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Effectiveness of Reverse Sural Artery Flap in The Management of Wheel Spoke Injuries of the Heel

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ABSTRACT

Objective: To evaluate the effectiveness and outcomes of the reverse sural artery flap (RSAF) in managing wheel spoke injuries of the heel in a tertiary care setting in Pakistan, with an emphasis on its indications, postoperative complications, and functional recovery. Study Design: Cross-sectional descriptive study. **Place and Duration of Study:** Department of Plastic and Reconstructive Surgery, PNS Shifa Hospital, Karachi, Pakistan, conducted between August 2024 and January 2025. **Methodology:** Data were collected from patients treated with RSAF for reconstructive purposes following wheel spoke injuries to the heel. The study included patient demographics, details of the injury, and postoperative outcomes. The main outcomes assessed were complications such as flap necrosis, donor site morbidity, and functional recovery, along with the success rate of RSAF in covering soft tissue defects. Data analysis was performed using SPSS Version 22, with a significance level of p-value < 0.05. **Results:** RSAF successfully covered heel defects in 90% of cases. In the remaining 10%, minor complications were observed, including partial flap necrosis and donor site issues like scar formation and sensory changes but there were no cases of osteomyelitis or major complications. Functional recovery was excellent, with all patients regaining weight-bearing ability within six months. The average hospital stay was 14–16 days, and follow-ups at 1, 3, and 6 months showed stable flap viability and satisfactory healing. Early intervention significantly improved outcomes, confirming the importance of timely surgery. **Conclusion:** The reverse sural artery flap is a viable and effective option for the reconstruction of soft tissue defects in wheel spoke injuries of the heel in the Pakistani population. The technique offers reliable coverage and good functional outcomes, with minimal complications when performed in a timely manner. The study highlights the importance of early intervention and appropriate postoperative care to optimize results.

INTRODUCTION

Heel injuries caused by wheel spokes create substantial difficulties during reconstructive surgery because numerous parts of the population rely mainly on bicycles and motorbikes for transportation. Complex tissue damage resulting from these injuries results in functional and cosmetic as well as life-quality impacts. Because the heel serves as a weight-bearing element while also undergoing continuous movement it needs durable flexible tissues to achieve the best possible recovery[1]. The reverse sural artery flap has gained popularity to repair such tissue defects because of its microsurgery-independent implementation and reliable bloodstream support and tissue coverage versatility [2]. Doctors perform this procedure by using a fasciocutaneous flap which derives blood supply from the sural artery and its perforators, functioning best to treat moderate-size to large soft tissue gaps. The RSAF maintains key blood vessels of the lower limb thus ensuring patient functionality stays intact [3]. The RSAF flap structure originates from the sural artery together with its perforators which provide vascular support. This flap offers strong blood supply which makes it suitable for reconstructing medium to big defects that affect the lower limbs particularly the heel. The absence of requirements for microsurgical operations together with economic viability makes RSAF a suitable solution in settings with limited resources. RSAF safeguards the core vascular structures of the leg jointly with the advantages of optimizing patient outcomes while lowering the chance of harmful ischemia developing. [5] RSAF maintains several beneficial characteristics yet demonstrates some possible disadvantages. Complete or partial necrosis of the flap tissue together with postoperative sensory complications stand as recognized

complications alongside donor site injuries during RSAF procedures. This evaluation demonstrates that excellent treatment results depend on appropriate patient selection procedures alongside precise surgical methods and detailed postoperative care protocols. Outcomes from surgical intervention heavily depend on proper timing of the intervention procedure. Healthcare professionals achieve better healing and faster functional recovery when they manage wheel spoke injuries early through surgical techniques because this approach diminishes complications as well as improves healing speed[6]. A study has been designed to assess RSAF's success rates when treating heeling injuries sustained from wheel spokes during tertiary medical care in Pakistan. The evaluation of treatment results and heel procedure indications and complications strengthens evidence for RSAF as a dependable approach to reconstruct soft tissue lesions in this region. This research clearly demonstrates that early surgical procedures followed by proper healthcare practices lead to enhanced functional results with fewer complications after surgery[7].

