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The Importance of Soft Tissue Conditions for Fractures of the Tibial Plafond: Advantages of a 2-Stage Treatment with External Fixation and Locked Plate

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Abstract: Special care must been taken to the treatment of soft tissues of patients with fractures of the distal lower-limb, particularly in the treatment of high-energy trauma with participation of the tibial pilon. We used a two-staged treatment plan for 38 patients suffering from closed fractures of the distal lower limb between January 1998 and October 2003. All patients received a joint immobilizing external fixator at the day of trauma. After consolidation of soft tissues at an average of 8,3 days after trauma and after planning surgery on the basis of native X-ray and CT-scan we performed open reduction and internal fixation with a multi directional locked-screw plate fixator. Nine cases without joint participation could be operated in a minimal invasive pattern. We could follow up all Patients after an average of 28 months. In 17 cases no reduction of Range Of Motion (ROM) of the ankle joint compared to the opposite side was recorded. Twenty one patients showed a moderate reduction of less than a third of range of motion compared to the not injured side. Four patients showed a reduction of ROM of up to two thirds. Bony consolidation was achieved in all cases. As complications we noted one deep vein thrombosis and three superficial wound necrosis which could be treated conservatively. We performed early autologous bone graft due to delayed bony consolidation in two cases. We observed a direct correlation between type of fracture and restriction of ROM and post traumatic arthritis. Eleven Patients with extra-articular fractures showed no restriction of ROM. Ninteen patients with a fracture involving the tibial pilon showed no or only mild post-traumatic arthritis of the ankle (according to the Bargon classification system). Because results of surgical treatment of the tibial pilon depend on soft tissue condition at the time of trauma we recommend a two-staged surgical treatment plan with external fixation and secondary internal locked-plate osteosynthesis to reduce soft tissue complications and to achieve good functional results.

Key words: Tibial pilon, two-stage treatment, plate osteosynthesis, angular stability

INTRODUCTION

Fractures of the distal lower limb with or without participation of the ankle joint are still a challenge for the surgeon. Due to high energy released at the time of injury, these fractures are always accompanied by a severe soft tissue damage (Jergesen, 1959; Bonar and Marsh, 1994). Boehler pointed out that even smallest joint incongruence of the tibial joint surface can lead to post-traumatic arthritis (Boehler, 1960). Allgoewer and Rueedi (1969) reported encouraging results in the surgical treatment of tibial pilon fractures (Fig. 1) (Ruedi and Allgower, 1978). They suggested a four-staged strategy which represents the base of the surgical therapy of distal lower limb fractures until today:

- Open reduction of the Fibula fracture for reconstruction of length and stabilization of the second column of the ankle.
- Reconstruction of the joint surface.
- Autologous bone graft.
- Medial plate osteosynthesis.

Success of the surgical therapy depends on the extent of the soft tissue damage. The outcome of tibial pilon fracture depends on the quality of reconstruction of the tibial joint surface (Chen *et al*., 1998; Sirkin *et al*., 1999; Egol *et al*., 2000). However, the stricter anatomical reconstruction is pursued, the larger the associated soft tissue problems will be (Hutson, 2004; Harris *et al*., 2006).

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Table 1: Two stageed therapy-strategy

Type I	Simple gap-fracture with little dislocation of the joint surface
Type II	Fracture including the joint surface with dislocation, but without destruction
Type III	Intraarticular fracture with substantial joint destruction and collateral soft tissue damage

Fig. 1: X-Rays of tibial pilon fractures

Altogether unsatisfying results and an alarming increase of complications after Open Reduction and Internal Fixation (ORIF) of tibial pilon fractures are reported (Marsh, 1999; Dickson *et al*., 2001; Pollak *et al*., 2003; Leung *et al*., 2004; Marsh *et al*., 2006). Most problems are concerning wound healing, non-unions, secondary dislocation and post traumatic bone infection. Due to these problems a change in the treatment strategy for distal lower limb fractures occurred in the last years. One approach was external fixation combined with minimally-invasive applied screw fixation, another a two- or more-staged concept for internal fixation. By this it was tried to fulfil the high requirements of this type of injury (McFerran *et al*., 1992; Bone *et al*., 1993; Tornetta *et al*., 1993; Syed and Panchbhavi, 2004).

