Proximal fibula resection in the treatment of bone tumours

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Abstract

Background and objectives We present a large study of patients with proximal fibula resection. Moreover we describe a new classification system for tumour resection of the proximal fibula independent of the tumour differentiation.

Methods In 57 patients the functional and clinical outcomes were evaluated. The follow-up ranged between six months and 22.2 years (median 7.2 years). The indication for surgery was benign tumours in ten cases and malignant tumours in 47 cases. In 13 of 45 patients, where a resection of the lateral ligament complex was done, knee instability occurred. In 32 patients a resection of the peroneal nerve with resulting peroneal palsy was necessary.

Results Patients with peroneal resection had significantly worse functional outcome than patients without peroneal resection. An ankle foot orthosis was tolerated well by these patients. Three of four patients with pathological tibia fracture had local radiation therapy. There was no higher risk of tibia fracture in patients with partial tibial resection. **Conclusions** Resection of tumours in the proximal fibula can cause knee instability, peroneal palsy and in cases of local radiation therapy, a higher risk of delayed wound healing and fracture. Despite the risks of proximal fibula resection, good functional results can be achieved.

Introduction

The fibula is a rare location for primary bone tumours or metastases. Only 2% of primary osteosarcoma [1] and 8% of primary Ewing sarcoma originate in the fibula [2]. The close relation of the common peroneal nerve, the anterior tibial artery and the lateral collateral ligament to the proximal fibula are major challenges in surgical resection of proximal fibula tumours. For wide resection of malignant bone tumours the peroneal nerve or the peroneal muscle group must sometimes be resected. Damage to the peroneal nerve or the peroneal muscle group leads to drop foot or sensory deficit [3]. Sacrifice of the proximal tibiofibular joint and lateral stabilisers of the knee is often unavoidable (Fig. 1). The loss of the lateral stabilisation structures leads to an instability of the lateral knee compartment [4]. Local radiation therapy increases the risk of a tibial fracture [5].

Since the number of bone sarcomas of the fibula is limited, there have only been a few reports on the outcome of treatment. In the following study we present the largest series of patients with proximal fibula tumours and a new

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Fig. 1 A 17-year-old patient with an osteosarcoma of the proximal fibula. A wide resection of the proximal fibula Type FIN1T1 was necessary. **a** Pre-operative X-ray findings show osteolytic–osteoblastic lesion with periosteal reaction. **b** T2-weighted magnetic resonance imaging showing the contact of the proximal fibula tumour with the tibia. **c** Postoperative X-ray findings two years later with an anchor in the proximal tibia for refixation of the lateral ligament complex

classification system. The aim of this study was to evaluate the functional and clinical outcome after proximal fibula resection.

Materials

In a retrospective study we analysed the functional and clinical outcome of 57 patients with tumours of the proximal fibula which had been treated between 1987 and 2009. Local X-ray, MRI scan, staging with CT scan of the chest and bone scintigraphy were performed preoperatively. The patients' age ranged between six and 72 years (median 22.4 years). Indications for surgery are listed in Table 1. There were 26 female and 31 male patients. All malignant tumours had an extraskeletal tumour component. The surgical stage of patients with primary sarcoma was IB in six cases, IIB in 40 cases and IIIB in one case according to the grading system of the Musculoskeletal Tumour Society [6]. In four cases an intralesional resection preserving the proximal fibula had been performed at another hospital. For

classification of the resection we use a new classification system independent of the surgical margins (Table 2).

All patients with high grade malignant tumours received chemotherapy according to the corresponding protocol. Fifteen patients with Ewing sarcoma, one patient with myofibroblastic sarcoma and one patient with synovial sarcoma GII received local radiation therapy pre- or postoperatively. In one case of Ewing sarcoma a perioperative brachytherapy was performed. After resection of the lateral ligament complex ($n=45$), reconstruction with an anchor or transosseus suture of the remaining biceps tendon and ligament or a fascia lata plasty was performed in 41 cases. In one case a primary vascular graft was necessary because of infiltration of all three arterial vessels.

