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Evaluation of the gastrocnemius muscle flap for coverage of upper third leg defect

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Abstract
Covering complex lower limb wounds is a major challenge. The medial gastrocnemius muscle flap is usually indicated for reconstruction of loss of substance of the knee and proximal third of the leg. The objective of this study was to evaluate the results using gastrocnemius muscle flaps in lower limb wounds. A total of 25 patients with loss of substance in the lower limbs were treated with gastrocnemius muscle flaps. Data were obtained from clinical records of patients who underwent surgery from January 2016 to December 2016. In 25 patients (20 male and 5 female) with the mean age of 34.13 years (14 to 65). The etiology of the lesions was a road traffic accident accident in all cases leading to soft tissue loss with exposed tibia. In all 25 patients, adequate coverage was provided by gastrocnemius muscle flap. The medial Gastrocnemius Muscle flap was done in 21 patients, and the lateral Gastrocnemius Muscle flap was done in 4 patients. The maximum width of the defect in our series was 10 cm, and the maximum length of the defect was 18 cms. Minor complications were noted in 6 patients but they all settled with conservative management. No case of muscle flap necrosis was found. The period of hospitalization was 15 - 20 days. The follow-up period for earlier operated patients is more than two years. Transfer of a gastrocnemius muscle flap is a simple and safe procedure in the treatment of lower limb injuries. The application of the gastrocnemius muscle flap was demonstrated in different situations, with satisfactory results and easy reproducibility.
The present study was planned in the Department of Plastic Surgery, Pulse Emergency Hospital, Patna, Bihar. Total 25 cases operated from Jan 2016 to Dec 2016 were included in the present study. The cases of large post-traumatic defect in upper third of leg were treated with gastrocnemius Muscle flap in department of plastic surgery. All cases were initially treated with debridement and, in some cases, fixation of fractured bone with external fixator.
The data generated from the present study concludes that fewer complications would result with careful preoperative evaluation and surgical planning, adequate debridement of bone and soft tissue and the transfer of healthy, non-traumatized muscle. When these basic surgical tenets are not violated, gastrocnemius muscle provides the best form of coverage for the defects located over upper one third of tibia and knee joint.

Keywords: gastrocnemius muscle flap, upper third leg defect, plastic surgery

Introduction
Leg and tibia bone are common sites that need reconstruction repair because of soft tissue defects. The subcutaneous location of the tibia and anatomic location of the leg, which are easily exposed to trauma, cause tibia fractures - becoming the most common fractures of long bones and the most common site for open fractures of long bones. Also, poor blood flow of this region easily allows complications after open fractures and surgical operations [1-2]. Overall, soft tissue defects are common and it is difficult to manage complications in this region.
The early history of the lower extremity reconstruction dates back to the Hippocrates (460-370BC). Since then, until the First World War, amputation was the best option for saving the lives of the patients [3]. Sushruta Sumhita (600BC) was the first person who used the cheek flap for nasal reconstruction [4]. However, the new era of the flap reconstruction commenced during the First World War. Although in that time Stark was the first person who used muscle flap to cover lower extremity due to osteomyelitis. The first report of the lower extremity reconstruction by muscle flap was done by Ger [4]. Gastrocnemius muscle has also been used to cover the exposed implant of tibia and knee prosthesis [5, 6]. Early coverage of the complicated wound of the tibia by the gastrocnemius muscle flap can prevent major complications [7, 8]. Based on the Mathes and Nahai classification [9] for vascular pedicle, gastrocnemius muscle flap is classified as type one and it has one vascular pedicle. The gastrocnemius muscle flap is often used to cover soft tissue defects of the knee and the upper third of the leg. Its major benefits include minimal donor morbidity, easy harvest and reliability [10].
The gastrocnemius flaps are one of the most versatile and useful flaps in lower extremity reconstruction [11]. Conventionally, they can be harvested as the proximally based medial gastrocnemius muscle or musculocutaneous flaps, proximally based lateral gastrocnemius muscle or musculocutaneous flaps for coverage of the knee and upper third tibia defects [12]. They can also be harvested as distally based flaps based on branches of posterior tibial artery for lower third limb reconstruction [13, 14]. Flaps based on the perforators of the gastrocnemius muscle like the medial sural artery perforator flaps very commonly and the lateral sural artery perforator flaps rarely are gaining popularity in the recent days because of their thinness, and their ability to be used as pedicled or free flaps [15, 16].
Hence the present study was planned to evaluate the Gastrocnemius Muscle Flap for coverage of upper 3rd leg defect.

