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ORIGINAL ARTICLE

A STUDY OF LOWER EXTREMITY RECONSTRUCTION

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ABSTRACT: BACKGROUND: The reconstruction of the lower extremity poses a great challenge because of the complexity of the injuries. Road traffic accidents are the most common cause of mortality and morbidity in patients. High speed traffic accidents result in a variety of associated life-threatening injuries. Lower extremity poses problems of wound healing and also the lack of suitable donor local flaps. The development of Microsurgical techniques in the past 25 years has changed the whole spectrum of reconstruction of the lower limbs. **AIMS AND OBJECTIVES:** The aim of this study is to evaluate the use of various flaps in the lower extremity reconstruction in a tertiary care center. The main objective is to study the process of rehabilitation with main focus on early return to normal activities following the reconstructive procedures. **SETTINGS AND DESIGN**: Seventy three patients between the ages 17 to 65 years (mean age-36.43) with an injury period of up to 4 weeks were included in the study. For the 73 patients, 74 flaps were used. Patients with collagen disorder, liver disease. HIV positive patients and patients with history peripheral vascular diseases were excluded from the study. **METHODS AND MATERIAL:** This study was conducted in a tertiary teaching hospital over a period of two years from July 2012 to July 2014.Flap surgery was done in 73 patients with a total of 74 flaps. Defects of various regions of the lower extremity were selected for the study. A variety of reconstructive options are available for the lower extremity. This study includes patients from my private practice also. **OBSERVATION AND RESULT**: The flap surgery was successful in a variety of indications like trauma, infected chronic wounds, tumor excision and bone infections. There was a total failure of reverse sural artery flap in one patient. There was a partial necrosis of small area of the tip of the flaps in two patients with transposition fasciocutaneous flaps which healed by secondary intention in two weeks period. Venous congestion in two patients subsided on its own in 3 days. Three patients had minor infection problems which were treated with appropriate antibiotics. Two patients had partial skin loss in the donor areas which required secondary skin grafting procedures. **CONCLUSION:** Despite the fact free flaps are used more in the recent times, other flaps are still effective in the treatment of lower limb defects. Cross leg flap, a staged procedure was also used in our series for very large defects with good results. Muscle flaps and free flap were associated with fast recovery of patients and with minimal infection and non- union complications. Early skin cover gives the best results and the patients returned to normal activities earlier. Patients with fractures in whom flaps were done early along with bone graft procedures were ambulant early without problems of non-union. Patients who had muscle flaps for fractures and infective problems showed early wound healing. Most of the patients accepted the appearance of the flaps and a. very little percentage of patients returned back for secondary procedures of dog ear correction and thinning of the flaps.

KEYWORDS: Leg surgery, Surgical flaps/method Treatment outcome, Soft tissue injuries/ surgery, Reconstructive surgical procedures/ methods, Rehabilitation, Surgical flaps, Foot injuries.

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1. INTRODUCTION: Lower extremity reconstruction is indicated in a variety of conditions like management of chronic wounds, defects due to trauma, following tumor resection and chronic disease process. Trauma is the commonest indication for reconstruction. They occur as an isolated injury or in association with other life threatening injuries. The principles of trauma care are followed and life threatening injuries take priority in the management of the patients. Multidisciplinary approach by a team of trauma surgeon, vascular surgeon, orthopedic surgeon and plastic surgeon must evaluate the patient.[1,2] The purpose of this article is to assess the effectiveness of flap surgery and to analyze the pattern of rehabilitation of the patients.

1.1 The following protocols are followed in trauma Patients:

- Clinical assessment.
- Treatment of shock.
- Surgical debridement.
- Bone stabilization.
- Vascular reconstruction.
- Nerve repair.
- Skin cover.

Gustilo Grade	Definition
I	Open fracture, clean wound, wound <1 cm in length
II	Open fracture, wound > 1 cm but < 10 cm in length without extensive soft-tissue damage, flaps, avulsions
III	Open fracture with extensive soft-tissue laceration (>10 cm), damage, or loss or an open segmental fracture. This type also includes open fractures caused by farm injuries, fractures requiring vascular repair, or fractures that have been open for 8 hr prior to treatment
IIIA	Type III fracture with adequate periosteal coverage of the fracture bone despite the extensive soft- tissue laceration or damage
IIIB	Type III fracture with extensive soft-tissue loss and periosteal stripping and bone damage. Usually associated with massive contamination. Will often need further soft-tissue coverage procedure (i.e. free or rotational flap)
IIIC	Type III fracture associated with an arterial injury requiring repair, irrespective of degree of soft-tissue injury.

