Reconstruction of Complete Knee Extensor Mechanism Loss with Gastrocnemius Flaps

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Abstract We assessed the outcome after reconstruction of traumatic, complete, infected, extensor mechanism loss attributable to high-velocity open knee injuries in eight consecutive patients (all males) who presented to us between February 2005 and September 2007 at an average followup of 24 months. All were treated with gastrocnemius flaps. The loss in extensor mechanism was the patellar tendon in five patients, patella and patellar tendon in two patients, and combined patella, quadriceps, and patellar tendon in one patient. The size of the defect ranged from 8×5 cm to 15×15 cm. The patients were evaluated for functional outcome of the knee, resolution of infection, range of flexion of the knee, and return to work. Four

patients had an excellent outcome whereas the others had a good outcome using the Hospital for Special Surgery knee rating scale. All flaps healed primarily with resolution of infection. The average knee flexion was 110° . All patients except two returned to their original occupation. Three patients had an extensor lag of 5° . The gastrocnemius flap is a good option for open knee injuries with extensor mechanism loss, giving consistent results across a wide spectrum of presentation.

Level of Evidence: Level IV, case series. See the Guidelines for Authors for a complete description of levels of evidence.

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Introduction

High-velocity open knee injuries present a challenge for the orthopaedic surgeon and often involve distal femur and proximal tibia fractures. When these injuries are attributable to direct trauma to the knee, multifragmentary patellar fractures and disruption of the extensor mechanism of the knee can occur.

It has been shown that the frequency and severity of open injuries in developing countries are different from those in developed countries [8]. In developing countries, motorcycle accidents are common, with victims often not wearing thick protective clothing, exposing the knee to severe contamination. In addition, patients often present late without adequate primary care. The presence of infection adds to the complexity of treatment, often requiring repeated and extensive débridement before reconstruction.

Options for reconstruction of the extensor mechanism of the knee include the gastrocnemius flap, free latissimus dorsi flap, free rectus femoris flap, semitendinosus, and

allografts [4, 5, 7, 11, 13]. The advantages of the gastrocnemius flap are its local availability and reliability. Although allografts are an option, in the presence of infection and soft tissue loss, they are not ideal. The other option is knee arthrodesis with sacrifice of all movement.

The gastrocnemius flap has been used extensively for anterior knee cover and in reconstruction of extensor mechanism loss after tumor surgery and arthroplasty [2, 3, 10, 12]. However, the usefulness of this technique in infected traumatic extensor mechanism defects has not been reported often [1, 7]. We used the gastrocnemius because of our experience with its reliability for coverage of the knee and proximal tibia.

The aims of this study were to assess functional outcome of the knee, resolution of infection, range of motion of the knee, and return to work, at least 1 year after injury, following reconstruction of extensor mechanism loss after open knee injuries with gastrocnemius muscle flaps.

Materials and Methods

This was a cross-sectional study of eight consecutive patients treated between February 2005 and September 2007 in Units 1 and 3 of the Department of Orthopaedics, Christian Medical College, Vellore, Tamil Nadu, India, who fulfilled our criteria for traumatic complete loss of extensor mechanism. All were treated with gastrocnemius muscle flaps, either one or both, depending on the extent of the defect. They then were followed up for at least a year and their outcomes were evaluated. Complete loss of extensor mechanism of the knee was defined as loss of patellar tendon and/or patella along with loss of medial and lateral retinaculum, which was not amenable to direct repair. Patients who had open knee injuries with incomplete loss of extensor mechanism and those with loss after tumor surgery and arthroplasty were excluded.

The prerequisites for performing the extensor mechanism reconstruction were the ability to reconstruct the skeletal injury resulting in painless knee motion and the presence of healthy posterior skin. The contraindication for performing this procedure would be damaged gastrocnemius and extensive intraarticular bone loss. All the flaps were performed by two surgeons (TSJ, PRJVCB).

The average age of the patients was 32 years (range, 13–47 years) and all were male. All patients had sustained high-velocity injuries with multiple skeletal injuries and intraarticular fractures of the knee. In addition, two patients had multiorgan injuries. Four patients (Patients 3–6) presented to us primarily and the others presented late (Fig. 1). Even the patients who presented primarily to us had débridement more than 12 hours after injury and had gross contamination at presentation. All but one (Patient 6) had

Fig. 1 The infected wound of Patient 1 is shown before débridement.

positive bacterial cultures from the interior of the wound at the time of the second débridement (Table 1).

The loss in extensor mechanism was the patellar tendon in five patients, patella and patellar tendon in two patients, and combined patella, quadriceps, and patellar tendon in one patient. The size of the defect after débridement ranged from 8×5 cm to 15×15 cm (Fig. 2). Extensor mechanism reconstruction (Fig. 3) was performed at an average of 24 days (range, 2–60) after injury. The average followup was 24 months (range, 12–46 months).

