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CLINICAL AND SURGICAL MANAGEMENT OF SOFT TISSUE DEFECTS AROUND THE ANKLE REGION

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ABSTRACT

BACKGROUND

Soft tissue defects around the ankle pose significant challenges due to limited soft tissue coverage, frequent exposure of vital structures, and complex biomechanical demands. Causes include trauma, diabetic ulcers, chronic osteomyelitis, and malignancy. Surgical reconstruction aims to preserve limb function, provide durable coverage, and optimize aesthetic outcomes. The reconstructive approach has evolved from basic wound care to sophisticated flap surgeries, including microsurgical free flaps and perforator-based options.

METHODS

This retrospective study was conducted at the Department of Plastic Surgery, RGSSH (Rajiv Gandhi Super Speciality Hospital), RIMS (Raichur Institute of Medical Sciences), Raichur, from June 2020 to May 2024. A total of 71 patients with soft tissue defects in the ankle region were included. Data collection involved clinical history, imaging, preoperative planning, operative details, postoperative outcomes, and follow-up. Inclusion criteria were defects in the ankle, heel, dorsum of foot, or lower third of the leg unsuitable for primary closure. Surgical techniques varied based on defect size, location, and associated exposure of tendons, bones, or vessels. Patients were followed for at least six months to assess functional and aesthetic outcomes.

RESULTS

The most affected age group was 20–39 years (46.5%), with a male predominance (57.7%). Trauma was the leading cause (76%), followed by diabetic ulcers (11.3%) and osteomyelitis (9.9%). The posterior ankle was the most common wound site (50.7%). Most reconstructions involved reverse sural artery flaps, local flaps, or microvascular free flaps. The highest hospital stay was associated with free flaps (24.8 days). Complications included flap necrosis, infection, and the need for reoperation in some cases. Aesthetic and functional rehabilitation was satisfactory in the majority of patients.

CONCLUSION
Soft tissue reconstruction around the ankle requires individualized, multidisciplinary approaches. Flap selection should be based on defect location, size, and patient comorbidities. Reverse sural artery and microvascular flaps offer reliable coverage with acceptable functional outcomes. Early debridement, meticulous planning, and postoperative care are critical to successful reconstruction and limb salvage.

KEYWORDS: Ankle Soft Tissue Defects, Reconstructive Surgery, Flap Coverage, Trauma, Reverse Sural Flap, Microvascular Flap, Functional Rehabilitation.

INTRODUCTION
Soft tissue defects around the ankle region present significant reconstructive challenges due to the area's limited tissue availability, complex anatomy, and high functional demand. The foot and ankle are subjected to repetitive mechanical stress, with an individual averaging more than 10,000 steps per day. Although the plantar tissue is specialized to absorb this stress, trauma, infection, ischemia, and systemic illnesses such as diabetes can lead to tissue breakdown and chronic wounds. In diabetic patients, failure to salvage the foot often results in major amputations, which are associated with high morbidity, premature mortality, and increased risk of contralateral limb amputation.[1]

The ankle's unique anatomical structure-comprising bones, tendons, and vessels in a tight, poorly vascularized space-necessitates a multidisciplinary approach. Reconstructive success often involves coordination between plastic surgeons, orthopedic surgeons, vascular specialists, and infectious disease teams to achieve both durable coverage and limb function.[2]

Over recent years, surgical innovations have expanded treatment options. Local and regional flaps, such as the reverse sural flap, medial plantar flap, and lateral supramalleolar flap, have become effective for moderate-sized defects. These options offer good reliability and acceptable morbidity.[3,4] For extensive or complex defects, microvascular free flaps-particularly the anterolateral thigh (ALT) flap-are now considered the gold standard due to their versatility, size, and low donor site complications.[5]

Muscle flaps, including the rectus abdominis and gracilis, play an important role in reconstructing infected or osteomyelitic wounds. Their robust vascularity aids in infection control, promotes healing, and reduces dead space, making them preferable in compromised wound beds.[6]

This study evaluates the clinical and surgical management of soft tissue defects around the ankle region, focusing on reconstructive techniques, postoperative outcomes, and long-term functional and aesthetic rehabilitation.

Aims and Objectives
The aim of this study was to evaluate the clinical and surgical management of soft tissue defects around the ankle region by assessing the incidence, natural history, and clinical presentations of such cases, along with the treatment strategies employed. It further seeks to analyze the nature of post-debridement or resection defects, the types and suitability of various flap reconstruction options available, and to document both early and late complications arising from these procedures. Additionally, the study aims to assess the overall outcome of flap reconstructions, focusing on both aesthetic appearance and the extent of functional rehabilitation achieved in patients.

