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The Probable outcome of Soft Tissue Defect of Sole Reconstructed with Rotation Advancement Flap

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Abstract

Introduction: *A soft tissue defect on the sole can arise from various causes, including trauma, infection, ischemia, or tumour excision. The primary goal of sensory recovery and durability of the flap is to sole soft tissue reconstruction depending on different options, the choice of the flap depends on the side of the defect, it's location and the availability of the donor area.*

Objective: *This study aimed to investigate the probable outcome of soft tissue defect of sole reconstructed with rotation advancement flap.*

Methodology: *This study included 30 patients diagnosed with sole defects who visited IBN Sina Medical College Hospital, Bangladesh with sole defects. This 18-month-long study included adult patients who were suffering from soft tissue defects. The outcome was evaluated in terms of flap survival, recovery of sensation, durability of coverage, and functional denouement. The outcomes between neuropathic and non-neuropathic ulcers of the sole were also analysed.*

Results: *Among 30 selected patients, two flaps showed delayed wound healing. Only one flap showed marginal necrosis as an immediate complication when other flaps remained intact during the follow-up period. The return of protective sensation was significantly higher in the non-neuropathic ulcer group (P=0.006), as was the mean American Orthopaedic Foot and Ankle Society subjective score (P=0.025).*

Conclusion: *The functional outcome was higher in the rotation advancement flap. Local rotation and advancement flaps are effective with no donor site issues.*

Keywords: *Soft tissue reconstruction, rotation advancement flap, soft tissue defect, sole defect.*

1. INTRODUCTION

Soft tissue defects of the sole are challenging to manage due to the unique anatomical and functional characteristics of the plantar surface [1]. The sole is a weight-bearing area that requires durable and sensate coverage to ensure optimal functional outcomes [2]. These defects may arise from trauma, infection, pressure ulcers, or neuropathic conditions, such as diabetes mellitus. Reconstructive options for these defects should aim to restore function, provide long-term durability, and prevent complications such as ulceration, infection, and further tissue loss [3]. Traditional approaches often struggle to balance these demands, especially when donor site morbidity and functional denouement are considered [4].

Rotation advancement flaps have emerged as a reliable method for addressing soft tissue defects of the sole [5]. These flaps involve local tissue rearrangement to achieve defect coverage without sacrificing

vascular supply or necessitating distant donor sites [3]. The technique is particularly advantageous for preserving the biomechanical integrity of the sole while minimizing complications [6]. Rotation advancement flaps are preferred in clinical practice because of their ability to maintain similar skin texture and thickness, ensuring effective load distribution and long-term durability [1].

One of the critical considerations in sole reconstruction is the presence or absence of neuropathy [7]. Neuropathic ulcers, common in conditions like diabetes, present unique challenges due to altered sensation, impaired wound healing, and increased risk of recurrence [5].In contrast, non-neuropathic ulcers typically have better healing potential and sensory recovery. Evaluating the differential outcomes between these two categories provides valuable insights into tailoring reconstructive strategies for diverse patient populations [8].

In this context, assessing the functional outcomes of rotation advancement flaps is essential for optimizing patient care [4]. Key indicators of success include flap survival, recovery of protective sensation, durability of coverage under mechanical stress, and overall functional recovery, as measured by validated scoring systems like the American Orthopaedic Foot and Ankle Society (AOFAS) subjective score [3]. Moreover, immediate complications such as wound dehiscence, infection, and necrosis need to be carefully monitored to evaluate the overall efficacy of this technique [9].

2. OBJECTIVES

- ***General Objective:*** The primary aim of this study was to evaluate the outcomes of the sole reconstructed soft tissue defect
- ***Specific Objective:*** This study targeted to evaluate the probable outcome of soft tissue defect of sole reconstructed with rotation advancement flap.

3. METHODOLOGY

This 1.5-year cohort study included a total of 30 patients who had soft tissue reconstruction of the sole. These patients visited IBN Sina Medical College Hospital, Bangladesh with sole defects, from January 2022 to June 2023. The present study included all adult patients who were selected by purposive sampling.

- ***Inclusion Criteria:*** The current study included adult patients who had soft tissue reconstruction of the sole during the study period.
- ***Exclusion Criteria:*** Patients who were critically ill, unable to communicate, and had soft tissue reconstruction other than the sole.

