Nonviable injuries of the tibia

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Management of severe open fractures and nonviable injuries of the tibia remain both difficult and controversial. The orthopedist must carefully assess the injured limb in order to determine whether it should be salvaged or amputated. The difficult operative procedure requires thorough knowledge of microsurgical techniques necessary to repair vascular and neural injury. Over a 10 year period, 13 patients with non-viable, open fractures of the tibia underwent limb salvaging attempts using identical treatment protocol. 5 of the 13 limbs were salvaged, while 8 limbs were later amputated, because of either failure of revascularization or severe infection. 2 patients died; one with good circulation in the limb because of a massive pulmonary embolism 5 days postoperatively and the other because of severe septicemia 13 days postoperatively.

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Nonviable injuries of the tibia which are often associated with comminuted fractures type IIIc are usually the result of high energy impact (Gustilo et al. 1984). Less frequently the tibia remains intact, but there is a severe crushing injury to the soft tissues and the skin (Schatzker 1987). A number of factors are related to the decision of whether saving the limb or amputation is indicated (Hansen 1987, Johansen et al. 1990, Pozo et al. 1990, Robertson 1991). These include: the patient's age, interval between injury and surgery, fracture at one or more levels, fracture comminution with possible bone loss, posterior tibial nerve damage and the patient's general condition (Johansen et al. 1990, Gustilo et al. 1990, Robertson 1991). However, the decision to salvage the limb is associated with possible life threatening complications and the end result may not always be rewarding (Caudle et al. 1987, Makin 1990).

Patients and methods

Over a 10-year period, 788 patients with major trauma to the tibia were treated at the Department of Orthopaedic Surgery, University of Ioannina Medical School. Of these, 13 patients had nonviable limbs secondary to severe vascular injury as determined by clinical and radiological examination. There were 12 men and 1 woman with ages ranging from 2.5 to 60 years. The injury was caused by a motor vehicle accident in 6 patients, farming accident in 3, industrial in 2 and shotgun injury in 2 patients. The time elapsed between injury and hospital admission ranged from 2 hours to 10 days.

The operative procedure followed the same protocol in all patients. Because these patients are usually multi-trauma patients, a detailed general examination was carried out. Contraindications for revascularization attempts of the limb included: 1) vascular injury at multiple levels; 2) severe and extensive crushing; 3) 6 hours or more of ischemia in cases where the limb was not preserved or transported properly; 4) elderly patients with a history of diabetes, arteriosclerosis, asthma or autoimmune disease; 5) immunosuppressants or cortisone therapy; and 6) polytrauma patients with life threatening shock, intra-abdominal bleeding, head or chest injury.

Once a thorough lavage of the wound with 10–15L of normal saline followed by extensive surgical debridement had been performed, the fracture of the tibia was stabilized with external fixation which was supplemented in some cases by an interfragmental screw. In 2 cases with Salter II physiolisthesis, Kirschner wires were used. Vascular repair which followed was aimed at repairing 1 artery, the posterior tibial, and at least 2 veins. Whenever possible, repair of the anterior tibial artery was also attempted. In 11 patients vein autografts were used due to arterial endothelium damage or loss of arterial length.

Table 1. Characteristics of patients with severe non-viable injuries to the tibia and clinical results

Sex	Age	Mechanism of injury[a]	Revasc.[b] time	Vessel repair	Complications	Results
M	12	MVA	5.5 h	end-to-end	infection -drop foot	good
M	12	MVA	10 d	vein graft	Volkmann	amputation 2d postop.
M	50	industrial	8.5 h	vein graft	infection	amputaion 30d postop.
M	25	MVA	7.5 h	vein graft	vein thrombosis	death-pulmunary embolism 5d postop.
F	7	industrial	8.5 h	vein graft	vein thrombosis	distal amputation
M	60	industrial	7.25 h	end-to-end	vein thrombosis	amputation 3d postop.
M	47	industrial	9.5 h	vein graft	infection/ext necrosis	amputation 15d postop.death-septicemia
M	19	industrial	7 d	vein graft	infection	amputation 20d postop.
M	17	gun-shot	5 h	vein graft	infection	satisfactory
M[c]	25	gun-shot	5 h	vein graft	infection	good
M	17	MVA	4.5 h	vein graft	infection	distal amputation
M	14	MVA	28 h	vein graft		excellent
M	2.5	MVA	2 h	vein graft	vein/artery thrombosis	amputation 14d postop.

[a] MVA motor vehicle accident.
[b] Time until revascularization was achieved, d day, and h hours.
[c] See Figure 1.

To assess revascularization of the limb, distal circulation was observed in the theatre for 30 minutes, during which time further surgical debridement was performed to remove any crushed tissue which did not revascularize. Injured nerves were only identified for secondary neurorhaphy.

