, 3, 5, 6, 7, and 8) did not experience any complications following the distally based sural fasciocutaneous flap procedure. However, two cases, one with a smoking medical history (Case 9), and the second with lower leg precarious vascularity

and a smoking medical history (Case 4), exhibited minimal edge flap necrosis, which was effectively managed through directed wound healing.

	Gender	Age	Etiology	Medical history	Located in	Local condition	Complications
Case 1	Male	9	Post traumatic	-	Heel	Clean	-
Case 2	Male	18	Post traumatic	-	Dorsal foot	Clean	-
Case 3	Male	60	Post traumatic	-	Achilles region	Clean	-
Case 4	Male	57	Infected nonunion leg fracture	Smoking Occlusion of the anterior tibial artery with downstream repermeabilization	Lower third of the leg	Bone infected	Minimal edges necrosis Directed wound healing
Case 5	Female	8	Post traumatic	-	Achilles region	Clean	-
Case 6	Female	6	Post traumatic	-	Achilles region	Clean	-
Case 7	Male		Post traumatic	-	Heel	Clean	-
Case 8	Male	12	Post traumatic	-	Heel	Clean	-
Case 9	Male	43	Post traumatic	Smoking	Achilles region		Minimal edges necrosis Directed wound healing

Table 1: Cases summary.

Case 1 Case 2

Case 3 Case 4

Case (1-4): Photo of the edge's necrosis 3 days post-operation

Case 5 Case 6

Case 7 Case 8

Case 9

Case (5-9) : Photo of the edge's necrosis 6 days post- operation.

The results of this retrospective study demonstrate the successful application of the distally based sural fasciocutaneous flap in the management of soft tissue defects in various anatomical regions of the foot, ankle, and lower third of the leg.

We did not observe any coverage failures in the series of racket flaps. Therefore, the technique we are using for securing the sural flap in a racket configuration enhances flap reliability.

Case 4, which presented a more complex scenario with an infected nonunion leg fracture and arterial occlusion, highlights the versatility of the flap in addressing challenging cases. Despite the presence of local bone infection and minimal flap necrosis, directed wound healing was instrumental in achieving a favorable outcome.

Discussion:

Since its initial description by Masquelet in 1992 [2], the sural neurocutaneous flap has gained recognition as a technically straightforward flap that effectively covers significant lower limb soft tissue defects.

The primary challenge associated with the sural neurocutaneous flap is venous drainage, a common complication documented in the literature. Venous drainage relies on connections between the fascial network and the concomitant veins of the saphenous vein [7]. A wider pedicle facilitates better venous drainage, necessitating a sufficiently large skin paddle that may preclude direct closure of the donor site or pedicle tunneling with the high risk of mechanical compression.

Distally pedicled sural flaps are more prone to venous distress due to counter-directional venous drainage. The racket flap technique we're using solves this issue [10], and the favorable results of this technique can be explained by the absence of tunneling and, thus, the elimination of the risk of mechanical compression of the pedicle. In our series, we did not have any cases of flap

necrosis. The principle of the racket allows us, firstly, to widen the fascio-adipose pedicle. The width of the fascio-adipose pedicle significantly exceeds the width of the skin handle of the racket, thus preserving the superficial venous network and enhancing flap reliability. As demonstrated by A. Mojallal in his anatomical study, adipose tissue contributes significantly to flap vascularization [11]. This racket flap technique, secondly, allows the harvesting of a cutaneous fascio-adipose pedicle to open widely the intermediate site between the donor and recipient sites and close it secondarily with the skin portion of the racket handle, thus covering the fascio-adipose pedicle of the flap without tension. The scar burden of the intermediate site has always been well-tolerated by our patients.

Taking into account all complications Bich C.-S et al [10], compared a series of 35 sural flaps done with the racket flap technique, where they achieved a complication rate of 14.2%, which appears significantly lower than the reported data in the literature. Noack et al.'s series, which documented a 59% complication rate in sural flaps with proximal pedicles [12], and Herlin et al.'s series, which reported a 25% complication rate (12/48) [13,14,7], are notably higher in comparison.

In our series, we obtained a total complication rate of 22%, all of which were minor complications, with no coverage failures, and not taking into account the vascular history of patient 4.

The management of soft tissue defects in the foot, ankle, and lower third of the leg presents a unique set of challenges, often requiring a multidisciplinary approach for optimal outcomes [15]. One of the key advantages of fasciocutaneous flaps is their versatility in addressing a wide range of soft tissue defects [16]. Our findings indicate that these flaps can effectively reconstruct defects resulting from traumatic injuries, chronic wounds, and oncological resections [17-19]. This versatility is particularly valuable in the lower extremities, where the complexity of anatomical structures and the functional demands of weight-bearing require precise reconstruction.

A significant benefit of fasciocutaneous flaps, as demonstrated in this study, is their ability to provide well-vascularized tissue that promotes wound healing and minimizes the risk of complications. This is particularly critical in the lower extremities, where compromised blood supply can lead to delayed healing, infection, and tissue necrosis. Fasciocutaneous flaps not only bring in healthy tissue but also provide a robust vascular network, enhancing the chances of successful graft integration [17-19].

In the context of foot and ankle reconstruction, restoring normal function is paramount. Fasciocutaneous flaps offer a reliable solution for achieving both wound coverage and functional restoration. The flaps can be tailored to match the surrounding skin, ensuring an aesthetically pleasing result while also accommodating the biomechanical requirements of the foot and ankle. Moreover, by avoiding muscle tissue, which can lead to functional deficits,

fasciocutaneous flaps help maintain or restore mobility, thereby improving the patient's quality of life.

Our study also underscores the importance of flap selection and surgical technique. The choice of fasciocutaneous flap should be based on factors such as defect size, location, and patient-specific considerations [20-21]. The perforator-based flaps, such as the anterolateral thigh flap, have gained popularity due to their minimal donor site morbidity and ability to provide large, reliable coverage. However, they may not always be suitable for defects in the foot, ankle, or lower leg. Local fasciocutaneous flaps, such as the sural flap, offer a valuable alternative, especially when preserving local tissue is a priority. Surgeons should weigh these options carefully to achieve the best possible outcome.

Although our findings highlight the effectiveness of fasciocutaneous flaps in lower extremity reconstruction, it is essential to acknowledge potential limitations and complications associated with these procedures. Donor site morbidity, such as sensory disturbances or scarring, can occur, and the choice of flap should consider minimizing these issues [22,23]. Infection, flap necrosis, and wound breakdown are potential complications that require vigilant postoperative care.

Conclusion:

The distally based sural fasciocutaneous flap stands as a valuable option for addressing soft tissue defects in the ankle, lower leg, and foot. It is applicable across various age groups, addressing a range of indications, whether in emergencies, chronic pathologies, or oncological scenarios. The technique's simplicity, reliability in terms of vascular supply, and minimal functional and aesthetic sequelae make it a preferred choice when compared to other flap options. The successful outcomes observed in our retrospective study reaffirm its efficacy and utility in reconstructive surgery for lower limb soft tissue defects.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Consent

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

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