MATERIALS AND METHODS
Study Design
This retrospective study was conducted at the Department of Plastic Surgery, RGSSH (Rajiv Gandhi Super Speciality Hospital), RIMS (Raichur Institute of Medical Sciences), Raichur, from June 2020 to May 2024. The study population was selected based on specific inclusion and exclusion criteria, with a focus on individuals presenting with soft tissue defects around the ankle region. Data was collected through clinical evaluations, surgical interventions, and follow-up assessments to analyze the management and outcomes of these cases.

Inclusion and Exclusion Criteria

The study included patients with soft tissue defects in the ankle region, specifically the lower third of the leg, ankle joint, heel, and dorsum of the foot, where simple skin closure by primary intention was not possible. Additionally, patients with exposed bone (with or without fractures), exposed tendons, or vessels requiring coverage were included, provided they gave valid informed written consent. The exclusion criteria consisted of patients for whom primary closure was feasible, those whose defects were managed with skin grafts or left to heal by secondary intention, and patients at high anesthetic risk. All participants underwent thorough pre-operative evaluations, including detailed history-taking, clinical examinations, necessary imaging, and management of underlying conditions like hypertension and diabetes, with the final treatment plan determined based on flap selection and suitability.

Data Collection Procedure

Data collection for this study involved a comprehensive approach, starting with the detailed clinical history of each patient, focusing on the mode of onset and progression of the soft tissue defect. A thorough clinical examination was conducted to assess risk factors and establish the diagnosis. Patients underwent all necessary investigations available at RGSSH and RIMS, Raichur, including imaging and laboratory tests. Pre-operative planning was carried out, taking into account the patient's clinical condition and investigation results. Surgical management was determined based on this planning, with appropriate procedures selected for each case. Post-operative recovery was closely monitored, including the identification and documentation of any complications. Patients were then followed up in the plastic surgery OPD, and the final outcome was assessed based on both aesthetic and functional parameters.

Statistical Analysis

Descriptive statistical analysis was performed in this study. Continuous variables are expressed as mean ± SD (Standard Deviation) along with the range (min–max), while categorical variables are presented as frequencies and percentages. The significance of differences between groups was evaluated at the 5% level ($p < 0.05$). Student's t-test (two-tailed, independent) was used to compare continuous variables between two groups. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. Fisher's test was applied when expected frequencies were small, based on the multivariate hypergeometric distribution. Significance levels were denoted as follows: '+' for suggestive significance ($0.05 < p < 0.10$), '*' for moderate significance ($0.01 < p \leq 0.05$), and '**' for strong significance ($p \leq 0.01$). Statistical analysis was conducted using SPSS 15.0, Stata 8.0, MedCalc 9.0.1, and Systat 11.0, with data visualization performed in Microsoft Word and Excel.

RESULTS

Parameter	**Category**	**Frequency**	**Percentage**
Age (in years)	<20	7	9.9%
	20–39	33	46.5%
	40–59	25	35.2%
	≥60	6	8.5%
Sex	Male	41	57.7%
	Female	30	42.3%

Table 1: Demographic Profile of Patients

In Table 1, most patients (46.5%) were in the 20–39 year age group, with a male predominance (57.7%), reflecting trauma-related injuries in a younger, active population.

Parameter	Category	Frequency	Percentage
Cause of Defect	Trauma (Fall + RTA)	54	76.0%
	Diabetic Foot Ulcer	8	11.3%
	Chronic Osteomyelitis	7	9.9%
	Malignancy	2	2.8%
Comorbidities	None	59	83.1%
	Diabetes Mellitus	7	9.9%
	Hypertension (± DM)	3	4.2%
	Hansen's Disease	2	2.8%
Tobacco Use	Yes	39	54.9%

Table 2: Clinical Characteristics and Comorbidities

Table 2 indicates trauma was the leading cause of soft tissue defects. Most patients were otherwise healthy, though over half reported tobacco use, a known risk factor for wound complications.

Parameter	Category	Frequency	Percentage
Wound Location	Ankle Posterior	36	50.7%
	Medial Malleolus	10	14.1%
	Heel	8	11.3%
Indication for Flap	Exposed TA	32	45.1%
	Exposed Bone	13	18.3%
	Heel Pad Loss	9	12.7%
Pre-Op Doppler Study	Done	17	23.9%

Table 3: Wound and Flap Characteristics

Table 3 shows posterior ankle wounds were most common. Tendoachilles exposure was the leading indication for flap reconstruction, emphasizing the need for durable and flexible coverage.

Flap Technique	Frequency	Percentage
Reverse Sural Artery Flap	13	18.3%
Propeller Flap	12	16.9%
Medial Plantar Artery	9	12.7%
Free Flaps (Various)	7	9.9%
Peninsular Flap	36	50.7%
Island Flap	28	39.4%

Table 4: Flap Type and Technique

According to Table 4, reverse sural artery and propeller flaps were the most commonly used. Free flaps were reserved for complex cases. Peninsular flaps were preferred in over half the patients.