Patients' data, including age, sex, concurrent medical conditions, aetiology, defect size, and location, were recorded. Different flaps were planned based on the location and size of the sole defect, as well as the available options. The data were entered into an MS Excel spreadsheet, and analysis was conducted using SPSS (version 21.0, Inc., Chicago, IL, USA). Independent t-tests were used to compare variables between the two groups. A P-value of ≤0.05 was considered statistically significant. The study was approved by the Institutional Review Board, and informed consent was obtained from all participants prior to enrollment.

4. RESULT

Among 30 study patients, 26 were males and 4 were female. Diabetes is the most common comorbidities found among patients followed by peripheral nerve injury. Trauma (70%) is the mainly found aetiology of defects [Table-1]. Pain was a maximum of 40 points and function was a maximum of 20 points **[Table-2].** Return of protective sensation and mean AOFAS subjective score was significantly higher in the nonneuropathic ulcer group [Table-3]. Figure 1, 2, 3 and 4 shows preoperative, after flap raised, after flap inset, 21 postoperative days, and after 3 months of four patients respectively.

Table1. *Demographic data of the study patients*

Characteristics	Variables	N (%)
Sex	Male	26 (87%)
	Female	4 (13%)
	Male: Female ratio	13:2
Comorbidities	Diabetes	10 (33%)
	Hypertension	6 (20%)
	Ischemic Heart disease	4 (13%)
Aetiology of defect	Trauma	21 (70%)

	Neuropathic ulcer	6 (20%)
	Malignancy	3 (10%)
Location of the defect	Front foot	18 (60%)
	Instep	8 (27%)
	Heel	4 (13%)

Table2. *AOFAS Hindfoot clinical ratings scale (Maximum score 60)*

Scale		Score
Pain (maximum 40 points)	None	40
	Mild, occasional	30
	Moderate, daily	20
	Severe, almost always present	0
Functional (maximum 20 points)	*Activity limitations, support requirement*	
	No limitations, no support	10
	No limitation of daily activities, limitation of recreational activities, no support	7
	Limited daily and recreational activities, cane	4
	Severe limitation of daily and recreational activities, walker, crutches, wsole chair, brace	0
	Maximum walking distance in blocks (1block= 150meter)	
	Greater than 6	5
	4-6	4
	1-3	2
	Less than 1	0
	Walking surfaces	
	No difficulty on any surface	5
	Some difficulty on uneven terrain, stairs, inclines, ladders	3
	Severe difficulty on uneven terrain, stairs, inclines, ladders	0

Table3. *Outcome analysis between Neuropathic and non-neuropathic sole defect groups*

Group	Delayed ulceration (n)	Return of protective sensation (n)	Mean AOFAS Score and range (Maximum Mean Score 60)
Neuropathic (n=12)	3 (25%)	4 (33.3%)	41 ± 10.7
Non-neuropathic(n=18)	2 (10%)	14 (78%)	48.5±5.7
P value	0.25	0.006	0.025

Figure1.*First patient (Preoperative, after flap raised, after flap inset, 21 postoperative days,and after 3 months)*

Figure2. *2nd patient (Preoperative after flap inset, 21 postoperative days, and after 3 months)*

Figure3. *3rd patient (Preoperative, after flap inset, 21 postoperative days, and after 3 months)*

Figure4. *4th patient (Preoperative, after flap raised, after flap inset, 21 postoperative days)*

5. DISCUSSION

Soft tissue defects of the sole present a significant challenge in reconstructive surgery due to the unique demands placed on the foot in terms of both function and sensation. Various methods of reconstruction are available, including local flaps, free flaps, and pedicled flaps, each with its own advantages and limitations. In this study, we aimed to evaluate the outcomes of soft tissue defects of the sole reconstructed using the rotation advancement flap, specifically focusing on flap survival, recovery of sensation, durability, and functional outcomes.

Our study included 30 patients with sole defects, predominantly male (87%), with a mean age that reflects the typical demographic for foot and ankle trauma. The most common comorbidity was diabetes (33%), a known risk factor for delayed wound healing, which is consistent with the literature highlighting the impact of systemic conditions on the outcome of foot reconstructions. Trauma was the leading cause of defects (70%), followed by neuropathic ulcers (20%) and malignancies (10%). This distribution is in line with the observed higher incidence of traumatic injuries in young and middle-aged adults and the increasing prevalence of neuropathic ulcers in diabetic patients.