Table 1: Open Fractures- Gustilo classification

Gustilov classification[3,4,5] along with the Mangled Extremity Severity Score (MESS) and Limb Salvage Index (LSI) are used as predictors of prognosis in the patients with lower extremity injuries.

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1. 2 Aims of lower extremity Reconstruction:

- Complete coverage of the defects.
- Heal any raw areas present.
- Early ambulation of the patient.
- Rehabilitation and early return to job.
- Prevent amputation.

1.3 Lower extremity defects can be the result of the Following:

- Trauma.
- Tumor resection.
- Peripheral vascular disease.
- Diabetes mellitus.

2. MATERIALS AND METHODS: The study was conducted for a period of two years from July 2012 and July 2014 in a tertiary care center. The defects of the lower extremities were included in the study. Reconstructions with skin grafts were excluded from the study. Patients with major vascular injuries and patients with electrical burn injuries were also excluded from the study from the study. Clinical assessment in relation to the fractures was based on Gustilov classification. Post-operative assessment was based on viability of the flap, the matching of the flap with the recipient site and donor site morbidity**.** The sites of soft tissue defect included over the thigh, knee region, upper, middle and lower thirds of the leg, dorsum of foot, non-weight bearing, non-weight bearing heel and the sole. The etiology of the defects was trauma, infection and tumor excision. The procedures followed were in accordance with the ethical standards laid down by the Institution.

2.1 Surgical Anatomy: The lower extremity consists of the thigh segment and the more complex leg and foot segments. The thigh is the source for multiple and large donor tissues. The vascularity is predictable and is the source of free tissue flaps. The leg consists of tibia and fibula connected by the interosseus membrane. The anterior compartment is divided into anterior and lateral compartments by an intermuscular fascia. The anterior compartment has 4 muscles: the extensor digitorum longus, extensor hallucis longus, peroneus tertius and tibialis anterior. The muscles are supplied by the anterior tibial vessels and innervated by deep peroneal nerve. The lateral compartment has peroneus brevis and longus. They are supplied by peroneal artery and innervated by the superficial peroneal nerve. The posterior compartment has superficial compartment containing gastrocnemius, soleus and plantaris muscles. The gastrocnemius and soleus form the tendo Achilles and inserted into calcaneal bone. They are supplied by popliteal artery and innervated by the tibial nerve. The deep compartment has the popliteus, flexor digitorum longus, flexor hallucis longus and tibialis posterior. The blood supply is by posterior tibial and peroneal vessels. The tibial nerve is the nerve of the compartment.

2.2 Reconstructive Ladder: Reconstruction is based mainly on the principles of reconstructive ladder. The principle is to start the reconstruction from a simpler procedure to more complex and technically demanding procedures

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Free tissue transfer
Distant, regional flap
Local flap
Tissue expansion
Skin grafting
Direct wound closure
Secondary intention healing

Table 2: The reconstructive ladder

Primary closure of the wounds in the lower limb may not be possible due to paucity of tissues and also due to exposure of the underlying bones especially in the leg. Small areas of exposed bone may be treated conservatively with dressings or vacuum assisted wound closure system. The advantages are they are simple to follow and there is no need for further surgical procedures especially in patients who cannot undergo complex reconstructions.