Postoperative management included i.v. antibiotics (second generation cephalosporine and aminoglycocide) which administration had begun preoperatively and was continued for 4 days after the last surgical debridement or final wound closure, as well as i.v. heparin (during the last 2 years low molecular weight heparin has been used).

Results

Revascularization and limb salvage was achieved in 5 out of the 13 patients (Table 1). Secondary distal amputations, however, were required in 2 cases where the limb was salvaged. In the remaining 3 patients, one young patient (12 years) with a type IIIC fracture of the distal third of the tibia developed skin necrosis on the dorsum of the foot which required a secondary posterior-tibial tendon transfer and a latissimus dorsi free flap. Because of severe equinus deformity, an ankle arthrodesis was also performed. The second patient (14 years) suffered an physiolysis of the proximal tibia and thrombosis of the popliteal artery occurred 1 day postoperatively. Immediate revision of the anastomosis with a vein graft was successful and resulted in a normal leg and foot. The third patient with a shot-gun wound in the proximal tibia was brought to the hospital with a 30 hour delay. Revascularization with a vein graft to the posterior tibial artery was successful in spite of the protracted ischemia. The end result was satisfactory as the patient had normal sensation and could walk independently, although with weakness of the extensors and a stiff ankle joint. The same patient was later successfully treated for chronic osteomyelitis by the removal of screws and necrotic bone (Figure 1).

Of the other 2 patients with successful limb salvaging, one had a shot-gun injury in the proximal third of the tibia and underwent secondary amputation of his toes and arthrodesis of the ankle joint. The second patient suffered a knee dislocation with extensive damage to the popliteal artery. Thrombosis of the vein graft resulted in the patient undergoing a Syme's amputation.

10 out of 13 patients had severe crush injuries and thus, prognosis was relatively poor. One patient had undergone a complete amputation of the distal third of the tibia from a power saw. Although end-to-end anastomosis of the posterior tibial artery was possible in this case, thrombosis occurred 3 days postoperatively and embolectomy failed to restore circulation. The end result was amputation. Moreover, it should be noted that salvage was attempted in this patient despite the relatively poor prognosis attributed to the patient's age (60 years) and arteriosclerosis. Revascularization was also attempted in 4 children (2.5–12 years of age), although the procedure was contraindicated by the presence of severe crushing and/or extensive injury. One limb survived and 3 were amputated. In the present series, 2 patients died; 1 from a massive pulmonary embolism 5 days postoperatively and 1 because of sever septicemia 13 days postoperatively. Revascularization had been successful in the former, while in the second patient

