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Reverse Sural Flap for Soft-Tissue Defects in the Dorsal Foot and Anteromedial Ankle after Trauma

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Abstract: Background: *Tight skin and inadequate blood flow are characteristics of the distal third of the leg and ankle. Reconstructive surgeons frequently face difficulties due to soft tissue loss in these regions. The thinness of the subcutaneous tissue often exposes the bones and tendon. Skin grafts, local flaps, distant flaps, and free flaps are all viable reconstructive alternatives, but their application is restricted and fraught with issues.**Objectives:**This study was done toevaluate the outcomeof reverse sural flap for soft-tissue defects in the dorsal foot and anteromedial ankle after trauma.**Methods:**The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of42patients of both sexes were included in the study. Data was collected over a period of 12 months and analyzed by appropriate computer based programmed software Statistical Package for the Social Sciences (SPSS), version 24.**Results:**In this study, the highest number of patients 17 (40.5%) were observed in the 3rd decade followed by11 (26.2%) in the2nd decade of life. The remaining 4th, 5th, 6th and 7th decade consists of 4 (9.5%) cases each. The mean age was 34.13 ± 14.27 years, ranging from 11 to 69 years.More than half of the patient 35 (83.30%) were male and 7 (26.70%) patients were female.More than half of the 28 patients (66.70%) were non-smoker and 14 (43.30%) patients were smoker.Only 4 (9.50%) had comorbidities which was type II Diabetes Mellitus. The rest 38 (90.50%) were free from any other systemic diseases.Among the 42 cases, in 23 (54.8%) cases, the soft tissue loss was over the distal 3rdof leg. 17 (40.5%) were around the ankle and the rest 2 (4.8%) was over the tendoachillis.Motor vehicle accidents (MVA) accounted for 33 (78.6%) cases which was the most common cause of injury. Other causes of injury were fall from height 5(11.9%), toilet commode injury 2 (4.8%) and machinery injury 2 (4.8%) in descending order.Most of the primary wound size was between 20 cm2 to 30 cm2 which was in 21(50.0%) cases. In 10 (23.8%) cases, it was <20 cm2 and the rest11 (26.2%) cases, the wound size were ≥30 cm2. The mean wound size was 23.85±10.13 cm2, ranging from 8.75 cm2 to 54 cm2.In 10 (23.8%) cases, the flap size was <30 cm2. In most cases, 24 (57.1%), the flap size was in between 30 cm2 to 45 cm2. The mean flap size was 41.75±14.17 cm2, ranging from 18 cm2 to 78.75 cm2.About 13 (30.9%) cases were operated within 3 - 6, 17 (40.5%) cases were operated within 7-10 and 12 (28.6%) cases were operated within 11-14 days each. The average injury to operation time was 9.95 ±3.13 days ranging from 3 days to 14 days.Out of 42 cases, in 32 (76.2%) cases the flap has survived completely. Marginal necrosis, partial necrosis and subtotal necrosis occurred in 4 (9.5%), 2 (4.7%) and 2 (4.7%) cases respectively. Complete flap loss has occurred in only 2 (4.7%) cases.Complication occurred in 12 (28.6%) cases. Among them, 7 (16.7%) were wound infections. In 3 (7.4%) cases, there was mild hematoma. Venous congestion occurred in 2 (4.7%) cases.**Conclusion:**The sural island flap, which covers soft tissue defects in the distal third of the leg and around the ankle, demonstrated good survival with few complications in the current study.It was shown that smoking increased the likelihood of*

*flap loss. An adverse flap result was significantly correlated with diabetes mellitus.****Key words:****Reverse sural flap, soft tissue defect,Dorsal Foot, Anteromedial ankle.*

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I. Introduction:

Tight skin and inadequate blood flow are characteristics of the distal third of the leg and the area surrounding the ankle. Reconstructive surgeons find it difficult to deal with soft tissue loss in certain regions.The thinness of subcutaneous tissues often exposes tendon, bone, or metal. The reverse suralflap is one of the better solutions for covering these areas, despite the fact that there aren't many reconstructive possibilities.

One of the most difficult yet frequent procedures is still lower limb and foot reconstruction. Using cutaneous flaps to repair wounds is notoriously difficult when the lower limb subdermal plexus is unreliable [1]. The ideal choice for covering such abnormalities is a long-lasting flap with good skin texture, dependable vascularity, a good arc of rotation, ease of dissection, and minimal donor site morbidity[2, 3].