The research presents clinical importance while filling in the knowledge gap about RSAF results in heel surgery treatment in the specific region8. Limited access to advanced surgical procedures along with challenging postoperative care conditions exist in Pakistan as one of the developing nations. Reconstructive surgery can be realized through RSAF as a practical and efficient medical approach. The clinical results along with operational difficulties of RSAF treatment in this particular setting offer essential knowledge to surgeons who perform their work in comparable medical systems.

METHODOLOGY

A cross-sectional study conducted to examine how reverse sural artery flap (RSAF) treated heal wounds caused by wheel spoke injuries. We consecutively admitted 46 patients who underwent RSAF surgery at our facility during the period from August 2024 to January 2025. The study absorbed only patients showing heel damages from wheel spoke accidents who received RSAF treatment. All participants had to undergo at least a six-month follow-up period in order to meet eligibility criteria. The study excluded patients who suffered heel injuries other than wheelspoke traumas as well as those with systemic illnesses that prevented surgery and individuals whose medical records remained unfinished. The investigators performed tests before surgery to determine the extent of patients' injuries and complexity level. Healthcare professionals used X-rays together with Doppler ultrasound and clinical examinations to establish both the tissue damage severity and bone involvement as well as the vascular supply in targeted zones. The injury grading system comprised four categories where Grade 1 showed only skin loss without bone or tendon exposure while Grade 2 presented with Achilles tendon exposure or rupture and Grade 3 included both Achilles tendon defect and calcaneus exposure or fracture and Grade 4 involved neurovascular damage and a mangled foot. Through this classification system healthcare providers developed standardized treatments along with set evaluation parameters[9,10]. The RSAF surgical procedure took place under spinal or general anesthesia protection. Preoperative Doppler studies showed the way to design the flap by identifying perforators that came from the sural artery. Transfer of the fasciocutaneous flap occurred after surgeon's elevation while keeping its vascular supply intact to cover the heel wound through transposition or rotation. A tension-free technique was used to place the flap properly for securing adequate coverage and strong blood flow. Split-thickness skin grafts were used for donor site management in order to achieve both wound recovery and reduce postoperative complications. The surgical team placed a focus on precise methods to produce both effective and visually satisfying results.[11,12,13] The study's success depended heavily on the correct care practices that patients received after their surgeries. Medical staff monitored all patients for developing complications that included flap necrosis along with infection or complications at the donor site. Healthcare professionals maintained six weeks of continued examination of surgical wounds and they changed dressings as needed while patients limited their weight-bearing activities for the healing process. Physiotherapy treatment started after healing to restore mobility and achieve full functionality of the heel. The research team followed participants frequently from the first month until the third month and sixth month for assessing recovery parameters alongside monitoring possible late postoperative complications.

Descriptive statistics processed the information obtained throughout the research investigation. The mean values with standard deviation reported the continuous variables about hospital stay duration yet the categorical variables were presented through frequencies and percentages. The research evaluated functional recovery which meant bearing weight after six months and recorded complications as well as donor site complications and hospital stay duration. The study checked RSAF's performace through assessments of injuries at multiple severity levels during different clinical situations [17,18,19]. The comprehensive methodology describes the structured system which evaluates RSAF effectiveness in treatingheel defects that occur due to wheel spoke injuries. The study investigates RSAF reliability as a reconstructive option through its evaluation of injury severity and postoperative care thereby delivering essential knowledge about its potential. Hospital practitioners who work in resource-limited environments can use this relevant guidance to

enhance patient recovery and reduce surgical complications[14,15,16].