The main disadvantages are they may take weeks to heal and cosmetically may not be acceptable. Patients with loss of segment of bone need to be treated with non-vascularized cancellous bone graft or by Illizarov's bone lengthening procedures when the bone gap is less than 5 cm. Large bone defects are indication for vascularized bone graft. For bone gaps more than 6cm fibula free flaps are the treatment of choice. Patients with nerve defects have very poor results. The loss of posterior tibial nerve with loss of sensation of the plantar aspect of the foot is a relative contraindication for lower extremity salvage. Local and regional flaps are the main stay in soft tissue cover of the defects.[6]

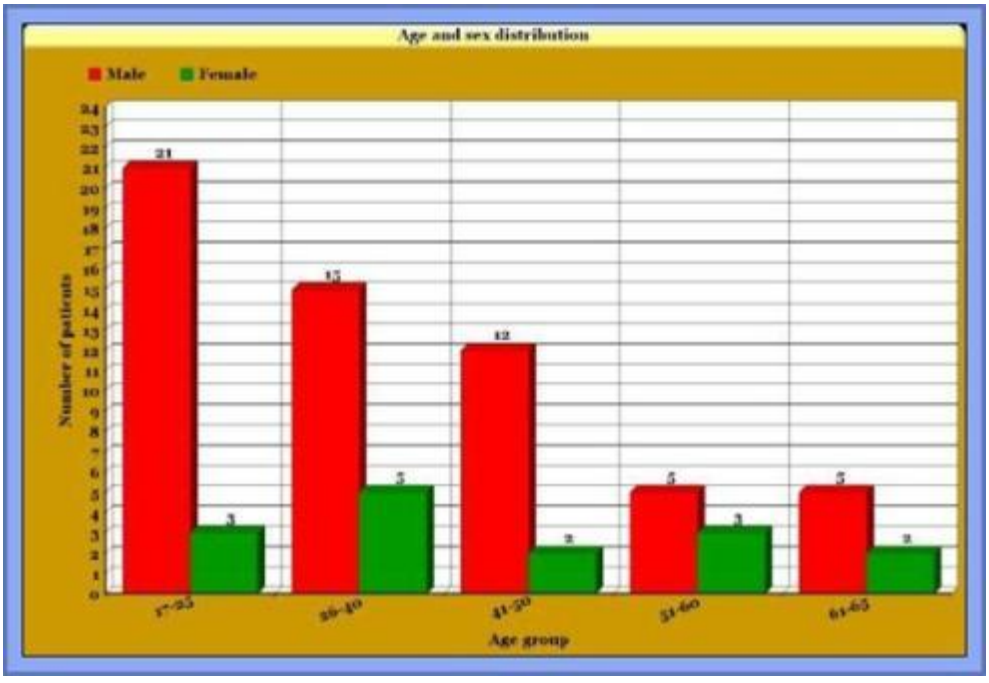

Fig. 1: Age and sex distribution

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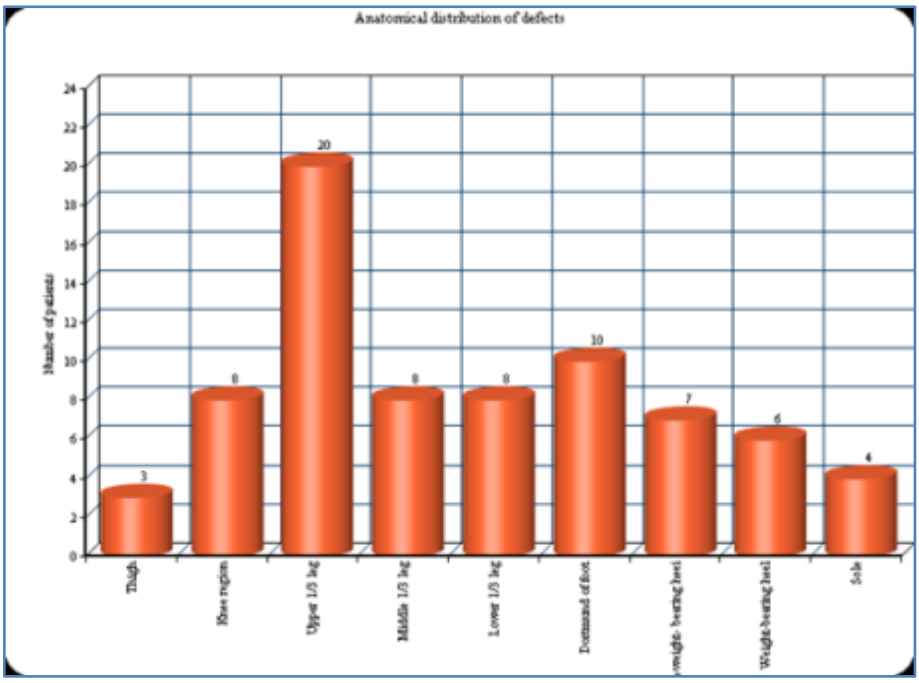

