Fibulectomy for Primary Proximal Fibular Bone Tumors
A Functional and Clinical Outcome in 46 Patients

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Abstract

Background: Primary benign and malignant tumors of the proximal fibula are not very common. Upper fibula being an expendable bone; the majority of the primary bone tumors at this site are usually treated with *en bloc* proximal fibulectomy. There is scarce literature on functional results, difficulties faced during dissection when to preserve or sacrifice common peroneal nerve and importance of lateral collateral ligament repair after proximal fibulectomy. The present study attempts at assessing these variables. **Materials and Methods:** This retrospective study included 46 patients; 30 males and 16 females with age ranging from 12 to 44 years (average: 26 years) operated between 2003 and 2014. There were 34 benign and 12 malignant tumors. All were treated with proximal *en bloc* fibulectomy as indicated and decided by the operating surgeon keeping in view its extent on magnetic resonance imaging. Peroneal nerve sacrifice or preservation was decided as per the type (benign/malignant), its involvement by the tumor and the extent of the tumor. In 14 (for 12 malignant and two benign giant cell tumors [GCTs]) patients, the peroneal nerve required resection for the margins. Partial upper tibial resection was performed in cases of malignant tumors and three GCTs. The followup ranged between 24 and 120 months (median: 48 months). **Results:** Patients with peroneal nerve resection had inferior functional outcome than those without peroneal nerve resection. There was no higher risk of tibia fracture in patients with partial tibial resection. Lateral collateral reconstruction yielded better results and should be performed in all cases. Functional outcome was significantly better in patients with benign tumors than in patients with malignant tumors as these required neither resection of the peroneal nerve nor large amount of muscle excision. The functional results were evaluated using Musculoskeletal Tumor Society (MSTS) score, and clinical outcomes were evaluated using knee and ankle movements and stability. The overall average MSTS score was 26.50. **Conclusions:** With good reconstruction of lateral ligament we can achieve good results after proximal fibulectomy for benign as well as malignant tumor without much instability. With partial upper tibial resection (i.e., the extra-articular resection of proximal tibiofibular joint) adequate margins are feasible even in malignant tumors.

Keywords: *Benign, bone tumor, en bloc resection, fibula, malignant, proximal fibula*
MeSH terms: *Giant cell tumors, musculoskeletal system, fibula, Ewing's tumor*

Introduction

Primary benign and malignant tumors of the proximal fibula are relatively uncommon.[1] The common lesions occurring at this location include giant cell tumors (GCTs), aneurysmal bone cysts, osteochondromas, osteosarcomas, and Ewing sarcomas.[2] The evaluation of the tumor with roentgenograms, computerized tomography (CT) scan or magnetic resonance imaging (MRI) and sometimes angiography play a pivotal role in preoperative surgical planning. In addition, the malignant tumors are staged with X-ray chest, CT scan of thorax, Tc-99m methylene diphosphonate bone scan[3] and histopathological grading. MRI is helpful in delineating proximal tibial involvement, the proximity of the neurovascular structures and soft tissue extent.[4] The treatment modality and prognosis depends primarily on the histopathological confirmation and the involvement/encasement of the neurovascular structures and extension of the lesion in the proximal tibia. The small benign lesions contained within the bone can be curetted, but the large lesions and malignant tumors are treated with proximal fibulectomy.[5] The resection at this site is challenge due the peculiar anatomy of the proximal leg and the tibiofibular region. The major issues are (1) trifurcation of popliteal artery into the anterior tibial, posterior tibial and peroneal artery medial to the fibular head. (2) The presence of tibial nerve and the deep and superficial peroneal nerves

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winding around flushing the neck of fibula. (3) Detachment and then the reconstruction of the lateral collateral ligament with biceps femoris tendon (stabilizers of varus thrust) on the proximal fibula.[6]

The resection of the proximal fibula is a difficult surgery and should preferably be taken up by well experienced orthopedic surgeon with adequate training in the field of bone tumors. The primary focus is on the limb salvage with maintained function and stability of the knee, foot, and ankle.

This study describes the functional and clinical outcomes of the tumors treated with proximal fibulectomy for benign and malignant tumors.