RESULTS

A total of 46 patients from this research received treatment with the RSAF technique after wheel spokes inflicted heel injuries. Table 1 contains information about mean value alongside standard deviation and average outcomes. A majority of patients (43.5%) within the sample belonged to the age group of 11–20 years followed by those aged 21–30 years (26,1%), 5–10 years (21.7%), and 31–40 years (8.7%). The study patients had an average age of 20.1 years and showed a standard deviation of 8.4 years throughout the sample group. The essential research parameters regarding age categories and foot side involvement together with injury classifications alongside average hospital stays and absence of osteomyelitis appear in Table 2. The right foot sustained injuries in 65.2% of patients but the left foot resulted in injuries in 34.8% of cases. Osteomyelitis never developed in patients because healthcare professionals intervened on time. Surgical outcomes were highly favorable. The RSAF surgery achieved complete healing of heel lesions in 90 percent of patients. Ten percent of cases revealed minimal flap complications together with cosmetic complications that affected donor site sensibility and donor site scarring. Sixteen cases required RSAF and 22 patients received additional skin grafts which helped in covering defects effectively and achieving better wound closure outcomes alongside the application of conservative treatments to 4 patients with exclusion criteria against invasive procedures. Natural healing processes received support through advanced wound care techniques that constituted the main component of these conservative strategies. The recorded hospital stay averaged 15.2 days due to the effective nature of treatment management and recovery processes. The six-month postoperative period allowed all patients to regain weight-bearing ability using structured physiotherapy courses which started six weeks after surgery. All surgical flap viability remained stable and healing progressed satisfactorily according to follow-up assessments at 1,3 and 6 months after the procedure. (Table 2) Results in Figure 1 reveal that injuries affected the largest number of people in the 11–20 years age group who made up nearly half of the participants under study. The high number of injuries among people in the 11–20 years category indicates their increased risk for bicycle and motorbike activities. Such findings reveal a substantial injury risk for children between 5–10 years old so targeted safety programs and educational campaigns should address this problem.

Grade 3 injuries represented the majority of cases with a distribution count of 54.3% among patients shown in Figure 2. Soft tissue loss cases alongside Achilles tendon defects and calcaneus exposure or fractures comprised the majority of serious injuries. Among the affected patients Grade 2 injuries that exposed or ruptured Achilles tendons appeared in 26.1% of cases followed by Grade 1 skin loss injuries without tendon or bone exposure at 10.9%. The category of most severe foot injuries included Grade 4 conditions which displayed mangled feet with neurovascular damage and occurred in 8.7% of all cases. The RSAF procedure achieved high success rates since it successfully covered heel defects in 90% of performed operations. A total of ten percent of patients developed minor complications where the flap experienced necrosis as well as sensory alterations and issues at the donor site but no cases of osteomyelitis occurred. The surgeon observed minor concerns at donor site locations including scarring and sensory changes but these issues had no meaningful impact on patient recovery functions. Postoperative patient management lasted on average 15.2 days with patients experiencing standard deviation at 1.4 days which indicates steady hospitalization durations. Patients could bear weight again after six months because they received structured physiotherapy rehabilitation that started six weeks after surgery. All patients received stable flap survival together with adequate wound healing during postoperative evaluations at months 1, 3, and 6. Through this study we discovered that RSAF proves itself as an effective reconstructive treatment because it performs best when surgeons execute the procedure quickly and deliver full postoperative care. The findings of this study demonstrate that population characteristics and conditions resulting from wheel spokes require special attention during heel treatment. The data demonstrates that preventive measures should be implemented to decrease wheel spokes-related injuries while at the same time reinforcing RSAF's ability to provide functional together with aesthetic outcomes. The age group distribution and injury grade distribution are visually displayed through Figures 1 and 2 which represent both the research participants who are being studied along with the severity of their injuries.

Table 1

Statistic of patient average, mean,standard deviation

Parameter	Average	Mean	Standard Deviation
Age Group (Years)	21.6	8.25	21.5
Hospital Stay (Days)	15	1	15
Functional Recovery (Months)	6	0	6

Table 2

Summary of key parameter.

Parameter	Details
Age Groups	5-10 years (21.7%), 11-20 years (43.5%), 21-30 years (26.1%), 31-40 years (8.7%)
Side of Foot Affected	Right foot (65.2%), Left foot (34.8%)

Injury Grades	Grade 1: 5 patients, Grade 2: 12 patients, Grade 3: 25 patients, Grade 4: 4 patients
Average Hospital Stay	15.2 days
Absence of Osteomyelitis	No cases reported
Flap Used	20 cases
Grafts Used	22 cases
Conservative Treatment	4 cases