Beside the soft-tissue situation, main problem in external fixation is the fixation of screws in the distal tibial bone. Either a high number of secondary dislocations occur, or unsatisfactory functional results are reported due to long time immobilization in cast, used because of a fear of loss of reduction (Patterson and Cole, 1999; Pollak *et al*., 2003). Operating method and its results after two-staged treatment with external fixation and secondary angular stable plate osteosynthesis are reported (Table 1).

MATERIALS AND METHODS

From January 1998 until October 2003, we treated 38 patients suffering from closed distal lower limb fractures.

Table 2: Type of Fracture (according to Rueedi and Allgoewer)

Extraarticular	7
Type-I I injury	3
Type-II injury	12
Type-III injury	16

Fig. 2: X-Rays after stabilization with external fixator

Average age was 43,7 years (16-63 years), 30 patients were male. In 29 cases the cause of injury was work-related. Twenty five patients suffered a high-energy trauma (fall from height >3 m, road traffic accident), two of these were polytraumatised.

In 31 cases there was a distal intra-articular fracture. These cases were classified according to the classification suggested by Rueedi and Allgoewer (1969) (Table 2).

Treatment protocol: At the first treatment-stage, on the day of trauma, all patients were treated with a joint-immobilizing external fixator (AO Fa. Synthes, Bochum Germany). Depending on the surgeon performing the operation, the external fixator was either used as a frame-construction or in a three-dimensional pattern (Fig. 2 and 3). It was taken care not to place the Schanz-screws in the area of the planned definitive plate and screw position. The definitive treatment was performed as soon as soft tissue situation allows. The operative procedure was planned on the basis of native X-ray and a CT-scan when joint-surface was involved (Fig. 4 and 5). We used a multi-directional angular stable internal plate fixator (Tifix©, manufactured by LITOS, Hamburg/ Germany). The plate is made of pure titanium with locking

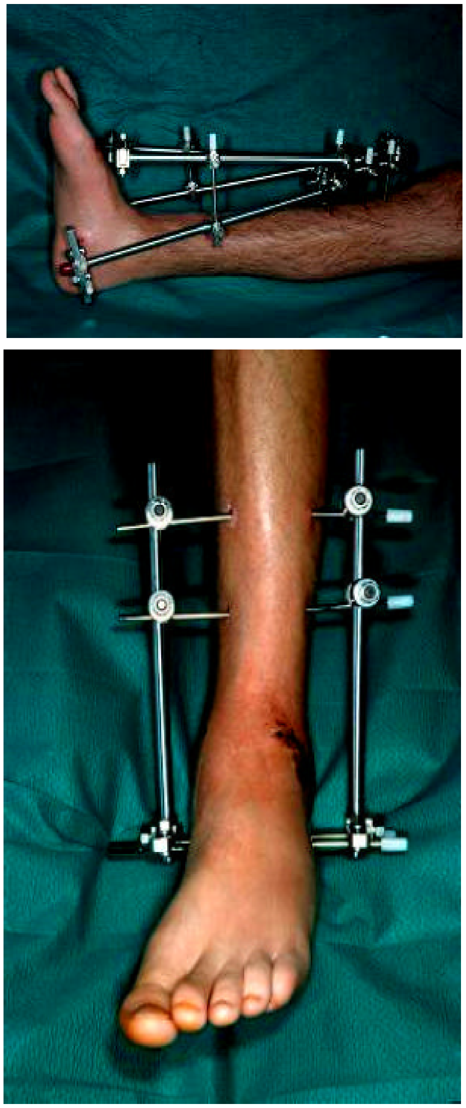

Fig. 3: Clinical pictures after stabilization with external fixator

wholes for titanium screws which can be fixed in different angles. (Fig. 6). When the joint surface was not involved, a minimally invasive approach was performed. In these cases an approximately 3 cm incision was performed over the anteromedial side of the tibial pilon and another proximal of the fracture at the ventral tibial edge. A subcutaneous tunnel was formed and the plate then placed in this tunnel. Otherwise an anteromedial approach to the tibia was used. After visualization of the joint surface, attention was paid on the precise reconstruction of the tibial joint surface. Usually all plate holes were used with locked screws, three screws placed proximally and three screws distal of the fracture.