The follow-up ranged between six months and 22.2 years (median 7.2 years). The functional evaluation was performed without a brace at the most recent follow-up examination. The Musculoskeletal Tumour Society Score (MSTS) [7] was evaluated in 46 cases and the Toronto Extremity-Salvage Score (TESS) [8] was evaluated in 40 cases. One patient with a secondary amputation was

Table 1 Tumour types of patients with proximal fibula resections

Benign tumours		Malignant tumours	
Type	Number	Type	Number
Aneurysmal bone cyst (ABC)	1	Low grade chondrosarcoma	6
Recurrence of an ABC	2	Dedifferentiated chondrosarcoma	1
Intraosseous haemangioma	1	Ewing sarcoma	17
Osteblastoma	1	Osteosarcoma	19
Osteochondroma	2	Primitive neuroectodermal tumour (PNET)	1
Giant cell tumour	1	Malignant fibrotic sarcoma (MFH)	1
Recurrence of giant cell tumours	2	Myofibroblastic sarcoma G2	1
		Synovial sarcoma G2	1

Table 2 Classification system for resection of the proximal part of the fibula

Description	Details
Resection of the lateral ligament complex (L)	0=preserving 2-3 cm of the proximal fibula with the lateral ligament complex 1=resection of the entire proximal fibula with lateral ligament complex
Resection of the peroneal nerve (N)	0=preserving the peroneal nerve 1=resection of the common or deep peroneal nerve
Partial en-bloc resection of the adjacent tibia (T)	0=intraarticular resection of the proximal fibula or resection without adjacent tibia 1=extraarticular resection of the tibiofibular joint or partial en-bloc resection of the adjacent tibia

For example, L1N1T1: extraarticular resection of the tibiofibular joint with resection of the proximal fibula including the lateral ligament complex and sacrificing the common peroneal nerve

excluded. Statistical evaluation was done using Sigma Plot (version 11). The Mann–Whitney U test was used to compare the difference between the means of MSTS and TESS scores. The Fischer's exact test was used to evaluate the risk for delayed wound healing after radiation therapy and for the risk of tibial fracture after radiation therapy or partial tibial resection.

Results

Classification of the 57 patients is shown in Table 3. Nine patients developed a delayed wound healing either postoperatively or during the adjuvant radiation therapy (five of 41 without, four of 16 with radiation therapy). Eight patients were treated conservatively; one patient needed a surgical debridement. One patient developed a venous thrombosis, which was treated by anticoagulation therapy. One patient had an arterial thrombosis after a vascular graft. Despite revision of the graft, necrosis of the forefoot occurred. A Chopart-amputation was necessary.

One patient with an osteosarcoma developed local recurrence after 1.5 years because of an undetected skip lesion of the proximal tibia which was finally treated by amputation. Another patient with osteosarcoma developed

local recurrence with synchronous pulmonary metastasis and died one year after initial resection. Both patients had a poor response grade (grades 4 and 5 according to Salzer-Kuntschik). A successful proximal fibula resection with wide margins could be performed in all the remaining cases of malignant tumours. One patient with a giant cell tumour developed two local recurrences in the soft tissue. Ten years after the last resection there was no evidence of disease.

Four patients had a pathological fracture after minor trauma. Three of these patients had adjuvant radiation therapy. One patient had a fracture after adequate trauma. There was no significant higher risk of fracture in patients with partial tibial resection. Three of the patients with tibial fractures were treated with a brace. Two patients needed an osteosynthesis with an internal stabilisation. One of these patients postoperatively developed a pseudarthrosis. Two revisions of the pseudarthrosis were needed. One patient, who was treated conservatively, had an additional osteopenic femoral fracture because she was afraid to do full weight bearing after the tibial fracture. In two patients with a tibial fracture a limb-length discrepancy of 3 cm occurred. One of them was treated by epiphysiodesis, the other was treated conservatively.

In 13 of 45 patients where a resection of the entire proximal fibula with lateral ligament complex was neces-

Table 3 Postoperative MSTS and TESS-scores of patients with benign and malignant tumours

Classification	Total patients	Patients with benign tumours	MSTS benign tumour	TESS benign tumour	Patients with malignant tumours	MSTS malignant tumours	TESS malignant tumours
F1N0T0	10	4	98%	99%	6	95%	91%
F1N0T1	5	2	100%	100%	3	90%	88%
F1N1T0	7				7	90%	96%
F1N1T1	23				23	90%	88%
F0N0T0	9	4	100%	99%	5	97%	94%
F0N0T1	1				1	90%	87%
F0N1T0	1				1	97%	-
F0N1T1	1				1	97%	99%

sary, knee instability occurred. One of two patients, where a revision of the lateral ligament complex was performed, had a stabile knee postoperatively. In the other case the instability persisted. In one of four patients without reconstruction a persisting instability occurred. This patient used an orthosis intermittently. At the time of interview four patients were still using an orthosis for sports intermittently, another used it permanently. One patient (57 yrs) developed a varus deformity of the affected leg without any pain eight years after initial operation. None of these patients complained of pain.