Fig. 2: Anatomical location of the defects

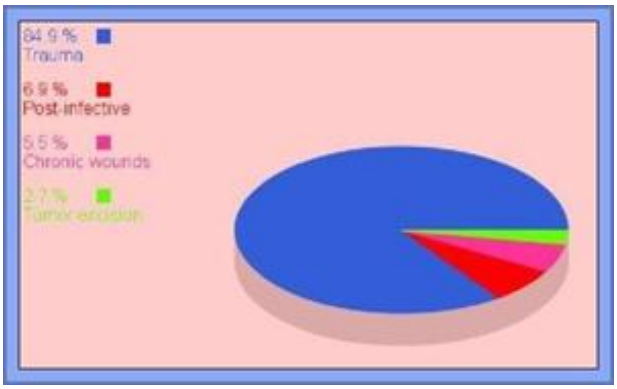

Fig. 3: Etiology of the defects

2.3 Surgical Procedure: All the patients underwent a routine surgical workup, including surgical profile, chest X-ray, and electrocardiograph and pre anesthetic evaluation. All the patients were treated and followed by the same team of surgeons. The flaps for the patient were decided based on the following factors:

- Type of injury.
- Energy involved.
- Tissues damaged/lost.
- Size of the defect.
- Age and the job of the patient.
- Duration of the wound.

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The patients requiring orthopedic procedures were referred to the orthopedic department and followed after their procedure is completed and coordination between the two departments was assured for management of the patient.

Local flaps	Doppler able perforator close to the base of the flap
For pedicle flaps	Dominant branch to the flap should be present
For free flaps	Adequate sized artery and vein should be present.

Table 3: Assessment of the blood flow is based on the following criteria before the flap surgery

After satisfying all the standardizing criteria patients were taken up for surgery.

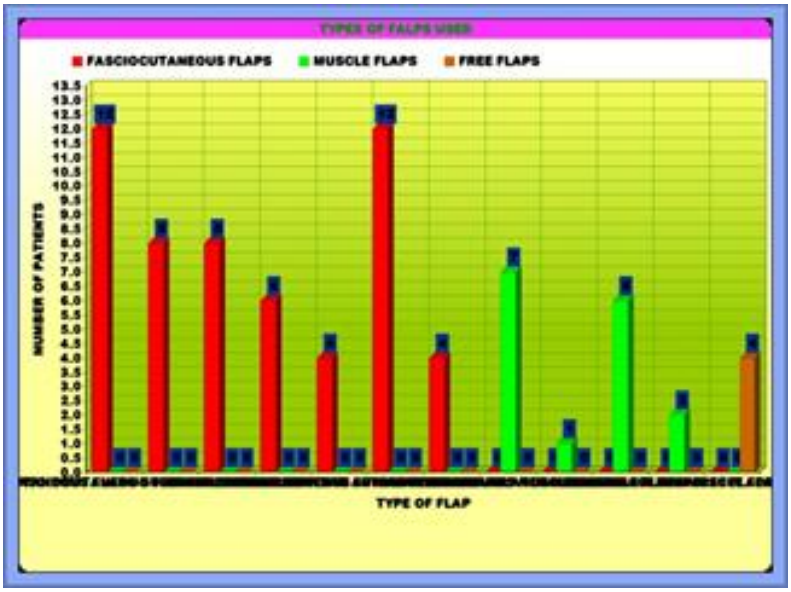

Fig. 4: Name of flaps used

Fig. 5: The defect in the knee region covered with Gastocnemius muscle flap and skin graft

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Fig. 6: Defect in the knee region and the middle third of the leg covered with Gastrocnemius flap and a bi-pedicled flap

Fig. 7: Pedicled anterolateral thigh flap cover

Fig. 8: Bipedicled flap cover for exposed bone

Fig. 9: Cross leg flap cover to an extensive defect of the dorsum of foot extending to the medial malleolar region

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Fig. 10: Fasciocutaneous flap cover

Fig. 11: Propeller flap cover

Fig. 12: Medial plantar artery flap cover

In the series reverse sural artery flap was the most commonly used for different anatomical locations of the distal third of the leg, malleolar region and heel defects.