Flap Type	Mean Hospital Stay (in days)
Free Flap	24.8 ± 3.12
Medialis Pedis Flap	14.2 ± 6.75
Reverse Sural Artery Flap	10.0 ± 3.50
Local Transposition Flap	5.7 ± 2.71

Table 5: Hospital Stay by Flap Type

In Table 5, free flap patients had the longest hospital stays due to the complexity of surgery and postoperative care, while local flaps resulted in shorter admissions.

Complication Type	Category	Frequency	Percentage
Immediate	Bleeding	2	2.8%
	None	69	97.2%
Early	Partial Necrosis/Venous Issues	7	9.8%
Late	Bulky Flap	16	22.5%
	Ankle Joint Stiffness	6	8.4%
Donor Site	Graft Loss	5	7.0%
	None	65	91.5%

Table 6: Flap Complications

Table 6 shows most flaps healed without immediate complications. A small percentage had partial necrosis or venous congestion. Bulky flaps were the most common late complication.

Parameter	Category	Frequency	Percentage
Aesthetic Outcome	Good	62	87.3%
	Not Satisfactory	3	4.2%
Functional Outcome	Good	52	73.2%
Secondary Procedures	STSG, Defatting	11	15.5%
	None	60	84.5%

Table 7: Outcomes and Secondary Procedures

In Table 7, the majority of patients had good aesthetic (87.3%) and functional (73.2%) outcomes. Few required secondary procedures like defatting or repeat grafting.

DISCUSSION

This study evaluated 71 patients with soft tissue defects around the ankle region. The majority were young males aged 20–39 years, with trauma (especially road traffic accidents) being the predominant cause. These demographics align with global data-the World Health Organization predicts that road traffic accidents will become the third leading cause of disability-adjusted life years by 2030,[7] and the National Trauma Data Bank (2009) reports peak incidence among individuals aged 25–34 years.[8]

The mean hospital stay was longest in patients who underwent free flap reconstructions (24.8 days), reflective of more severe injuries. The **"**reconstructive ladder**"** approach was used in selecting flap types, progressing from simpler local flaps to complex free flaps as needed.[9] However, more recent literature suggests using a **"**reconstructive elevator,**"** prioritizing flap choice based on wound complexity rather than sequential escalation.[10]

In this study**,** reverse sural artery flaps were the most frequently used (18.3%), followed by propeller flaps and medial plantar artery flaps, all of which have shown reliability and versatility in distal lower limb coverage.[3,11] Free flaps such as the ALT (Anterolateral Thigh) and gracilis muscle flaps were reserved for extensive soft tissue loss, and anastomoses were done using dorsalis pedis or posterior tibial arteries. These choices are consistent with published microsurgical principles and techniques.[12]

Exposed tendoachilles was the most common indication for reconstruction (45.1%). Its superficial location and tenuous blood supply make it highly vulnerable to trauma and difficult to manage without soft tissue coverage. This reflects prior findings on anatomical challenges in posterior ankle reconstruction.[13]

Preoperative Doppler studies were used in 24% of patients to map perforators and assess vascularity. As Lutz et al. have shown, Doppler is a valuable, non-invasive alternative to angiography in flap planning, especially in resource-limited settings.[14]

Complications were minimal: bleeding (2.8%) and venous congestion (4.2%) were the most frequent early issues, managed successfully. These are consistent with expected rates in lower limb reconstructions.[11,15] Late complications included bulky flaps (22.5%) and ankle stiffness (8.4%), manageable with secondary procedures. Muscle flaps, while useful for obliterating dead space, are known to result in bulkiness without contouring.[16]

A significant portion (54.9%) of the cohort reported tobacco use, which may contribute to poor wound healing. This is supported by previous literature highlighting nicotine's vasoconstrictive effects and its role in increasing flap failure risk.[17]

In patients with diabetes, flap reconstruction was vital to avoid major amputations. Diabetic foot ulcers, neuropathy, and osteomyelitis are key contributors to soft tissue loss. Several studies support the use of muscle and perforator flaps for durable coverage in diabetic foot salvage.[18,19] The aesthetic and functional outcomes were encouraging-87.3% of patients rated their outcome as aesthetically good, and 73.2% reported good functional restoration. These findings support existing evidence that thoughtful flap selection, adequate debridement, and postoperative monitoring yield favorable results in lower limb salvage.[20]

CONCLUSION

Soft tissue defects around the ankle and foot are commonly encountered, with trauma-particularly road traffic accidents-being the leading cause. Other contributing factors include falls, diabetic foot ulcers, and chronic osteomyelitis. Smoking and diabetes mellitus were prevalent among patients. Preoperative vascular assessment using Doppler techniques guided flap planning. A range of local, regional, and free flaps were successfully utilized, with minimal complications and only one flap failure. Overall, the majority of patients achieved satisfactory functional and aesthetic outcomes, highlighting the effectiveness of appropriate surgical reconstruction in managing these complex defects.

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