In 32 patients resection of the peroneal nerve was necessary; almost complete anterior and lateral muscle groups were resected in three patients. Postoperatively, 38 patients developed a paresis of dorsal extension. In three cases, where the nerve was preserved, four weeks after the operation full function was restored. Permanent paresis of the foot extensors occurred in 35 patients. Patients without peroneal resection (MSTS mean=96%) had a significantly ($p>0.001$) better functional outcome in the MSTS score compared to the patients with peroneal resection or resection of the anterior and lateral muscle groups (MSTS mean=91%). In one patient a tendon-transfer of the tibialis posterior was done. Afterwards the patient still had a slight paresis, but could walk without an ankle foot orthosis. In another patient, where the peroneal nerve was resected, secondary nerve transplantation was performed one year after initial surgery. However, postoperatively there was no improvement of dorsal extension of the foot. At the time of interview, 29 of 36 patients used an ankle-orthosis permanently and one patient used it for sports intermittently.

In the functional follow-up there was a significant difference between the patients with benign (mean MSTS 99%, $p>0.001$; mean TESS 99%, $p>0.021$) and malignant tumours (mean MSTS 92%, mean TESS 95%). The specific scores for the different groups are listed in Table 3.

At the final oncological follow-up of the patient with malignant bone tumours ($n=47$) 36 patients continued to be disease free, three were alive with disease, seven had died of disease and one had died in an accident.

Discussion

For local control of bone tumours a wide resection is necessary [9]. To achieve a wide resection a MRI scan is an essential step in assessing resectability of the tumour. The relationship between the adjacent neurovascular structures and the tibia is especially important. Malawer et al. described a classification for two resection types depending on the differentiation of the tumour [3]. Erler et al. modified this classification and described two more detailed types of resection [10]. The disadvantage of both classifications was

that they were dependent on the tumour differentiation but not on the tumour size or extension. We have developed a classification system which is independent from the differentiation or the tumour size or the extension (Table 2). Our classification system considers the resection of the lateral ligament complex, the peroneal nerve and the adjacent tibia.

In order to preserve the lateral ligament complex in malignant tumours there has to be a proximal area of more than 3–4 cm of healthy bone. If there is less than 3–4 cm of healthy bone an intraarticular resection of the proximal fibula with the lateral ligament complex must be done. If the tumour infiltrates the proximal fibula head an extra-articular resection of the proximal fibulotibial joint is unavoidable. Gait abnormalities and knee instability occur after proximal fibula resection [11]. Studies in a cadaver have demonstrated that the fibular collateral ligament provides the main resistance to varus rotation at the knee [12]. Draganich et al. reported increased anterior and anteroposterior translation of the knee in flexion, varus-valgus rotations at 20° flexion and several abnormalities in ground reaction forces [11]. There is evidence that instability of the knee can cause osteoarthritis as in one case of our study [13]. Therefore the remaining lateral collateral ligament and biceps tendon should be properly reattached to the tibia. If there is insufficient biceps tendon or ligament left, a reconstruction using the fascia lata should be performed [11]. Bickels et al. reported a knee instability in 7% of cases in Malawer type I resections (marginal resection of the proximal fibula with a small muscle layer, preserving the peroneal nerve) and in 50% of cases in Malawer type II resections (wide extraarticular en-bloc resection of the proximal fibula, the common peroneal nerve and the anterior and lateral muscle groups) [4]. In our study 12 of 45 patients, in whom a resection of the lateral ligament complex was necessary, developed knee

Fig. 2 Intraoperative situs of the same patient. Preparation of the N. peroneus communis. In this case a resection of the peroneal nerve larger than 6 cm was necessary

instability. Two revisions of the lateral ligament complex were done. Subsequently one of these patients had a stable knee. In our series patients with knee instability used knee orthoses in one case permanently and intermittently for sports or vigorous activity in four cases.