Fig. 13: Reverse sural artery flap cover to the malleolar defect

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Fig. 14: reverse sural flap cover to the defect of the dorsum of foot

Fig. 15: Reverse sural artery flap cover to weight-bearing heel defect

Fig. 16: Reverse sural flap cover to a chronic infected area on the non-weight-bearing heel

One patient had an associated tendo Achilles tendon injury with skin loss.In this patient the tendon repair was done and an immediate flap cover was given.

Fig. 17: Tendo achilles tendon injury with skin loss covered with a fasciocutaneous flap cover

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We used four free flaps in the series with hundred percent success rate. The single staged procedure was effective in early wound healing and rehabilitation of the patients.

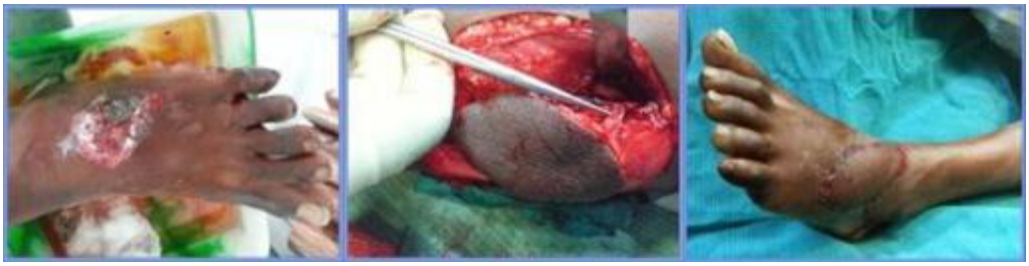

Fig. 18: Lateral arm free flap cover to the defect on the dorsum of foot

The majority of the flaps used in this series was fasciocutaneous flaps. They were technically easy to perform and anesthesia time was also short and they were performed mostly under regional anesthesia. The different tissue types of flaps used in the series can be summarized as follows.

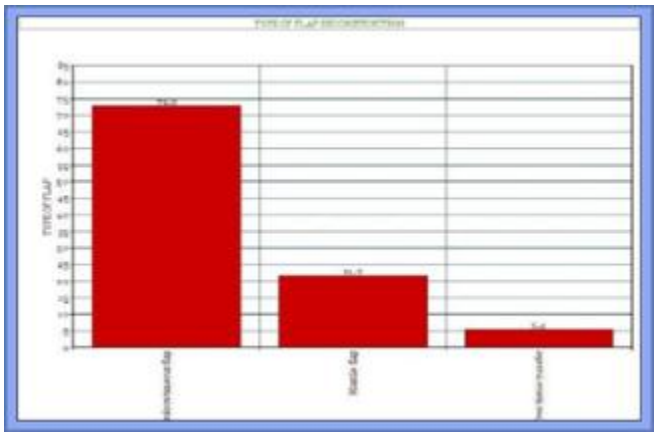

Fig. 19: Tissue type of flaps used in this series

The flaps were monitored in the postoperative period. No Pharmacological products were used in the initial or in the immediate post-operative period. Every effort was taken for good surgical technique, good mobilization of the tissues with tension-free suturing of the flaps. Whenever a problem of the viability of the flap was noticed simple steps like removal of tense sutures and avoiding of the pressure and correct positioning was attempted.

2.4 Post-operative assessment Criteria:

1. Viability of the flaps.
    - Venous congestion.
    - Flap loss.
    - Suture line dehiscence.
2. Matching of the flap to the recipient area.
3. Donor site morbidity.
4. Wound infection.
5. Development of osteomyelitis after flap cover.
6. Need for secondary procedure like skin grafting.

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2.5 RESULTS: Patients were evaluated post-operatively in terms of viability of the flap, matching of the flap with the recipient site and donor site morbidity. There was total loss of reverse sural artery flap in an elderly uncooperative patient due to kinking and pressure on the vascular pedicle. The necrotic flap was excised, treated with vacuum assisted closure and secondary skin graft was done.