Methodology

This prospective study was undertaken on 25 patients (20 male and 5 female) with the mean age of 34.13 years (14 to 65). This group consisted of all of the patients referred to Department of Plastic Surgery, Pulse Emergency Hospital, Patna, Bihar with leg soft tissue defects between Jan 2016 and Dec 2016. Total 25 cases operated from Jan 2016 to Dec 2016 were included in the present study. After fully explaining to the patients about the possible options of soft tissue coverage, they were operated on. Those patients whose soft tissue defects could have been repaired by other ways such as skin graft or skin flap were excluded from this study. The cause of soft tissue defect in all patients was a Road traffic accident [Table 1]. Initially, in all of the patients the tibia fracture was fixed with an intramedullary nail, external fixator, or plate and screws. In case of soft tissue defect, first debridement was performed several times and finally after the wound was ready the flap was designed and performed. Patients usually required further debridement and preparation of wound. Swab culture of wound was done in all cases and any overt infection was treated. We used gastrocnemius flaps in soft tissue defects in the proximal third of the leg. Medial gastrocnemius was used in 21 cases and lateral gastrocnemius in 4 cases. In no case both heads of gastrocnemius were required.

All our patients subjected to routine laboratory investigations such as complete blood picture, liver profile, kidney function test, prothrombin time and activity, international normalized ratio, fasting blood sugar, and hepatitis markers. Radiography of the injured limb to rule out underlying fracture and osteomyelitis.

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion criteria

Cases of large post-traumatic defect in upper third of leg were treated with gastrocnemius muscle flap; Patients age ranged from 14 to 65 year.

Exclusion criteria

Patients having associated injuries that required multidisciplinary treatment.

Table 1: Preoperative data of the studied patients

Preoperative	No. of Cases
Etiology	
Trauma due to RTA	18
Osteomyelitis	4
Exposed prosthesis	3
Site	
Upper third of the tibia	18
upper third of tibia with upper portion of middle third	7
Associated fractures	
Present	16
Absent	9

[RTA=Road Traffic Accidents]

Operative procedure

All patients were operated under tourniquet. Thorough debridement was done to ensure complete removal of necrotic tissues and osteomyelitic bone (fig. 1 (b). Defect was assessed for the adequacy of muscle coverage. For medial gastrocnemius, incision was given 2-3 cm behind the medial border of tibia avoiding the great saphenous vein extending from the poplitial fossa to below mid-calf level. Incision was deepened to deep fascia and medial head of gastrocnemius was identified and separated from underlying soleus muscle. Distal end of the muscle was sharply divided from the achilles tendon taking care to include some portion of tendinous material with the muscle belly as this improved suture holding. It was then divided and separated from lateral gastrocnemius at the midline raphe. Care should be taken to avoid injury to sural nerve and short saphenous vein (Fig. 3 (b).

Muscle was then transposed anteriorly to cover the defect (fig. 1(d). We never felt the need to detach the muscle from its origin to improve the arc of rotation. We usually remove the investing fascia and perimysium of the muscle as this improves expansion and more uniform contouring of the muscle can be done. The skin graft take up is also facilitated. Primary skin grafting of muscle was done in all cases (fig. 1 (e).

Results

The Gastocnemius Muscle flap was executed successfully in all the 25 cases over a period of one year from January 2016 to December 2016. The follow up ranged from 3 weeks to two years. In all 25 patients, adequate coverage was provided by gastrocnemius muscle flap. The medial Gastrocnemius Muscle flap was done in 21 patients, and the lateral Gastrocnemius muscle flap was done in 4 patients. The maximum width of the defect in our series was 10 cm, and the maximum length of the defect was 18 cms. Minor complications were noted in 6 patients but they all settled with conservative management, [Table 2]. No case of muscle flap necrosis was found. The period of hospitalization was 15 - 20 days. The follow-up period for earlier operated patients is more than two years. During this period, stable wound coverage was provided by the muscle flap. In patients with compound fracture, satisfactory bony union was found on serial skiagrams.