Materials and Methods

46 patients of histopathologically confirmed primary benign and malignant proximal fibular tumors operated between 2003 and 2014 were included in this retrospective study. The mean age was 26 years (range 12–44 years). Most common benign lesions were GCTs (n = 22) followed by osteochondromas (n = 8), and aneurysmal bone cysts (n = 4). The malignant lesions included Ewing sarcoma (n = 8), and osteosarcoma (n = 4). All the records were retrieved from the department of orthopedics and orthopedic oncology clinic of our institute. The plain X-rays in two views were studied in all the cases. Proper staging using MRI or CT scan of the local site along with X-ray chest was done. Histopathology confirmed the diagnosis in all except osteochondromas and thereafter the definitive surgery was planned. All the cases were evaluated histopathologically by the pathologist trained in musculoskeletal tumor pathology. The patients of osteosarcoma and Ewing sarcoma received neoadjuvant and adjuvant chemotherapy as per protocol of our hospital. None of the patients of Ewing sarcoma received post operative radiotherapy. All the patients were counseled for the treatment, and the informed consent for the procedures under spinal or general anesthesia was taken from all the patients. The study was approved by local institutional review board.

Operative procedure

En bloc resection for proximal fibular tumors was performed in all the cases included in this series. Two types of *en bloc* resections are described.[5] In Type 1 (mainly for benign tumors), there is resection of the proximal fibula and a 2 cm diaphyseal portion and a cover of soft tissue around it and the nerve and vessels are preserved [Figure 1]. In the more radical Type 2 resections (mainly for malignant tumors), 4 cm of normal diaphysis is resected along with peroneal nerve, extra-articular portion of fibula (i.e., along with tibiofibular joint) the anterior and lateral muscle groups all around the tumor [Figure 2]. Partial upper tibial resection was performed in all the cases of malignant tumors and three GCTs. In these cases the lesions were abutting tibia on MRI and it was required for wide resection.

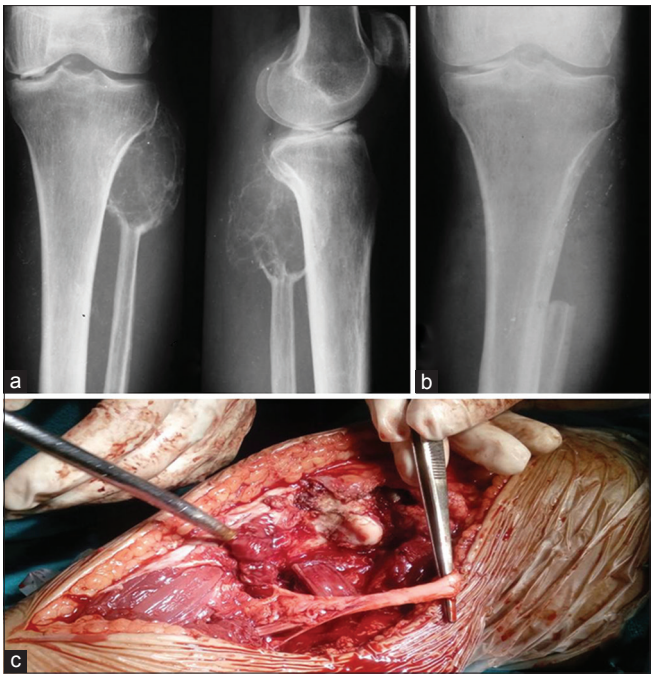

Figure 1: (a) X-ray of knee with proximal part leg bones anteroposterior and lateral views showing giant cell tumor of proximal fibula (b) X-ray of knee joint with proximal part of leg bones showing that the patient was treated with proximal fibulcetomy (c) Peroperative photograph showing that common peroneal nerve was preserved

The posterolateral approach was used to explore the lesions and neurovascular bundle in all but two cases. In two patients (one for massive GCT and the other for a very large Ewing sarcoma), we explored and dissected the tumor from posterolateral incision for peroneal nerve and lateral aspect of the tumor; and the second medial incision was used for dissection and preservation of tibial nerve and posterior tibial artery and resection of medial extent of these massive tumors.