Two patients had necrosis of the tip of inferiorly based fasciocutaneous transposition flaps probably due to increase tension at the suture line. The flaps were salvaged by timely intervention by removal of a few stitches and the resultant raw area was small and healed by secondary intention. Venous congestion in two patients subsided on its own within 3 days. Three patients with minor infection problems were treated with change of antibiotics as per the culture and sensitivity report. There was partial loss of skin graft to flap donor area in two patients which required a split thickness skin grafting to heal the raw areas.

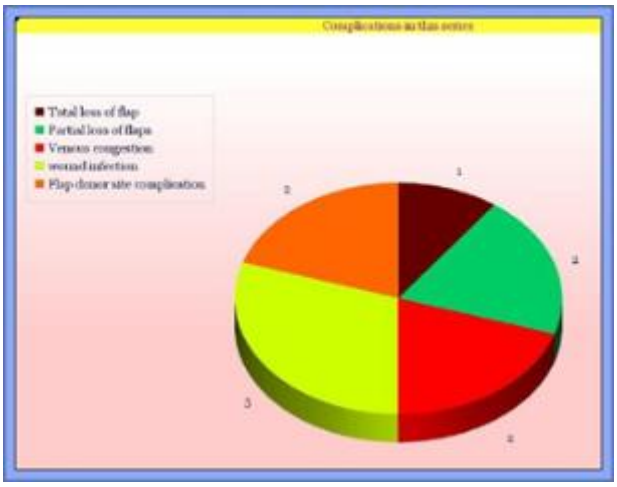

Fig. 20: Complications in this series

The timing of the reconstruction since the injury is most critical to early return to normal activities. Delayed reconstruction leads to prolonged period of rehabilitation

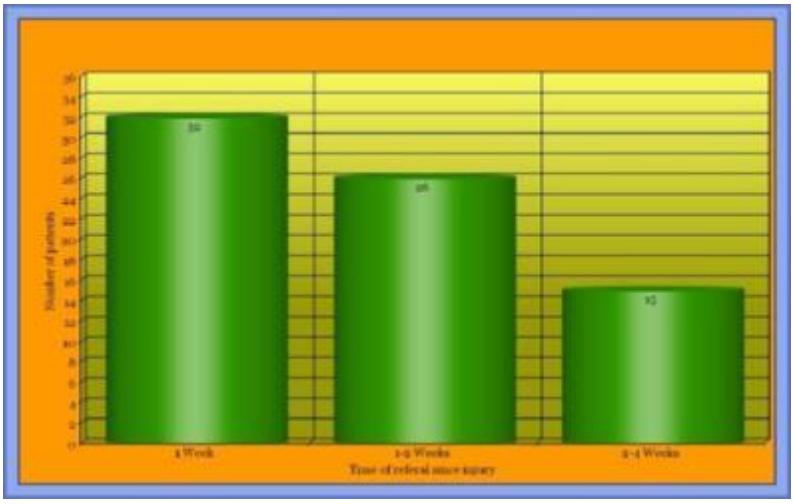

Fig. 21: Time interval between injury and referral for Skin cover

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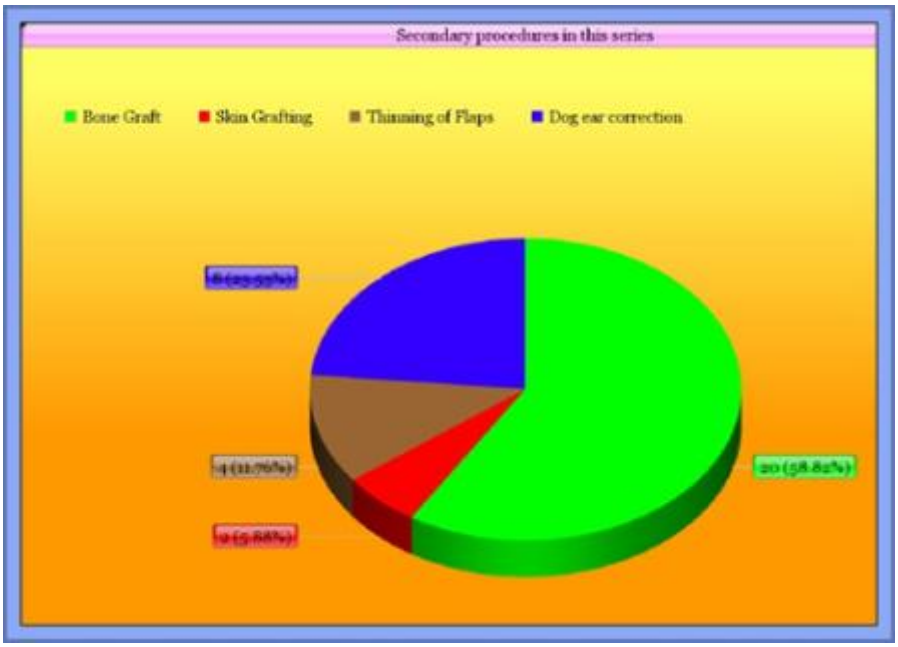