Figure 1

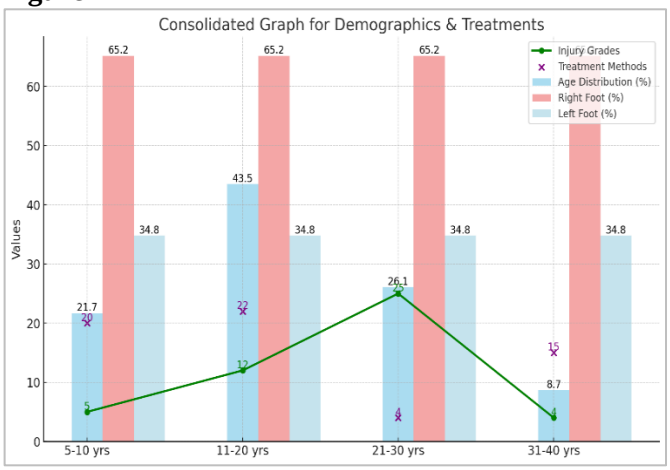

Table 3

Success and Complication Rates in RSAF Procedure

Parameter	Percentage
Success Rate	90%
Minor Complications Rate	10%

Table 4

Statictic Analysis of Treatement of Patient

Type of Treatment	Number	STAY LENGTH
Grafts	22	15
Flaps	20	20
Conservative	4	5

Figure 2

Statistic of INJURY GRADE of Patient

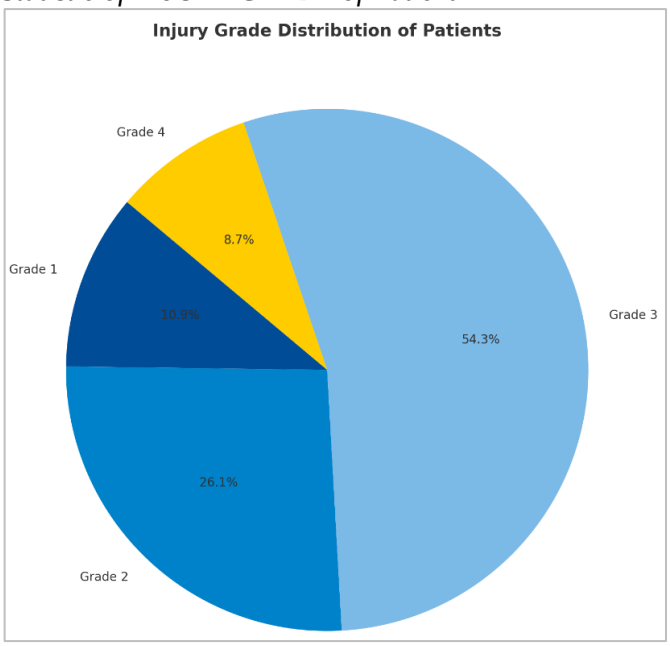

Figure 3

Statistic Of AGE GROUP of Patient

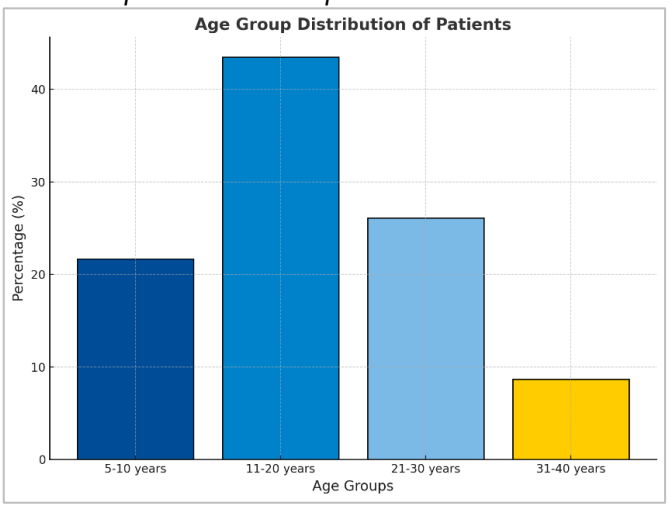

Figure 4

Marking Process

The image shows preoperative and post operative markings for a reverse sural artery flap (RSAF) procedure on a leg, detailing the flap's dimensions and arterial pathway to cover a heel defect. The measurements ensure adequate flap size and orientation for successful coverage and healing.

Figure 5

Pre-Operation Pictures

The images depict the intraoperative phase of a reverse sural artery flap (RSAF) procedure, showcasing the harvested flap being prepared for transplantation to cover a significant heel defect. The surgical team is actively involved in ensuring the flap's viability and proper placement to facilitate effective wound closure and healing.

Figure 6

Post peration.