The procedure began with dissection of peroneal nerve in all cases and exploration of the origin of trifurcation of popliteal vessels along with tibial nerve up to the distal extent of resection. The anterior tibial and peroneal vessels had to be ligated in tumors (n = 24) with large posterior and medial extent on MR scan and as per intra-operative evaluation and decision. Following this, the muscles attached to the fibula and all around were resected en mass; and the tibial nerve along with posterior tibial vessels was preserved. Then intraarticular disarticulation of tibiofibular joint for benign lesion and the extra-articular disarticulation of the tibiofibular joint were done with removal of a portion of the lateral tibia with the joint en masse for the malignant tumors abutting tibia and three cases of GCTs which were invading the adjacent surface of tibia as inteded for adequate wide excision. The most important part remained the identification of vessels after dissection of lateral head of gastrocnemius where the anterior tibial artery lies in the interosseous space and hinders mobilization, so ligation of the anterior tibial artery becomes essential many a times. With careful

Figure 2: (a) X-ray of the knee joint anteroposterior and lateral views showing massive giant cell tumor of proximal fibula (b) Excised specimen of proximal fibular large giant cell tumor (c) X-ray of knee joint with leg bones anteroposterior and lateral views showing the proximal fibula has been resected along posterolateral part of proximal tibia

dissection, all the tumors were resected *en bloc* with no rent in the capsule and with a good cuff of normal tissues all around the malignant tumors thus achieving adequate wide resection. After tumor removal we repaired and fixed the lateral collateral ligament with nonabsorbable sutures (Ethibond sutures no 4), and anchoring the biceps femoris to the lateral aspect of tibia by making drill holes for providing the additional stability.

In one patient, intra-operative damage to the trifurcation of vessel occurred for which the repair of the posterior tibial artery using saphenous vein graft was performed and the limb survived well, retaining good functions. In four patients, we performed tibialis posterior tendon transfer simultaneously at the time of initial surgery and in four patients after 6 months who were reluctant at the time of resection but during follow up they had problems with foot drop demanding its correction. Six patients did not opt for tendon transfer when they were counseled about it and were satisfied with the use of foot drop splint.

In one patient, there was preoperative peroneal nerve palsy in case of osteochondroma where the nerve was dissected and it recovered within 3 months after resection of the tumor.

Postoperative care and followup

The limbs were immobilized in plaster slab or cast for 6 weeks for the healing of lateral collateral ligament reconstruction. The patients with peroneal resection were given right angle foot splints to avoid the equinus contracture. After that they were allowed gradual range of knee motion exercises. They were allowed nonweight bearing ambulation after 2 weeks and full weight after 6 weeks. The patients were followed up at a 3 monthly interval in the 1st year and then 6 monthly for 5 years and annually thereafter. The mean followup period was 5.4 years (range 2–12 years).

Table 1: The types of lesions and resections performed

Diagnoses	Total cases	*En bloc* wide resection	Marginal excision
Giant cell tumors	22	12	10
Osteochondromas	8	Nil	8
Aneurysmal bone cysts	4	Nil	3
Ewing sarcoma	8	8	Nil
Osteosarcoma	4	4	Nil
Total	46	24	22

Results

We could achieve adequate margins in all the cases, i.e., marginal to wide margins in benign and all wide margins in malignant tumors [Table 1]. The margins were described as per the description given by Enneking *et al*.[7] These were further authenticated by the pathologists in their assessment of surgical pathology of the specimens. We were able to preserve all the three arteries in eleven cases of *en bloc* resection involving GCTs (n = 7) and aneurysmal bone cysts (n = 4). Both anterior and posterior tibial arteries could be preserved in 20 patients where we had to ligate the peroneal vessels and in rest 14 cases treated with Type 2 *en bloc* resection only posterior tibial vessels along with tibial nerve could be saved. After ligation of anterior and peroneal vessels, there occurred posterior tibial artery injury in one case per-operatively and was repaired with a saphenous vein graft. The vessel was too much adherent to the capsule in that case of big GCT. The limb could be saved well with sensate foot, i.e., with preservation of tibial nerve. It was observed that preserving posterior tibial artery was the most important of the three vessels.