All muscle flaps showed some decrease in the bulk after about three months of transfer. In 19 patients, excellent result was found with no evidence of complication, six patients had minor complications (infection 3, haematoma 1 and partial graft loss in 2[Table 2]) that increased the period of hospitalization but settled with conservative management. All patients were satisfied with the long-term result of surgery. Donor site morbidity was not a problem with gastrocnemius muscle flap.

Table 2: Postoperative complications among the studied patients

Complications	No. of Cases
Early	
Wound infection	3
Hematoma	1
Partial Graft loss	2
None	19

Figure 1. (Case 1) Medial Gasrocnemius Flap

Fig 1(a): skin and bone defect in the upper anterior tibia

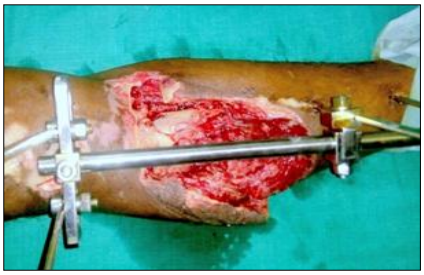

Fig 1(b): Debridement and recreation of the defect

Fig 1(c): Medial belly raised and denervated. Flap in setting done.

Fig 1(d): The medial incision is closed over a large drain.

Fig 1(e): The muscle and raw area is covered with a split thickness skin graft

Fig 1(f): 10th Post-Operative day

Figure 2. (Case 2) Medial Gasrocnemius Flap

Fig. 2 (a): Skin and bone defect in the upper anterior tibia

Fig 2(b): Debridement and recreation of defect

Fig 2(c): Medial belly raised and denervated

Fig 2(d): Flap in setting done and the medial incision is closed over a large drain

Fig 2(e): The muscle and raw area is then covered with a split thickness skin graft

Fig 2(f): 12th Post-Operative day

Figure 3. (Case 3) Medial Gasrocnemius Flap

Fig 3(a): Skin and bone defect in the upper anterior tibia

Fig 3(b): Medial belly raised and denervated

Fig 3(c): Flap insetting done and the medial incision is closed over a large drain

Fig 3(d): 15th Post Operative day

Figure 4. (Case 4) Medial Gasrocnemius Flap

Fig 4(a): Skin and bone defect in the upper anterior tibia (after debridemrnt)

Fig 4(b): Medial belly raised and denervated

Fig 4(c): The medial incision is closed over a large drain and the muscle covered with a split thickness skin graft.

Fig 4(d): 12th Post-Operative day

Figure 5. (Case 5) Medial Gasrocnemius Flap

Fig 5(a): a skin and bone defect in the upper anterior tibia

Fig 5(b): Medial belly raised and denervated and applied over defect through subcutaneous tunnel

Fig 5(c): Flap insetting done. The medial incision is closed over a large drain

Figure 6. (Case 6) Lateral Gastrocnemius Flap

Fig 6(a): a skin and bone defect in the upper anterior tibia

Fig 6(b): Debridement and recreation of the defect

Fig 6(c): Lateral belly raised and denervated

Fig 6(d): Flap insetting done

Discussion

Management of compound fractures of tibia Gustilo type III, with involvement of the knee joint, present a difficult problem to orthopedic and plastic surgeons. Reconstructive procedure is frequently required to cover the exposed bones or joints to obliterate the dead space and help eradicate infection [4].

Early cover has been found to reduce the incidence of complications [17]. The gastrocnemius muscle flap is the workhorse of all muscle flaps for soft tissue coverage around the knee [18]. The gastrocnemius muscle flap, described by Ger [4] as a muscle flap, is used in cases of exposed defects of the proximal tibia [19]. The lateral gastrocnemius muscle flap plasty was first described by Barford and Pers [20] and the medial gastrocnemius muscle flap plasty was first described by Ger [4]. The localisation of the damage dictates which muscle belly should be used. The medial head is often longer and wider than the lateral head which is why it is usually used. For the dermal closure of the implanted muscle flap, split-skin (MESH-graft) with a thickness of 0.3 to 0.5 mm should be used. The muscular aponeurosis and parts of the fascia of the muscle should be removed, so that it can heal well.The advantages of the flap are the presence of a constant, safe, and reliable vascular pedicle, with satisfactory width and length of the muscle. In addition, the optimal arc of rotation of the muscle and its plasticity allows closure without tension, and the coverage of injuries in most cases [21, 22]. The medial gastrocnemius muscle is characterized by being biarticular, comprising part of the structure of the triceps surae, along with the soleus and the lateral head of the gastrocnemius. Its function is to perform plantar flexion of the ankle, besides contributing to the circulation of the posterior cutaneous territory of the leg through at least 2 perforating vessels [23]. The resection of only one belly of the gastrocnemius does not impair plantar flexion and does not cause major deformity [24]. The easy dissection has a rapid learning curve. The medial head of the gastrocnemius muscle has an average length of 20 cm