Skin grafts, local flaps, distant flaps, and free flaps are only a few of the numerous reconstructive techniques available; nonetheless, their use is restricted, and issues arise in these areas. The exposed bone, tendon, malleoli, heel, and weight-bearing regions cannot be covered with skin grafts [4].

The drawback of locoregional flaps for lower leg and ankle abnormalities, such as anterior and posterior tibial artery flaps and peroneal artery flaps, is that they sacrifice a major artery in a limb that is already wounded [5]. Another approach is a supramalleolar flap, however challenge its dependability in cases of vascular impairment [6]. Local flaps are contraindicated in cases of peripheral vascular thromboses, diabetes, and absence of peripheral pulses [7].

Large soft tissue lesions of the distal extremities are now best treated using free flaps, which also address the issue of donor site morbidity in the flap's immediate vicinity. However, for surgeons with less microsurgical skill, it is a technically challenging surgery. Furthermore, the reversesural artery flap may be one of the few safe options for soft tissue coverage in a small number of trauma cases with damaged or two occluded main vessels, where a free flap may be potentially dangerous [8]. Cross-leg flaps do not introduce any new vascularization and are not well tolerated.Their assessment of the region with inadequate local vascularity may be highly ambiguous [9].

According to Hasegawa et al. (1994), Jeng & Wei (1997), Almeida et al. (2002), and Le Fourn et al. (2001), the distally-based or "reverse" sural fasciocutaneous flap offers dependable coverage for the lower leg and the area surrounding the ankle. This sturdy flap has a low failure rate and maintains the leg's primary blood supply [10, 11, 12, 13]. Donski and Fogdestam originally presented the flap in 1983, and Masquelet gave a thorough anatomical explanation of it in 1992 [14, 15].

The distally based sural fasciocutaneous flap has become a standard procedure in lower limb reconstruction following the work of Masquelet[12, 15]. The vascularity and range of motion of the reverse sural flap are both adaptable. Its 180° rotational arc ensures that the proximal and distal heels are adequately covered without causing the vascular pedicle to kink.

Internal fixation hardware, tendons, bones, and exposed arteries can all be covered with the flap. Research has demonstrated that it is a more dependable and superior option to the lateralsupramalleolar flap. According to Hseih et al. (2005) and Cavadas &Bonanand (1996), varicose leg veins and blockage of the anterior and posterior tibial arteries are not definite contraindications to the use of a distally based suture flap [8,16]. However, an obstructed peroneal artery is regarded as contraindicated[17].

Recent research has described isolated adipofascial and sensate flaps, as well as changes to the perforator and propeller styles [18, 19, 20, 21]. The sural flap is still evolving.These changes could make this adaptable and affordable reconstructive method more useful for high-risk populations.

II. Methodology:

The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of 42 subjects of both sexes were included in the study.Purposive sampling was done according to the availability of the patients who fulfilled the selection criteria.Face to face interview was done to collect data with a semi-structured questionnaire. After collection, the data were checked and cleaned, followed by editing, compiling, coding, and categorizing according to the objectives and variables to detect errors and to maintain consistency, relevancy and quality control. Statistical evaluation of the results used to be obtained via the use of a window-based computer software program devised with Statistical Packages for Social Sciences (SPSS-24).

III. Result:

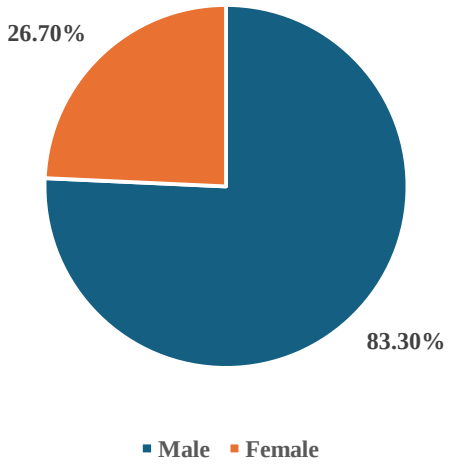
Table I: Distribution of the patients according to age (n = 42)

Table I shows that, the highest number ofpatients 17 (40.5%) were observed in the 3rd decade followed by11 (26.2%) in the2nd decade of life. The remaining 4th, 5th, 6th and 7th decade consists of 4 (9.5%) caseseach. The mean age was 34.13±14.27 years, ranging from 11 to 69 years.