In performing the surgical technique, the gastrocnemius flaps were raised through a posterior midline incision. The small saphenous vein and the sural nerve served as markers to identify the median raphe. The gastrocnemius with its aponeurosis was dissected from distal to proximal with 1 cm of tendon. Dissection was continued proximally until the vascular pedicle was reached at the popliteal crease. In three patients, the flap was denervated. If more length was required, the origin of the gastrocnemius at the posterior part of the femoral condyle was partially or completely disinserted. Where the lateral gastrocnemius was used, the common peroneal nerve was mobilized to allow rotation of the muscle belly without compression of the nerve. The fascia on the undersurface of the intervening skin bridge was incised to make sure the flap was not compressed. After the muscle belly was transferred anteriorly, it was made to lie obliquely across the defect as performed by Babu et al. [1]. The tough aponeurosis was sutured to both sides of the defect in the extensor mechanism. The tendon served to anchor the flap in healthy soft tissue. Suturing of the tendon was performed with the knee in extension. Where the soft tissue defect was extensive, both gastrocnemii were used. In one patient (Patient 2) with loss of the tibial tubercle after débridement, the flap was anchored to the surrounding periosteum and fascia for the distal attachment. This patient also required limb lengthening with a ring fixator to regain length of the leg. The suture material used to anchor the tendinous part of the flap was Number 1 Vicryl™ (Ethicon, Inc, Somerville, NJ), using simple sutures. Where the muscle also had to be sutured,

Table 1. Patients' details

Patient	Age (years)	Mode of injury	Skeletal injuries	Organisms isolated	Defect size (cm)
1	25	Skid and fall from motorcycle	Type IIIB right patella fracture, right distal femur lateral condyle fracture, right proximal tibia comminuted fracture, right fifth metatarsal shaft fracture	<i>Pseudomonas aeruginosa</i> , <i>Escherichia coli</i>	15 × 10
2	47	Traveling on a motorcycle and collided with a bus	Type IIIB right proximal tibia, left proximal tibia fracture, left ring finger proximal phalanx fracture	Methicillin-resistant <i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterobacter-R</i> , <i>Escherichia coli-R</i> , <i>Enterococcus-R</i> , <i>Klebsiella</i> species	10 × 10
3	29	Traveling on a motorcycle and collided with a truck	Type IIIB right proximal tibia fracture, right humerus shaft fracture	<i>Enterobacter</i> species-R, nonfermenting gram-negative bacilli	15 × 15
4	46	Traveling on a motorcycle and collided with a car	Right clavicle fracture with upper plexus injury, right distal radius intra articular fracture, right intertrochanteric fracture, Type IIIA distal third femur fracture, comminuted right patella fracture.	Methicillin-resistant <i>Staphylococcus aureus</i>	10 × 8
5	32	Fell into a dry well	Bilateral trochanteric fracture, bilateral Type IIIB femur shaft fracture, bilateral open patella fracture	<i>Escherichia coli-R</i>	15 × 10
6	13	Run over by bus while traveling on a bicycle	Type IIIB left femur fracture with open knee	Not done	8 × 8
7	41	Fell from a height	Infected left proximal tibia with lateral buttress plate, right foot multiple metatarsal fractures	<i>Klebsiella</i> species-R, methicillin-resistant <i>Staphylococcus aureus</i>	8 × 5
8	23	Traveling on a motorcycle and collided with a truck	Type IIIA left humerus fracture with C5 brachial plexus injury, open left comminuted patella fracture, splenic laceration, left kidney laceration, perforation of splenic flexure	Methicillin-resistant <i>Staphylococcus aureus</i>	15 × 8

Fig. 2 A photograph taken after débridement shows a deficient extensor mechanism.

2/0 Vicryl™ was used as simple sutures. The muscle then was covered with a split skin graft.

The postoperative protocol was knee immobilization for 6 weeks in full extension. During this period, static quadriceps

Fig. 3 The reconstructed extensor mechanism with both gastrocnemii is shown.

and active straight leg raise were encouraged. After this period, along with knee mobilization, quadriceps and gastrosoleus strengthening exercises were taught. Weight-bearing was dictated by the associated skeletal injuries.

Functional evaluation using the Hospital for Special Surgery (HSS) knee rating scale was performed by one investigator (PRJVCB). This scale assessed pain, function, range of motion, quadriceps muscle strength, flexion deformity, and instability with deductions for crutch use, extensor lag, and deformity. A score greater than 85 was considered excellent and 70 to 84 considered good [6]. The patients were evaluated clinically for resolution of infection periodically and at final followup. Undue pain, persistent discharge, fever, and failure of flap settling were used as guides to persisting infection. Range of motion was measured with a goniometer and return to work was recorded.