Fig. 4: X-Rays after ORIF

Fig. 5: X-Rays after removal of Ostheosynthesis

Postoperatively patients were mobilized on crutches with 10kg weight bearing. Depending on fracture pattern and follow-up x-ray, usually after 6 weeks weight bearing was increased incrementally.

The mean follow-up time was 27.5 months (6-61 months). All patients could be followed up. All follow-up examinations were performed by one specialised orthopaedic trauma Surgeon (C.Q.). Examination consisted of a set of standardized questions, clinical evaluation (AOFAS Score) and radiographs. Radiographs were

Table 3: Radiological result according to Bargon and Henkemyer (1977)

Grade of arthrosis	Radiological criteria of arthrosis	No. of pt. (n = 31)
0	Sclerosis of the weight bearing zone without narrowing of joint	3
1	Sclerosis of the weight bearing zone with small osteophytes and slight narrowing of joint	16
2	Sclerosis of the weight bearing zone with marked osteophytes and narrowing and marking of the subchondral lammellae	9
3	Near total waste of the joint space, subchonral defects and cystical lesions of the cancellous area	3

Fig. 6: Angular stable Implant (Fa. Litos, Hamburg, Germany)

assessed using the classification system as described by Bargon and Henkemeyer (1977) (Table 3).

RESULTS

The definitive treatment was performed after an average of 8,3 days (4-13 days). In six of the seven cases without joint participation minimal invasive plate osteosynthesis was possible. For the 31 remaining patients an antero-medial approach to the tibia was used. In 8 cases an autologous bone graft was necessary. Full weight bearing was reached after an average of 13.4 weeks (10-22 weeks).

Bony union could be achieved in all cases. In two cases an early autologous bone graft was performed for delayed union. In 16 cases Range Of Motion (ROM) of the ankle did not show any restriction compared to the opposite side. In 19 cases the range of motion was reduced less than a third compared to the opposite side. There was a reduction of up to two thirds in three patients. Restriction in the ROM of more than 2/3 was not noted. As expected there was a direct correlation between the type of fracture and restriction of the movement. In the seven patients with extra-articular fractures of the lower limb we did not see restrictions of ROM, 3 of the 4 patients with a type III fracture with severe destruction of the tibial joint surface had a restricted ROM of 2/3 compared to the opposite side. Radiologically, using the Bargon classification, 19 of the 31 patients with a fracture involving the tibial joint surface showed a grade I mild posttraumatic-arthritis, 9 patients a moderate grade II and 3 patients a severe posttraumatic-arthritis on follow up x-rays.

Complications: Superficial wound-necrosis was noted in three cases, conservative treatment lead to complete wound healing in all these cases. Deep vein thrombosis of the femoral vein occurred in one case. In two cases with insufficient bone healing early autologous bone graft was necessary after 4 and 5 months, respectively. Deep wound infection or postoperative osteitis was not observed.

DISCUSSION

Due to the high amount of energy released at the time of injury fractures of the tibial pilon are accompanied by severe soft-tissue damage. Therefore, it requires special tactical-strategy to avoid disappointing results (Marsh *et al*., 2003; Hutson, 2004). Jergesen (1959) stated that ORIF of tibial pilon fractures achieving good results is impossible. Ten years later Rueedi and Allgoewer for the first time reported the results of 84 surgical treated pilon-tibiale fractures (Rüedi and Allgöwer, 1969). The success of the surgical therapy depended on the extent of soft-tissue damage. Considering the increasing amount of high-energy trauma within the last years an alarming increase of complications after ORIF and a lower amount of successful treatments were reported (Marsh, 1999; Pollak *et al*., 2003; Queitsch *et al*., 2006). According to Pollak *et al*. (2003) the results depend on the primary existing soft-tissue damage (Pollak *et al*., 2003). For complex pilon-tibiale fractures with severe soft-tissue damage he could only achieve disappointing results. Goal of all surgical treated pilon-tibiale fracture should be an anatomical reconstruction of the tibial joint surface. Excessive soft-tissue dissection should be avoided (Bonar and Marsh, 1994; Patterson and Cole, 1999; Renzi Brivio *et al*., 2000).