Resection of the peroneal nerve causes serious functional problems such as a high stepping gait, a drop foot and gait instability [14]. Therefore resection of the peroneal nerve should be avoided if possible. However, the peroneal nerve should not be preserved if a wide resection in malignant tumours is not otherwise possible. If the tumour only contacts the peroneal nerve superficially, an epineurectomy is an acceptable procedure for a wide resection. In cases of infiltration of the nerve a resection is unavoidable [15] (Fig. 2). Because of the resulting drop foot, patients need an ankle foot orthosis (AFO) for stabilisation of the ankle. In our series the tolerance of orthoses in patients with peroneal palsy was good. In one case a graft repair of the peroneal nerve was done one year after initial surgery without any improvement of the foot extension. It is reported that the best results of nerve repair are achieved if an immediate or early operative intervention is done [16–18]. The results of repair and grafting of the common peroneal nerve in particular are poorer than in other peripheral nerves (46–54%) [19, 20]. Indeed chemotherapy [21] and radiation therapy [22] do not influence the results of a nerve repair or grafting significantly. However, in most cases grafts longer than 6 cm were needed (Fig. 2). The results of graft repair larger than 6 cm are even worse [19]. Furthermore massive resection of muscle tissue leads to loss of the foot extension. Because of the poor results after peroneal nerve grafting and extensive resection of muscle groups, we believe that a direct reconstruction of the peroneal nerve should not be attempted. A good alternative method for improving the foot extension is a primary or secondary tibialis posterior tendon transfer [10, 23, 24]. Up to 83% of patients after are able to walk without an AFO after tibialis posterior transfer [24]. AFOs, especially those constructed from light and flexible carbon materials, are tolerated well in patients with peroneal palsy. If patients do not tolerate an orthosis, a tibialis posterior tendon transfer might be a good alternative.

Delayed wound healing is to be expected in patients who receive chemotherapy and radiation therapy postoperatively [25]. In our series delayed wound healing was found in only nine patients who received adjuvant chemotherapy or radiation therapy. There was no delayed wound healing in patients with benign tumours.

Local radiation therapy is associated with osteopenia and fracture of the affected bone [5]. In our study patients who received local radiation therapy had a 3.8-fold higher risk of developing a pathological tibia fracture than patients without. Resection of the adjacent tibia did not

increase the risk of tibia fracture. Therefore a partial tibia resection can be achieved without any problems. Patients with local radiation therapy should be encouraged to continue weight bearing, if possible, to avoid osteopenia from inactivity, but nevertheless should avoid excessive activity.

There was a significantly better functional outcome in patients with benign tumours than in patients with malignant tumours. This is not surprising because in cases of benign tumours neither resection of the peroneal nerve nor great muscle excision was necessary.

Conclusion

Resection of tumours in the proximal fibula can cause knee instability, peroneal palsy and, in cases of local radiation therapy, a higher risk of delayed wound healing and fracture. In cases of peroneal palsy ankle foot orthoses were tolerated well. A good alternative might be a tendon transfer of the tibialis posterior muscle to improve the foot extension. Partial tibial resection did not increase the risk of tibia fracture in our study. Therefore partial tibial resection should be preferred to subperiosteal resection. Despite the risks of proximal fibula resection good functional results can be achieved.