Results

Four patients had excellent outcomes and four others had good outcomes using the HSS knee rating scale. All patients

had good or excellent quadriceps strength (Fig. 4A). No patient required a walking aid for community ambulation.

All patients had resolution of infection. All flaps healed primarily within 10 days with no recurrence of infection thereafter.

Table 2. Results and flap used

Patient	Time from injury to reconstruction (days)	Gastrocnemius used	Followup (months)	Range of motion (°)	HSS score
1	9	Both	46	0–100, lag 5	84
2	33	Both	30	0–110, lag 5	84
3	4	Both	24	0–110	88
4	60	Medial	22	0–140	95
5	22	Medial	20	0–100	90
6	2	Medial	20	0–60	79
7	30	Lateral	18	0–140, lag 5	84
8	30	Medial	12	0–110	89

HSS = Hospital for Special Surgery knee rating scale.

Fig. 4A–B Clinical photographs taken 46 months after trauma show (A) active extension and (B) flexion.

Fig. 5 A clinical photograph of Patient 6 taken 20 months after trauma shows the patient standing on tiptoe.

All patients except one had satisfactory knee flexion (Fig. 4B), with an average of 110°, whereas three patients had a mild extensor lag (Table 2). No patient had a flexion deformity.

All patients returned to their preinjury occupation except two who had brachial plexus injuries.

All patients could walk an unlimited distance on level ground. One patient with harvest of both gastrocnemii had difficulty walking on uneven ground, owing to ligamentous instability, for which he uses a hinged knee brace. The patient (Patient 6) with restricted knee flexion had difficulty climbing stairs. Patients who had both gastrocnemii harvested had difficulty standing unassisted on the affected limb on tiptoes. No other patients had significant donor site morbidity (Fig. 5).

Discussion

We assessed the treatment of patients with complete extensor mechanism loss after high-velocity open knee injuries. These injuries require tissue to bridge the gap and a flap for cover. All the patients in our series were treated with gastrocnemius muscle flaps, which were used to bridge the gap and as cover. The efficacy of this procedure was assessed at a minimum followup of 1 year for functional outcome, resolution of infection, range of motion, and return to work.

The main limitation of our study was the small number of patients available. The skeletal injuries were different in each patient and all patients did not present immediately for treatment. We also do not know the long-term outcome of the knees in these patients as they all had articular injuries. Another limitation of the study was that the assessment was done by one of the surgeons who had performed some of the flaps.

Literature is scarce regarding the use of the gastrocnemius in extensor mechanism reconstruction after trauma. Babu et al. [1] used the medial gastrocnemius flap in reconstruction in two patients, one of whom had a chronic isolated injury and the other had an acute isolated injury. These patients with isolated injuries had excellent results. Leung et al. [7] performed four reconstructions, two using the medial gastrocnemius, one using the lateral gastrocnemius, and one using both gastrocnemii. Their patients had more severe trauma than those of Babu et al., although the injuries were isolated to the ipsilateral limb. Our study included patients with life-threatening injuries, all of whom presented with infection and contamination, with some presenting late. Three of our patients also had reconstruction using both gastrocnemii. In the series by Leung et al. [7], two of four patients required crutches to

walk on level ground and the outcome probably depended on knee stability. Our study assessed, in detail, functional outcome of this reconstruction method for traumatic injuries. Rhomberg et al. [9] described folding the aponeurosis to increase the strength of reconstruction. We followed the technique described by Babu et al. [1], which seemed to be adequate. The paucity of literature regarding extensor mechanism loss after trauma may indicate this problem is underreported or such patients are treated with arthrodesis.

The ability of the intraarticular injury to be reconstructed, resulting in adequate stability, dictates outcome. Patients with extensive intraarticular bone loss with infection would be candidates for fusion. As all our patients had intraarticular injuries, they may require TKA in the future. Theoretically, it should be possible to elevate the flap and perform the arthroplasty.

All our patients had injuries requiring multiple procedures to combat infection and provide skeletal stabilization and functional knee cover. A dedicated team was able to perform all the above procedures, eliminating problems of cooperation and coordination of different teams, especially as the timing of the flap was important. The gastrocnemius muscle flap was hardy in the scenario of infection and strong enough to be a replacement for the extensor mechanism with an added advantage of minimal donor site morbidity in nonathletic patients.

The gastrocnemius flap is a good option for open knee injuries with extensor mechanism loss, giving consistent results across a wide spectrum of presentation.

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