Peroneal nerve had to be sacrificed deliberately for margins in 14 cases of which were Ewing sarcoma (n = 8), osteosarcoma (n = 4) and two cases of GCT. Total eighteen patients had foot drop postoperatively of which 14 cases were those where deliberate excision of peroneal nerve was

the part of procedure in Type 2 resections and in the rest of four patients foot drop occurred due to just handling and traction of the branches of this nerve during surgery but recovered well within 6 months.

On followup, no patient treated with *en bloc* resection complained of the significant instability of the knee joint or any hindrance in daily activities on clinical examination and weight bearing and stress X-ray films. Two patients used knee braces for 1 year after surgery due to mild instability as these required resection of more soft tissues at this site due to extensive lesions and on long followup they were satisfied with their knee functions and walked independently without any support.

Figure 3: X-ray of knee joint with leg bones anteroposterior view showing (a) Ewing sarcoma proximal fibula (b) Post chemotherapy Ewing sarcoma became very well defined and easy to excise

Complications

There was superficial infection in two cases which was treated with broad spectrum antibiotic (cefazolin 1 g intravenous twice per day for 1 week) and healed well. None of the cases reported immediate/delayed postoperative skin necrosis requiring skin graft or flap. None of the patients developed vascular insufficiency in distal part of the leg and the foot. There was no patient with tibia fracture with partial tibial resection in the cases with extra-articular resections.

Oncological results

Four patients (three with Ewing sarcoma and one with osteosarcoma) died of pulmonary metastasis. Rest of the eight patients with sarcomas and all with benign lesions are alive with disease free, i.e., with no local recurrence and no metastasis. The malignant tumors after chemotherapy became well defined and excision was easy [Figures 3 and 4].

Functional results

The functional status was determined using the Musculoskeletal Tumor Society (MSTS) scoring system.[8] This was based on the analysis of three factors (pain, functional activities, and emotional acceptance) pertinent to the patient as a whole and three factors specific to the lower limb which include the use of supports for ambulation, walking ability, and gait. For each of the six factors, values of 0–5 were assigned based on the established criteria. The result was expressed as a sum total, with a maximum score of 30, and as a percentage of the expected normal function for the patient. The range of MSTS score was 24–30 (mean 26.50).

Patients with peroneal resection had significantly worse functional outcome than patients without peroneal resection with a mean MSTS score of 24.60 (82%). An ankle-foot orthosis was tolerated well by these patients. Even after tendon transfer, the clawing of toes persisted, and functions

Figure 4: X-ray of knee joint with leg bones anteroposterior and lateral views showing (a) Osteosarcoma proximal fibula after chemotherapy (b) widely excised proximal fibula

were inferior to those cases with preservation of the nerve. Further overall functional outcome was significantly better in patients with benign tumors than in patients with malignant tumors and this was obviously because in cases of benign tumors neither resection of the peroneal nerve nor too much muscle excision was required [Table 2]. The mean MSTS score in these cases was 27.90 (93%). There was statistically significant difference in MSTS scores between the groups treated with peroneal nerve preservation and nerve sacrificing procedure with better scores in patients with intact nerve ($P < 0.01$). However, all patients had full range of the knee movement, and they were able to squat and sit cross leg. In one patient of osteochondroma, there was preoperative peroneal nerve palsy which recovered fully within 3 months after resection [Figure 5].