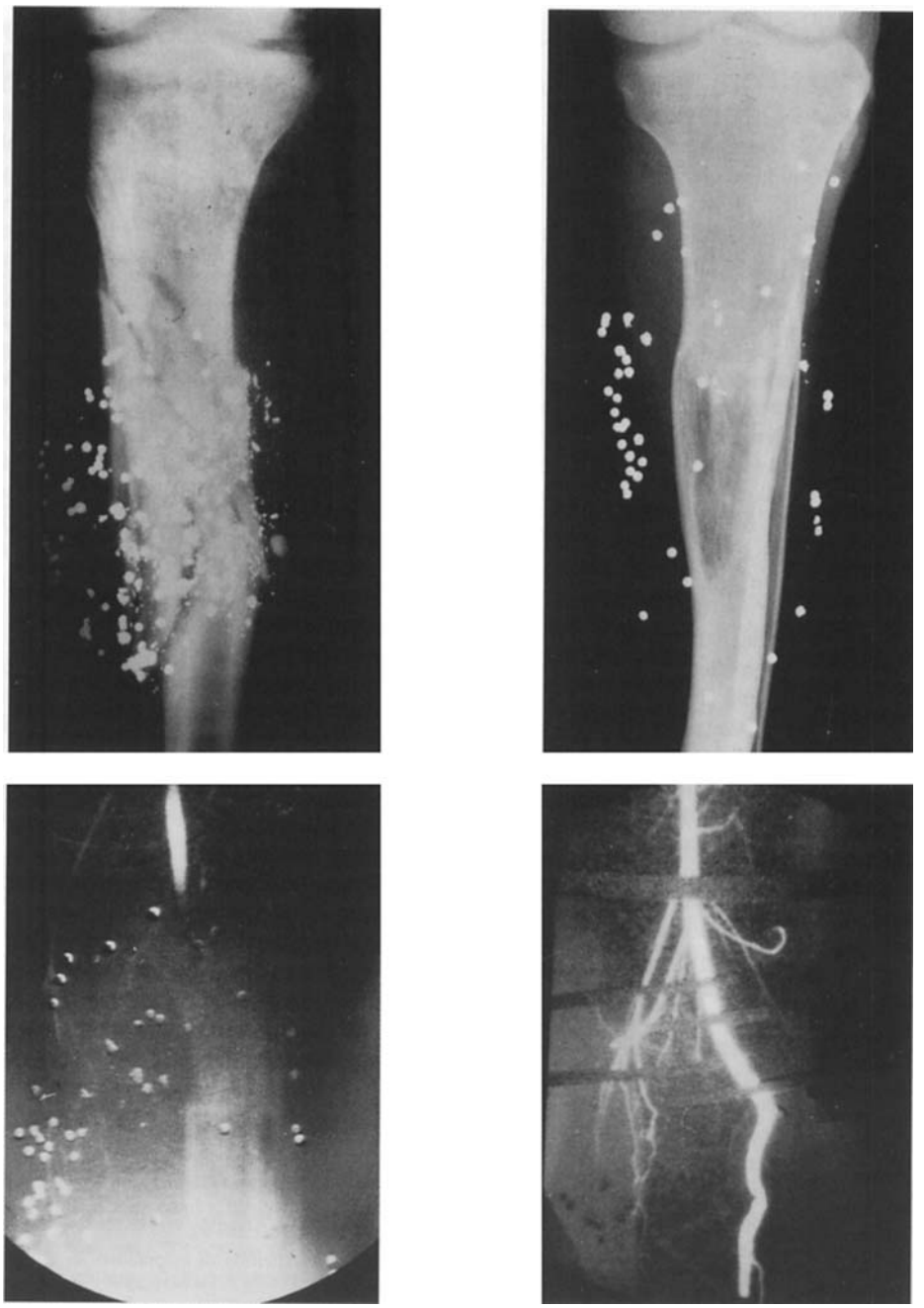

Figure 1. Open tibial fracture secondary to shot-gun injury (upper left). 3 years post-operative AP radiograph showing bony union of the tibial fracture (upper right). Preoperative arteriogram showing complete occlusion of the popliteal artery above bifurcation (lower left). 3 month-postoperative arteriogram showing patency of the popliteal artery after repair with use of a vein graft (lower right).

who had bilateral open tibial fractures (left IIIC; right IIIB), revascularization had failed in the left limb. Infection developed in both limbs, and the left was amputated 15 days postoperatively. The infection, however, could not be controlled in spite of repeated surgical debridements.

Discussion

Although the decision to salvage a limb necessitates certain traditional procedures (Johansen et al. 1990, Robertson 1991), it appears that the application of microsurgical techniques can improve the results considerably (Gustilo et al. 1990, Makin 1990, Soucacos et al. 1995). Our results are compatible with findings reported in the literature indicating that depending upon the mechanism of injury, the percentage of salvage limbs varies from 20 percent to 60 percent (Soucacos et al. 1995). In this regard, severe crush injuries and extended ischemia time are associated with lower success rates. In our patients severe crushing with extensive, often irreversible damage to the microcirculation was common. As recommended by several reports (Makin 1990) wide decompression of all compartments of the leg was performed. However, this did not appear to have a significant effect on the damaged microcirculation.

Crushing injuries of the tibia are complex as all anatomical structures, including skin, muscle, bone, vessels and nerves, are injured. Not only is treatment difficult, but complications are frequent and often life threatening. Due to the rarity of these injuries, relatively few papers regarding treatment exist in the literature. Since these few reports refer to patients with injuries induced by a variety of mechanisms, correct prognosis following revascularization is often difficult to determine. As a result of this and the non-uniformity of the injuries, indications for limb salvage versus amputation are both generalized and vague (Johansen et al. 1990, Pozo et al. 1990, Robertson 1991). Primary amputation can often be an attractive solution for both the surgeon and patient, as the problem is quickly resolved. furthermore, the surgical effort necessary to save a badly traumatized limb is enormous, requires team work, microsurgical expertise and considerable risk for the life of the patient. A salvaged limb, however, is rewarding for all concerned and usually justifies the prolonged effort, even when the functional result may not be satisfactory.

Advanced age is a disadvantage to most salvaging attempts. This was seen in a 60 year old patient who had a guillotine type amputation of the leg from a power saw. Salvage was thwarted by thrombosis of the arterial anastomosis, presumably because of atherosclerosis of the artery. The death of 1 patient from a massive pulmonary embolism while on anticoagulation therapy was attributed to the severity of the injury and not to the chosen therapy. Earlier amputation of the infected limb in the second patient who died may have prevented severe septicemia from developing (Chapman et al. 1988, Heppenstall et al. 1980, Gustilo et al. 1990). Infection and partial ischemia developed in most of out patients (10 out of 13) post-operatively, both of which appear to have an interrelated pathophysiologic etiology. In the initial ischemic environment in the tissues, infection develops. The infection allows for microthrombosis production and, as a result, further ischemia develops.

In conclusion, the application of microsurgical techniques along with a strict treatment protocol to salvage severe nonviable injuries of the tibia was associated with relatively encouraging results. However, the decision whether to amputate primarily, remains very difficult. Finally, our results suggests that patients with arterial disease or severe crushing injuries are not good candidates for revascularization and salvaging procedures.

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