Age group	Frequency	%
10–20 years	11	26.2
21 - 30 years	17	40.5
31 - 40 years	4	9.5
41 - 50 years	4	9.5
51 - 60 years	4	9.5
>60 years	4	9.5
Total	**42**	**100.0**
Mean ± SD: 34.13±14.27 years		

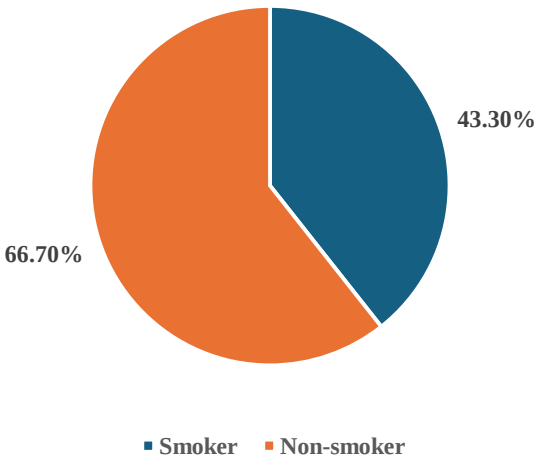
Figure I: Distribution of the patients according to sex (n=42)

FigureIshows that, more than half of the patient35 (83.30%) were male and 7 (26.70%) patients were female.



FigureII: Distribution of the patients according to smoking habit (n=42)

FigureII shows that, more than half of the patient28 (66.70%) were non-smoker and 14 (43.30%) patients were smoker.



FigureIII: Distribution of the patients according to comorbidities (n=42)

FigureIII shows that,only 4 (9.50%) had comorbidities which was type II DiabetesMellitus. The rest 38 (90.50%) were free from any other systemic diseases.

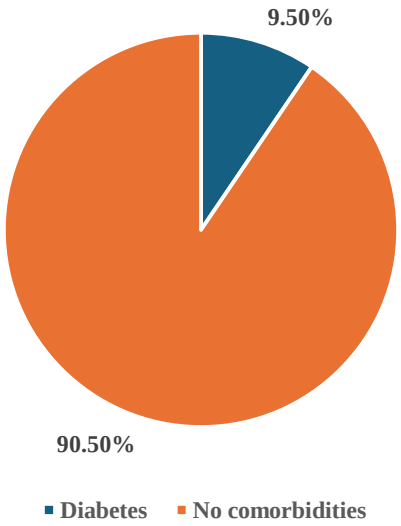


Table II: Distribution of the patients according to Site of Injury (n = 42)

Table IIshows that,Among the 42 cases, in 23 (54.8%) cases, the soft tissue loss was over the distal 3rdof leg. 17 (40.5%) were around the ankle and the rest 2 (4.8%) was over the tendoachillis.

Site of Injury	Frequency	%
Distal 3rd of leg	23	54.8
Around ankle	17	40.5
Over Tendoachillis	2	4.8
Total	**42**	**100.0**

Table III: Distribution of the patients according to Cause of Injury(n=42)

TableIII shows that, motor vehicle accident (MVA) accounted for 33 (78.6%) cases which was the most common cause of injury. Other causes of injury were fall from height 5(11.9%), toilet commode injury 2 (4.8%) and machinery injury 2 (4.8%) indescending order.

Cause of Injury	Frequency	%
Motor Vehicle Accident	33	78.6
Fall From Heig	5	11.9
Toilet Commode Injury	2	4.8
Machinary injury	2	4.8
Total	**42**	**100.0**

Table IV: Distribution of the patients according to primary wound size (n = 42)

Table IVshows that,most of the primary wound size was in between 20 cm2 to 30 cm2 which was in 21(50.0%) cases. In 10 (23.8%) cases, it was <20 cm2 and the rest11 (26.2%) cases,thewound size were ≥30 cm2. The mean wound size was 23.85±10.13 cm2, rangingfrom 8.75 cm2 to 54 cm2.

Primary wound size	Frequency	%
<20 cm^2	10	23.8
20-30 cm^2	21	50.0
>30 cm^2	11	26.2
Total	**42**	**100.0**

Table V: Distribution of the patients according toflap size (n = 42)

Table V shows that,in 10 (23.8%) cases, the flap size was <30 cm2. In most of the cases, 24 (57.1%), theflap size was in between 30 cm2 to 45 cm2. The mean flap size was 41.75±14.17 cm2,ranging from 18 cm2 to 78.75 cm2.