Table 2: Studies showing Musculoskeletal Tumor Society scores with and without peroneal nerve preservation

Study, year	MSTS scores (%)	
	Peroneal nerve spared	Peroneal nerve resected
Erler *et al*., 2004[9]	96	91
Dieckmann *et al*., 2011[10]	96	91
Inatani *et al*., 2016[11]	96	65
Present study, 2017	93	82

MSTS=Musculoskeletal Tumor Society

Discussion

Proximal fibula is relatively uncommon site for benign or malignant tumors. These are most commonly treated with proximal *en bloc* fibulectomy.[5] This is relatively difficult procedure and should preferably be performed at the hands of an experienced orthopedic oncologist. Most of the lesions require complete excision along with a safe margin as a mode of treatment. It may be in the form of marginal excision or *en bloc* wide resection depending on the size, extent, and type of tumor.[9,12,13] In view of the observations in the results after proximal fibulectomy four issues have been discussed in this article: (1) dissection and preservation or deliberate sacrifice of the common peroneal nerve, (2) dissection and preservation of the vessels at the trifurcation of the popliteal artery along with mandatory preservation of posterior tibial artery and tibial nerve, (3) wide resection with intraarticular or extra-articular resection of the proximal tibiofibular joint for the benign and the malignant lesions of proximal fibula respectively, and (4) the reconstruction of the lateral collateral ligament after resection of the tumor for achieving the stability of the knee joint.[14]

The common peroneal nerve is a major limiting structure seen in cases of *en bloc* resection of proximal fibular masses. In cases of benign tumors with Type 1

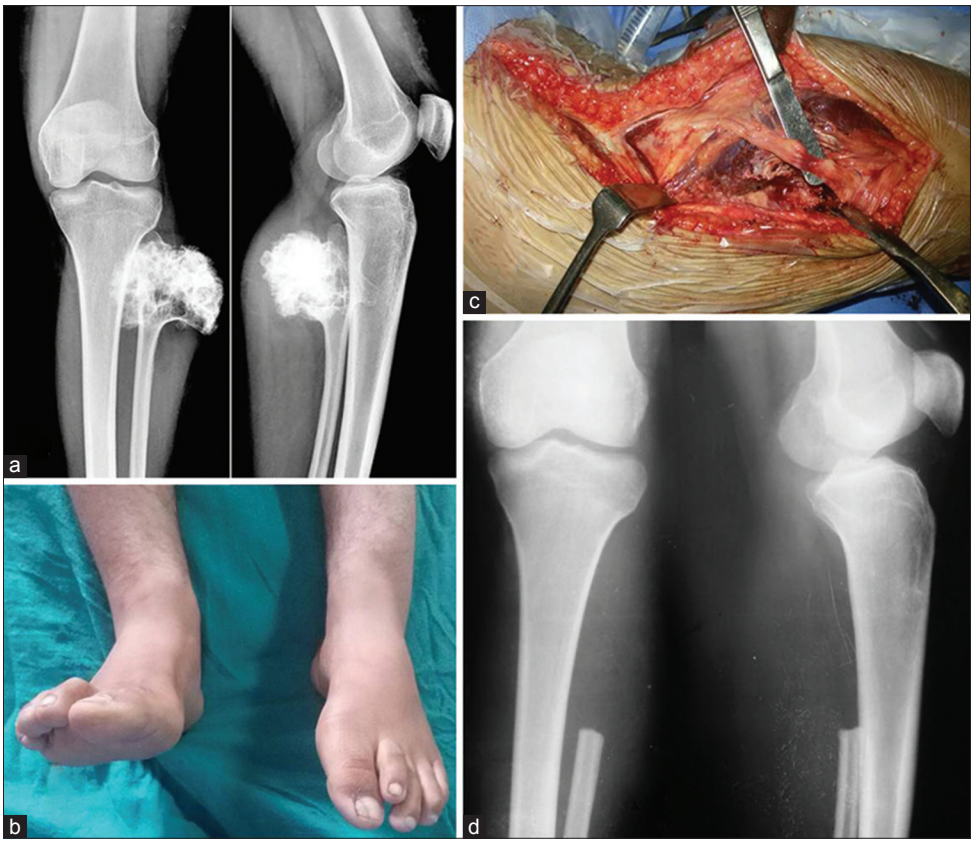

Figure 5: (a) X-ray of the knee joint with leg bones anteroposterior and lateral views showing osteochondroma of proximal fibula. (b) Clinical photograph showing foot drop, which was present preoperatively. (c) Peroperative photograph showing common peroneal nerve dissected and decompressed. (d) X-ray of the knee joint with leg bones anteroposterior and lateral views showing proximal fibulectomy