The location of the defect significantly influenced the flap choice and the surgical approach. Most defects were located on the front of the foot (60%), which presents a unique challenge due to the weight-bearing nature of this area. Flaps like the rotation advancement flap were preferred for their ability to provide adequate coverage and sensation in these areas, as supported by previous studies [7,10].

One of the primary goals of soft tissue reconstruction in the foot is to ensure flap survival. In our study, the overall flap survival rate was high, with only 3 patients (10%) experiencing delayed ulceration and 1 patient (3.3%) showing marginal necrosis. These findings are consistent with previous studies that reported satisfactory flap survival rates using rotation advancement flaps for foot reconstructions [11,12]. The relatively low rate of complications in our cohort supports the reliability of this flap technique for sole defects, with complications mainly limited to cases with comorbidities such as diabetes and peripheral vascular disease.

The delayed ulcerations observed in some patients may be attributed to factors like poor vascularization, the presence of systemic conditions, or inadequate postoperative care. The one case of marginal necrosis was likely due to technical challenges during flap inset or poor blood supply in the recipient site. However, the overall success rate of the rotation advancement flap for sole defects, as demonstrated in our study, reinforces its clinical utility in treating traumatic or ischemic soft tissue injuries of the foot.

Sensory recovery is a critical aspect of foot reconstruction, as the sole plays a crucial role in balance and the protection of deeper structures. In this study, the return of protective sensation

was significantly higher in the non-neuropathic ulcer group (78%) compared to the neuropathic ulcer group (33.3%) (P = 0.006). This finding is consistent with the literature, which suggests that neuropathic ulcers are less likely to exhibit satisfactory sensory recovery following reconstruction [13,14]. Neuropathic ulcers are often associated with diminished nerve function and impaired wound healing, factors that can limit the effectiveness of reconstructive techniques that rely on sensory recovery.

The results of our study suggest that the rotation advancement flap may be more beneficial for patients with non-neuropathic defects, where sensory recovery is more likely to occur. In contrast, patients with neuropathic ulcers may require additional measures, such as nerve repair or coaptation, to optimize sensory outcomes. Previous studies have highlighted the importance of considering nerve status when planning reconstructive procedures, as sensory recovery can significantly impact the long-term functionality and quality of life of the patient [15].

Functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) score, which assesses pain, function, and walking ability. The mean AOFAS score was significantly higher in the non-neuropathic group (48.5 ± 5.7) compared to the neuropathic group (41 ± 10.7), with a p-value of 0.025, indicating that non-neuropathic patients achieved better functional recovery. This aligns with findings from other studies that demonstrate a strong correlation between the restoration of sensation and functional outcomes following foot reconstruction [16,17].

In our study, the non-neuropathic group showed significantly less pain, greater walking distances, and improved functionality compared to the neuropathic group. The improved outcomes in the non-neuropathic group can be attributed to the better sensory recovery and less compromise in weight-bearing and ambulation. The mean AOFAS scores suggest that while the rotation advancement flap is effective for both neuropathic and non-neuropathic defects, the latter group benefits more from its functional potential.

While the rotation advancement flap has shown good results in this study, it is essential to recognize that other flap techniques may offer advantages depending on the defect's location, size, and the patient's overall health. Studies on free flaps, such as the medial plantar artery island flap and reverse sural flaps, have demonstrated good functional outcomes, particularly in large or complex defects [18,19]. However, these flaps often come with increased morbidity at the donor site and may require more complex surgical procedures.

Local flaps like the rotation advancement flap are advantageous in terms of simplicity, reduced donor site morbidity, and faster recovery times. However, they may not always be suitable for larger defects or defects with insufficient local tissue for rotation. Thus, while the rotation advancement flap remains a reliable choice for many sole defects, a comprehensive evaluation of the defect's characteristics and patient factors is essential when choosing the optimal reconstructive technique.

6. Conclusion

For small sole defects, local rotation and advancement flaps are effective with no donor site issues. The functional and sensory outcome of the rotation advancement flap to cover the sole defects showed better outcomes compared to other flaps.

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