Flap size	Frequency	%
<30 cm^2	10	23.8
30-45 cm^2	24	57.1
>45 cm^2	8	19.0
Total	**42**	**100.0**

Table VI:Distribution of the patients according to Injury toOperation time(n=42)

TableVI shows that, 13 (30.9%) cases were operated within 3-6, 17 (40.5%) cases were operated within 7-10 and 12 (28.6%) cases were operated within 11-14days each. The average injury to operation time was 9.95 ±3.13 days ranging from 3days to 14 days.

Injury toOperation time	Frequency	%
3-6	13	30.9
7-10	17	40.5
11-14	12	28.6
Total	**42**	**100.0**

Table VII:Distribution of the patients according to flap outcome(n=42)

TableVII shows that, out of 42 cases, in 32 (76.2%) cases the flap has survived completely. Marginal necrosis,partial necrosis and subtotal necrosis occurred in 4 (9.5%), 2 (4.7%) and 2 (4.7%) cases respectively. Complete flap loss has occurred in only 2 (4.7%) cases.

Flap outcome	Frequency	%
Completely survived	32	76.2
Marginal Necrosis	4	9.5
Partial Necrosis	2	4.7
Subtotal necrosis	2	4.7
Complete Flap Loss	2	4.7
Total	**42**	**100.0**

Table VIII:Distribution of the patients according to complications (n=12)

TableVIII shows that, complication occurred in 12 (28.6%) cases. Among them, 7 (16.7%) werewound infections. In 3 (7.4%) cases, there was mild hematoma. Venous congestion occurred in 2 (4.7%) cases.

Complications	Frequency	%
Wound Infection	7	16.7
Hematoma	3	7.4
Venous Congestion	2	4.7
Total	12	28.6

IV. Discussion:

For trauma surgeons, reconstructing abnormalities on the ankle, malleoli, and lower third of the leg is still a challenging task. Soft tissue, underlying bone, and ligamentous structures can all be affected by trauma and other deforming processes. Additionally, there is inadequate circulation and tight skin over this area. There are linear regions of heightened perfusion along the major artery route, according to research on the vascularity

of the leg. This anatomical feature made it possible to identify prospective flap donor locations and demonstrate perforators arising from each underlying artery [22].

The cross-sectional Observational study was conducted in the Department of Orthopedic, National Institute of Traumatology and Orthopedic Rehabilitation (NITOR) from June 2022 to May 2023. A total of 42 subjects of both sexes were included in the study.

In this study, the highest number of patients 17 (40.5%) were observed in the 3rd decade followed by11 (26.2%) in the2nd decade of life. The remaining 4th, 5th, 6th and 7th decade consists of 4 (9.5%) cases each. The mean age was 34.13 ± 14.27 years, ranging from 11 to 69 years. The most active decades of life who work outside aremore susceptible to trauma requiring soft tissue coverage. This picture is clearlyevident from the study age group. Study conducted by Rios-Luna, et al., (2007),showed an average age was 38 which was similar to this study [23]. But in the serises ofAhmed, et al., (2008) and Akhtar & Hameed, (2006) the average age was 59 and 47respectively. The difference can be explained by that, in this series, patient withperipheral vascular disease and uncontrolled DM was excluded [3, 17].

More than half of the patient 35 (83.30%) were male and 7 (26.70%) patients were female. Study conducted by Mileto, etal., (2007) showed a male female ratio of 3:1 [24] and Ajmal, et al., (2009) observed amale predominance where male 21 (81%) & Female 5 (19%) [25]. In all the series, male representation is the majority because of more outdoor physical activity.

In this study, Motor vehicle accident (MVA) accounted for 33 (78.6%) cases which was the most common cause of injury. Other causes of injury were fall from height 5(11.9%), toilet commode injury 2 (4.8%) and machinery injury 2 (4.8%) in descending order. In the series of Ajmal, et al., (2009), road traffic accident was thecause of soft tissue defect in 19 (76%) patients; other trauma (including earthquakeand falls) in 4 (16%), and electric and bomb blast injury in 1 (4%) patient each [25]. Thecause of soft tissue diffect was different from the studies of Chen, et al., (2006) orIsenberg, (2000) because they included venous ulcer and diabetic ulcer in their studieswhich was excluded from the present study [26, 27].

Among the 42 cases, in 23 (54.8%) cases, the soft tissue loss was over the distal 3rdof leg. 17 (40.5%) were around the ankle and the rest 2 (4.8%) was over the tendoachillis.As the lesion in distal 3rd of leg did not cover ankle joints, it did not affectankle joint movement. In the series of Ahmed, et al., (2008), The defect site includednon weight bearing heel in four (40%), tendo achilles in two (20%), distal tibia in two(20%), lateral malleolus in one (10%) and medial aspect of the midfoot in one patient(10%). Theses results are quite similar to the present study [3].