resection nerve can still be preserved by identifying its course under the peroneus longus. The peroneus longus tunnel is unroofed and articular branch to the knee is sacrificed to mobilize it.[15] It is possible to preserve the branches of the nerve and we can afford to be marginal in the benign lesions. Although some cases may have neuropraxia due to traction of the branches during retraction intraoperatively it usually recover within 6 months period. Thus, in all the cases with benign lesions we should try to dissect and preserve the common peroneal nerve. However, in cases treated with Type 2 resections involving the nerve particularly for the malignant tumors resection, we have to sacrifice the nerve for removal of the tumor with wide margins. In this type of resections involving massive resection of muscle tissue leading to loss of the foot extension peroneal nerve grafting or direct reconstruction of the peroneal nerve is also a futile exercise. Instead, a primary or secondary tibialis posterior tendon transfer is a better option.[9,16,17]

The second issue is the dissection at the level of trifurcation of the popliteal vessel and the tibial nerve posteriorly. MRI will delineate the extent of the lesion and the proximity and the encasement of the vessels in the tumor in this location, and thus accordingly we can counsel the patient and take consent for the possibility of vascular repair and even the requirement of amputation. Although it is wise to preserve all the major neurovascular structures but the most important is to preserve at least posterior tibial artery and tibial nerve for the survival of the limb and sensations in the foot. The rest of the two vessels (anterior tibial and the peroneal) can be ligated if required for the wide margins. Another point that makes the procedure complicated is aberrant vasculature and distorted anatomy. It is imperative to have a neat and meticulous dissection technique to identify essential neurovascular structures and save them and sometime even with a medial incision for the dissection of the posterior tibial vessels and the tibial nerve.[12,13]

Another important point of consideration is that for some of the large benign GCTs infiltrating the posterolateral aspect tibia and the malignant tumors flushing the tibia at this site we should try to resect the proximal fibula extra-articularly so that we can get wide margins and avoid the local recurrence. This step needs to be performed very carefully and meticulously so that we can avoid entering the tumor with the osteotome. Even after this type of the resection we should cauterize the posterolateral aspect of tibia to burn out the kissing area by benign lesions like GCTs.[18]

Furthermore, one should keep in mind to reconstruct the lateral collateral ligament which is important for the stability of the knee joint and it could be very well done with apposition of lateral soft tissues and their augmentation using the tendon of biceps femoris anchoring it to the lateral aspect of the tibia with nonabsorbable sutures (Ethibond sutures no. 4). Plaster cast application for 6–8 weeks postoperatively helps in the fibrosis and healing of this reconstruct maintaining the stability of the knee joint. Although stability is not much disturbed even without reconstruction[19] but some studies recommend that the reconstruction of this ligament adds to the stability of the knee.[20,21]

The outcome of *en bloc* proximal fibular resection solely depends on the expertise of operating surgeon thus discussing and stressing the steps of the surgical procedure. The best treatment should ensure local control of disease and maintain function. *En bloc* resection for tumors at this site meets both primary aims and hence thist remains the most suitable surgical procedure.[22,23]

This is a series of patients with a reasonably large number of patients treated at a single center operated by the same team of surgeons with its limitation that the different types of tumors with otherwise different biological behaviors have been included. However with proper preoperative clinical, radiological evaluation with staging and histopathological confirmation we can resect the benign as well as the malignant tumors with adequate wide margins achieving good functional and clinical results.

Conclusions

Proximal fibular resection is overall a difficult operation in view of the anatomy of this location particularly trifurcation of popliteal artery as posterior tibial, anterior tibial, and peroneal arteries. The most important is to at least preserve the posterior tibial vessels along with the tibial nerve for the survival of the sensate foot. The other challenge is to achieve the wide margin and extra-articular resection of proximal fibula along with postero lateral part of tibia. The third important issue is the reconstruction of the lateral collateral ligament and its augmentation using biceps femoris tendon by anchoring it to the lateral aspect of the tibia. With carefully executed wide *en bloc* resection of proximal fibula, we can achieve good results for the tumors at this location with good functions of the knee as well as foot.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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