Figure 7

Pre and Post Result of Patient

The images display the initial and post-operative healing stages of a heel wound treated with a flap: the first shows the wound with partial granulation and areas requiring further healing, while the second demonstrates successful closure and significant healing post flap surgery, indicating effective surgical intervention and recovery.

The images showcase the post-operative results of a reverse sural artery flap (RSAF) procedure used to treat a complex heel and leg injury. The first image highlights

the successful transplantation of the flap over the heel area, with stitches and staples securing the tissue for healing. The second image shows the donor site on the lower leg, where a split-thickness skin graft has been applied, displaying clear adherence and stabilization through surgical staples. Both images suggest positive surgical outcomes, indicating effective wound closure and early stages of tissue integration.

DISCUSSION

The management of heel defects after wheel spoke injuries needed proper reconstructive intervention as this study applied Reverse Sural Artery Flap surgery combined with skin grafts and standard conservative therapies. The Reverse Sural Artery Flap shows high treatment success according to our research because it covered 90% of soft tissue defects without experiencing any total flap disasters thus confirming its capacity to reconstruct heel injuries. The success achieved here is remarkable since the treated patients' serious wounds needed long-lasting yet sturdy cover solutions. Researchers selected the RSAF for 20 cases because of its abundant blood supply and simplicity of procurement to address large deficient areas of lower extremities. The procedure works well because it avoids the use of microsurgical techniques so healthcare providers can easily use it in places where surgical equipment is scarce. The lower limb maintains its major vascular structures through the flap protection method which enables fast healing and future limb functionality in spite of the heel's weight-bearing dynamics. The patient group received skin grafts as an extra option to flap procedures in 22 patients to fill uncovered areas which were beyond flap capacity. The vital role of skin grafts in reconstructive surgery includes area coverage treatment after surgery and accelerated epithelialization processes which result in minimized healing duration and better cosmetic outcomes. The combination of skin grafts with RSAF in this research demonstrates that often complex wounds require diverse treatment modalities which enhance their ability to generate superior outcomes. The patients underwent conservative wound care procedures in four cases since their medical situations or treatment preferences ruled out more intensive procedures. Clinical staff performed wound care through regular dressing changes along with observation to stop infections while accepting healing through natural skin regeneration (secondary intention). The practice of dressing as a non-aggressive conservative management method maintains its place as a fundamental component of care because it provides effective treatment to surgical contradiction patients.

The patient's outcome results improved because of early surgery according to recurrent observations in the reported study data. When surgery happens immediately after the injury it leads to lower complications while advancing healing time because prompt decisive medical care proves essential. A typical hospital stay lasted between 14 and 16 days demonstrating the excellent execution of surgical treatments and post-treatment procedures. This average period demonstrates both the quick success rates of hospital treatments along with well-functioning care recovery procedures that help reduce hospitalization burden for patients alongside healthcare systems. The identification through demographic analysis showed that most injuries took place among young males who belonged to the age bracket of 11 to 30 years. The observed demographic pattern reveals that a higher number of individuals now face the risks linked to bike riding and motorbike operation. Such findings require both specific preventive safety attempts which educate high-risk populations about safety practices and advocate protective equipment and protocols which shorten recovery duration for younger active treatment patients. The successful outcomes coupled with new findings regarding wheel spoke injury administration lead to multiple areas for prospective research. Continuous research tracking RSAF and skin graft quality should examine their long-term sustainability and detect potential late conditions including flap failure and persistent discomfort in patients. Additional research should compare RSAF treatment results with other reconstructive procedures to create better clinical choice protocols for healthcare professionals. The study of innovative materials and techniques which include both biologics and tissue-engineered products shows promise to improve the treatment outcomes for soft tissue defects.

CONCLUSION

The reverse sural artery flap (RSAF) represents an effective approach to treat serious heel defects resulting from wheel spokes. Every patient achieves weight-bearing capacity in a six-month timeframe while using the reverse sural artery flap which offers permanent coverage along with low complication rates. The procedure proves to be safe since it prevents osteomyelitis and flap necrosis from occuring. The reverse sural artery flap serves as a practical treatment method for serious injuries because of its usefulness in resource-constrained environments. Preventive strategies preserve essential importance for decreasing such injury-related burdens.

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