Most of the primary wound size was in between 20 cm2 to 30 cm2 which was in 21(50.0%) cases. In 10 (23.8%) cases, it was <20 cm2 and the rest11 (26.2%) cases ,the wound size were ≥30 cm2. The mean wound size was 23.85±10.13 cm2, ranging from 8.75 cm2 to 54 cm2. In 10 (23.8%) cases, the flap size was <30 cm2. In most of the cases, 24 (57.1%), the flap size was in between 30 cm2 to 45 cm2. The mean flap size was 41.75±14.17 cm2, ranging from 18 cm2 to 78.75 cm2. In the series of Ajmal, et al., (2009), thedimensions of the flap ranged from 6–12 cm in length and from 4–8 cm in width. Themean length was 8.4 cm and mean width 5.7 cm with an average flap size of 47.88cm2 [25]. In their series, Rios-Luna, et al., (2007) had taken an average flap size of 25 cm2.The significance between flap size and flap outcome was calculated by extended chisquare test with yate's correction. The calculated p value was <0.05 which wassignificant. The higher the flap size, the lower the chance of flap survivability [23].

In this study, More than half of the patient 28 (66.70%) were non-smoker and 14 (43.30%) patients were smoker. In their series, Parret, et al., (2009), identified smoking as a risk factor mostindependently associated with any reverse sural flap complication. Rios-Luna, et al.,(2007) also identified cigerrette smoking as an associated factor for flap failure. Themicro angiopathies caused by smoking are resposible for these adverse outcome [23].

Only 4 (9.50%) had comorbidities which was type II Diabetes Mellitus. The rest 38 (90.50%) were free from any other systemic diseases. In allcases of diabetic patient, the flaps were not completely survived. The p value wascalculated by Fisher's exact t test and found <0.05 which was significant. Severalstudies like Kneser, et al., (2005), Almeida, et al., (2002) and Rajacic, et al., (1996)showed that showed that Diabetes Mellitus independently can affect flap outcome [12, 28, 29].Parret, et al., (2009) showed prevalence of major and minor complications werehigher in diabetic patients [30]. Kneser, et al., (2005) also suggested that, a delayprocedure in diabetic patients could improve flap suvivality [28].

In this study, About 13 (30.9%) cases were operated within 3 - 6, 17 (40.5%) cases were operated within 7-10 and 12 (28.6%) cases were operated within 11-14 days each. The average injury to operation time was 9.95 ±3.13 days ranging from 3 days to 14 days. In the series of Akhtar & Hameed, (2006), they suggested early coverage of softtissue defect. The cause of delay in most of cases was infection of the recepient site [17].

Out of 42 cases, in 32 (76.2%) cases the flap has survived completely. Marginal necrosis, partial necrosis and subtotal necrosis occurred in 4 (9.5%), 2 (4.7%) and 2 (4.7%) cases respectively. Complete flap loss has occurred in only 2 (4.7%) cases. In the series of Kalam, et al., (2005), completeflapsurvival was seen in

26 cases out of 30 [31]. In the series of Mileto, et al., (2007) flapsurvivability was seen in 88% cases [24]. These results are quite similar with the presentstudy. In their series, Park, et al., (2013) successfully did 39 cases of sural flap. Out ofthem 4 (10.25%) were necrosed partially and 3(7.69%) were necrosed marginally [32].

Complication occurred in 12 (28.6%) cases. Among them, 7 (16.7%) were wound infections. In 3 (7.4%) cases, there was mild hematoma. Venous congestion occurred in 2 (4.7%) cases. In the series of Kalam, et al.,(2005), only one out of 30 patient developed an infection, which was controlled withantibiotics and daily dressing later required a small skin graft. Marginal necrosis wasseen among 3 cases. In the series of Park, et al., (2013), haematoma and infectionoccurred in only 1 (2.56%) cases each. In this series, there was a higher rate ofinfection [32].

V. Conclusion:

In general, the reverse sural flap procedure is easy to use and secure. The procedure can be completed quickly without affecting the leg's major vessels' ability to pump blood. The flap reconstructions were carried out in a busy orthopaedic facility with the best possible conditions and sufficient medical equipment. When tissue loss affects the distal portion of the leg and ankle, a reverse sural flap is a great choice. It was better than other flaps because of its adaptability and consistent, dependable vascularity.

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