(range: 19 to 23 cm) and a width of 6.5 cm (range: 4.5 to 9 cm), which allows a wide arc of rotation and good coverage of exposed bone of the leg and knee. The vascular pedicle has an average length of 4.5 cm, and the average area of a medial gastrocnemius flap is 32.5 cm^2 (range: 22.3 to 47.5 cm^2) [22, 23].

The lateral head of the muscle, compared with the medial, is used more rarely in reconstructive surgery [25]. The reasons for its restricted use are the size, the limited arc of rotation, and the potential risk of peroneal nerve palsy of the muscle, which might be caused by the surgical procedure itself [26]. The medial head of the gastrocnemius muscle, which is the part most often used, meets all requirements needed for a successful wound coverage [27]. This study was conducted to focus on the versatility of the superiorly based gastrocnemius muscle flap, either medial or lateral head, in upper-leg defects after trauma; no intraoperative mortality was recorded, with a mean operative time of about 2 h and a blood loss of about 540 ± 115 ml. Throughout the first 2-week follow-up period; there was no flap loss apart from partial skin loss, minor hematomas, or infections. There are disadvantages associated with the application of the gastrconemius flap, such as deformation of the donor area, [28] but this study revealed that no major complications occurred in the donor areas apart from wound infection, which was controlled with appropriate antibiotic treatment. The advantages of the gastrocnemius flap favor its use as this surgical technique is relatively easy to perform and requires lesser time than free tissue transfers. Furthermore, the gastrocnemius flap provides better tissue coverage and greater stability to the knee joint. Regarding bone healing in cases of traumatic tibial fracture the results were nearly similar that is rapid healing of the fracture occurred in all cases within 2 weeks after surgeryas compared with the healing in the preoperative period. This was monitored by a serial radiography, and overall wound healing was good. Regarding the functional outcome, no disability was recorded, with complete functions of the lower limb and minimal effect on the bulk of the cuff. This finding is supported by the study conducted by Liu *et al.* [29], who studied 65 patients who underwent resection of proximal tibial osteosarcoma and reconstruction of the bone defect by prosthesis: 35 cases underwent medial gastrconemius muscle flap transposition to reconstruct the soft tissues and, with a significantly higher functional outcome. Liu *et al*. [29] first explained that this good bone healing occurred because myogenic progenitors of the MyoD lineage contribute to bone repair, giving new perspectives for the treatment of fracture nonunion through the optimization of myogenic progenitor proliferation, migration, and differentiation. This eventually helps ensure a good safety margin in malignant tumor cases and helps bone healing in trauma cases. Also, Park *et al*. [30] used an extended medial gastrconemius muscle flap including a tendinous portion of the Achilles and a saphenous neurocutaneous flap for coverage in a patient who had multiple fractures with open comminuted patellar fractures that were initially managed, These findings are also supported by numerous other studies conducted to isolate progenitor cells from muscles for the purpose of bone tissue engineering; these approaches often utilize ex-vivo gene therapy approaches, where the forced expression of osteogenic bone morphogenetic proteins in cultured myoblasts can lead to new bone formation after their subsequent implantation into experimental animals [31]. Hence, muscle flaps in bone fractures not only bring blood supply, but also give the fracture myokines and progenitor cells, which differentiate into osteocytes; this fact supports the concept that muscles act as a 'secondary periosteum', which is able to contribute osteoprogenitors when the periosteum itself is damaged [32].

Conclusion

The data generated from the present study concludes that fewer complications would result with careful preoperative evaluation and surgical planning, adequate debridement of bone and soft tissue and the transfer of healthy, non-traumatized muscle. When these basic surgical tenets are not violated, gastrocnemius muscle provides the best form of coverage for the defects located over upper 1/3 of tibia and knee joint.

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