Internal stabilisation should strictly be avoided in cases with severe soft-tissue damage. Kilian *et al*. (2002) found an infection rate of 25,5% in the group of type III fractures with a soft-tissue damage grade 2 (Kilian *et al*., 2002). Ninety percent of these patients were treated with primary ORIF. The type III fractures with a soft tissue damage grade 3 showed an infection rate of 36.6%.

Due to the high rate of complications some authors prefered the definitive treatment of severe tibial pilon fractures with the use of external fixators (McFerran *et al*., 1992; Marsh *et al*., 2006). One disadvantage of this strategy is the fact that in many cases ankle-immobilizing constructions are necessary. Due to persisting temporary ankle arthrodesis it leads to a lasting high-grade restriction of ROM of the ankle. Another disadvantage, apart from the frequent local pin infections, is the missing possibility of accurate tibial joint surface reconstruction, leading to post-traumatic arthritis. To avoid temporary ankle arthrodesis Endres *et al.* (2004) recommended the use of an Ilizarov-Fixator and additional screws for the treatment of C2 and C3 fractures (Rueedi type III injuries) (Endres *et al.*, 2004; Rammelt *et al.*, 2004). These constructions should not be performed in a joint-immobilizing pattern. Following this treatment-strategy early physiotherapy of the ankle can be performed. In addition to frequent pin infections, the possibility for exact reconstruction of the tibial joint surface is missing. For good long-term results a strict anatomical reconstruction of the tibial joint surface with sufficient stabilization has to be claimed. Until today pilon-tibiale fractures have often been treated with solid implants, with its disadvantages for the bone vitality and for the soft tissues. Today we know that the disturbance of blood supply at the bone surface depends on the plate "covering" the bone (Sirkin *et al.*, 1999; Tyllianakis *et al.*, 2000; Sirkin and Sanders, 2001). Another reason for the high complication rate in ORIF is the missing stability of the screws in the bone of the tibial pilon. Especially in cases with osteoporosis a high primary stability cannot be achieved. That leads to the appearance of non-unions, infections and loss off reduction (Patterson and Cole, 1999; Sirkin *et al.*, 2004). The implant for internal stabilization of the pilon tibiale fracture should fulfil the following requirements:

- Secure and lasting stabilisation of the accurate anatomical reposition of all joint surface fragments.
- Keep correct alignment of the reconstructed joint surface to the lower leg axis.
- Flat implant-design to care for thin soft-tissue coverage.

Wolter *et al.* (1999) and Seide *et al.* (1999) reported about the advantages of angular stability (Seide, 1999; Wolter, 1999). In not angular stable connections the stabilisation depends on the pressure of the plate against the bone by screws. In the case of a locked plate-to-screw connection, a connection is build in the sense of a side clamped bar, which transfers the load from the bone to the plate. Applying pressure on the plate to the bone is not necessary and the blood circulation of the bone surface is less impaired. The reconstruction of the joint surface is not necessary in extra-articular distal lower limb fractures. In these cases the advantages of angle stability can be used in combination with a minimal-invasive approach (Seide *et al.*, 1999; Wolter *et al.*, 1999).

The described therapy-strategy offers the possibility to combine the advantages of an external fixator and ORIF. With the use of an external fixator on the day of trauma soft tissue damage is minimized and swelling can be reduced faster and easier. The time of ORIF should not be selected too early. In our patients after an average of 8.3 days after trauma. After optimal soft-tissue conditions are achieved, open reduction with accurate reconstruction of the tibial joint surface can be performed with minimized risk. Stabilization with the described implant leads to high primary stability. Without the pressure of the plate to the bone a maximum of periostal blood supply can be obtained.

Following this two-staged therapy-strategy we could achieve good functional results in our collective of patients with a low complication rate.

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