Fig. 22: Secondary procedures done in this series

III. DISCUSSION: In this series there was total loss of one reverse sural artery flap. The patient was an elderly uncooperative male patient. The reason for loss was probably due to compression of the flap by faulty position in the postoperative period. The patient was treated with VAC system and then a split thickness graft was applied. There was partial loss at the tips of inferiorly based fasciocutaneous flaps in two patients. The raw area was small and healed with secondary intention without the exposure of the underlying bone.

Venous congestion was seen in two patients in our series. Wound infection was seen in three patients. These three patients were from the group of patients referred 3 weeks following the injury. There were no problems with the flaps but the wound healing was delayed. Donor area infection was noticed in two patients. Donor site skin loss was noted in two patients who were treated with reverse sural artery flap cover. These two patients needed split thickness skin grafts. This is mainly due to the shearing of the skin graft in the lying posture of the patient. The following facts were observed in the series. The defects covered early within one week behaved well and settled without any complications. Immediate repair of tendo Achilles tendon along with immediate skin cover healed well and the patient was ambulant after the period of prescribed immobilization.

The patient with multiple discharging sinuses from previous Tendo Achilles repair was replaced with a reversed sural artery flap cover. The flap settled well but the patient had partial graft loss of the donor area and with infection. Appropriate antibiotic was administered and the wound healed within 14 days' time. Iliac bone grafting was done in 20 patients. In this group of 20 patients 6 patients had segmental loss of bone and they were on external fixators.[7,8] Bone grafting and flap cover was done in the early post-injury period for these 6 patients.[9] Patients who had flap cover early were ambulant much earlier than who had flap cover late. The patients who had muscle flap cover improved earlier and did not develop infection and non-union complications.[10]

Long term follow up of patients with fractures who were treated initially with fasciocutaneous flaps showed development of osteomyelitis at 6 months follow up in six patients and were treated with bone grafts.[11] There was an appreciable result in free flap surgery group which provided a single stage procedure with less infection and non-union complications. Selection of correct type of flap for the particular patient, proper planning of the flap with good mobilization of tissues to avoid tension at the suture line and proper post-operative immobilization is the gold standard in the survival of flaps.[12] This analysis showed early soft tissue cover is the most important step in the early rehabilitation of the patient.

IV. CONCLUSION: Our series proved results with free flap reconstruction was much superior in terms of reduced number of stages, wound healing, reduced hospital stay and less infection complications. Composite tissue reconstruction can be done in one stage using free tissue transfer. The fasciocutaneous flaps done immediately following the injury proved equally effective in early wound healing. Delayed reconstruction was seen to be associated with more complications like wound infection and osteomyelitis with non-union. Young patients with reconstruction for trauma showed good results compared to elderly patients with associated medical conditions. Patient with chronic infected wounds who underwent reconstruction showed signs of delayed healing. Muscle flaps in patients with associated fractures, infected and chronic wounds proved superior to fasciocutaneous flaps in terms of early rehabilitation. In conclusion, early reconstruction with ideal patient and flap selection, treatment of associated medical conditions will help in early rehabilitation of the patients. Early ambulation of the patient and return to their jobs is the ultimate goal of reconstruction of patients with lower extremity injury. This study confirms the versatility of the conventional flaps in lower extremity reconstruction which can be performed successfully even in centers where micro vascular facility is not available.

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