References

1. Dahlin DC, Unni KK (1986) Bone tumors, general aspects and data on 8542 cases, 4th edn. Thomas, Springfield
2. Huvos AG (1991) Bone tumor. Diagnosis, treatment, and prognosis, 2nd edn. WB Saunders, Philadelphia
3. Malawar MM (1984) Surgical management of aggressive and malignant tumors of the proximal fibula. *Clin Orthop Relat Res* 186:172–181
4. Bickels J, Kollender Y, Pritsch T, Meller I, Malawar MM (2007) Knee stability after resection of the proximal fibula. *Clin Orthop Relat Res* 454:198–201
5. Shapeero LG, De Visschere PJ, Verstraete KL, Poffyn B, Forsyth R, Sys G, Uyttendaele D (2009) Post-treatment complications of soft tissue tumours. *Eur J Radiol* 69(2):209–221
6. Enneking WF (1988) A system of staging musculoskeletal neoplasms. *Instr Course Lect* 37:3–10
7. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ (1993) A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. *Clin Orthop Relat Res* 286:241–246
8. Davis AM, Wright JG, Williams JJ, Bombardier C, Griffin A, Bell RS (1996) Development of a measure of physical function for patients with bone and soft tissue sarcoma. *Qual Life Res* 5(5):508–516
9. Bielack SS, Kempf-Bielack B, Delling G, Exner GU, Flege S, Helmke K, Kotz R, Salzer-Kuntschik M, Werner M, Winkelmann W, Zoubek A, Jurgens H, Winkler K (2002) Prognostic factors in high-grade osteosarcoma of the extremities or trunk: An analysis of 1,702 patients treated on neoadjuvant cooperative osteosarcoma study group protocols. *J Clin Oncol* 20(3):776–790

10. Erler K, Demiralp B, Ozdemir MT, Basbozkurt M (2004) Treatment of proximal fibular tumors with en bloc resection. *Knee* 11(6):489–496
11. Draganich LF, Nicholas RW, Shuster JK, Sathy MR, Chang AF, Simon MA (1991) The effects of resection of the proximal part of the fibula on stability of the knee and on gait. *J Bone Joint Surg Am* 73(4):575–583
12. Grood ES, Noyes FR, Butler DL, Suntay WJ (1981) Ligamentous and capsular restraints preventing straight medial and lateral laxity in intact human cadaver knees. *J Bone Joint Surg Am* 63(8):1257–1269
13. Del Pizzo W, Norwood LA, Kerlan RK, Jobe FW, Carter VS, Blazina ME, Shields CL Jr, Lombardo SJ (1977) Analysis of 100 patients with anterolateral rotatory instability of the knee. *Clin Orthop Relat Res* 122:178–180
14. Carayon A, Bourrel P, Bourges M, Touze M (1967) Dual transfer of the posterior tibial and flexor digitorum longus tendons for drop foot. Report of thirty-one cases. *J Bone Joint Surg Am* 49(1):144–148
15. Takahashi S, Ogose A, Tajino T, Osanai T, Okada K (2007) Osteosarcoma of the proximal fibula. An analysis of 13 cases in the Northern Japan. *Ups J Med Sci* 112(3):366–372
16. Khan R, Birch R (2001) Latrothatic injuries of peripheral nerves. *J Bone Joint Surg Br* 83(8):1145–1148
17. Mont MA, Dellon AL, Chen F, Hungerford MW, Krackow KA, Hungerford DS (1996) The operative treatment of peroneal nerve palsy. *J Bone Joint Surg Am* 78(6):863–869
18. Wisseman GJ (1981) Tendon transfers for peripheral nerve injuries of the lower extremity. *Orthop Clin North Am* 12(2):459–467
19. Kim DH, Kline DG (1996) Management and results of peroneal nerve lesions. *Neurosurgery* 39(2):312–319, discussion 319–320
20. Wood MB (1991) Peroneal nerve repair. Surgical results. *Clin Orthop Relat Res* 267:206–210
21. Brandt K, Evans GR, Johnson M, Gurlek A, Lohman R, Nabawi A, Williams J, Hodges J, Patrick CW Jr (1999) The effects of cisplatin and vincristine on peripheral nerve regeneration. *Plast Reconstr Surg* 104(2):464–469
22. Brandt K, Evans GR, Ang KK, Gurlek A, Peden E, Savel T, Patrick C Jr (1999) Postoperative irradiation: Are there long-term effects on nerve regeneration? *J Reconstr Microsurg* 15(6):421–425
23. Ozkan T, Tuncer S, Ozturk K, Aydin A, Ozkan S (2009) Tibialis posterior tendon transfer for persistent drop foot after peroneal nerve repair. *J Reconstr Microsurg* 25(3):157–164
24. Yeap JS, Birch R, Singh D (2001) Long-term results of tibialis posterior tendon transfer for drop-foot. *Int Orthop* 25(2):114–118
25. Chmell MJ, Schwartz HS (1996) Analysis of variables affecting wound healing after musculoskeletal sarcoma resections. *J Surg Oncol* 61(3):185–189