

The Orthoplastic Approach for the Management of Early Postoperative Infections of Tibial Plateau Fractures

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ABSTRACT

Introduction: The orthoplastic approach enables simultaneous treatment of soft tissues and fracture. The aim of the present study was to report the results of patients who received orthoplastic treatment for early postoperative infection after osteosynthesis of tibial plateau fractures.

Methods: From 2008 to 2018, 17 patients underwent orthoplastic surgery for early postoperative infection after internal fixation of tibial plateau fractures in our center. The median time from internal fixation to re-operation was seven weeks (4-10). Tissue cultures and sonication fluid cultures of implants were obtained. In all cases, circular external fixation was used. Soft-tissues were covered with either the medial head of gastrocnemius along with split-skin graft (13 patients) or local advancement flaps (four patients). Postoperatively, antibiotics were administered based on antimicrobial susceptibility testing. At follow-up, clinical and radiologic examination was performed to assess wound healing and fracture union.

Results: Circular external fixation was used for continuation of fracture stabilization in 14 patients and for knee arthrodesis due to severely damaged articular surfaces in two patients. One case was treated with anterior tibia bone transport. In all cases, bone union was achieved and skin was healed completely. SF-36 results at three years postoperatively were 61.29 ± 12.38 for the physical health component and 68.15 ± 13.34 for the mental health component.

Conclusion: In the right setting and with the required expertise, single stage orthoplastic treatment is a valid option that spares the patient from the distress of multiple procedures and offers acceptable clinical outcomes.

Keywords: orthoplastics, tibial plateau fractures, ORIF, infection.

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INTRODUCTION

Tibial plateau fractures represent 1% of all fractures and typically exhibit a bimodal distribution: high-energy fractures in young active individuals, who are more likely to have severe soft-tissue damage, and low-energy fractures in the elderly (1). The intra-articular nature of tibial plateau fractures is associated with high complication rates, even after surgical treatment. These include malunion, nonunion, infection and knee stiffness (2, 3). Mixed results regarding the long-term functional outcomes and quality of life in patients with surgical fixation of tibial plateau fractures have been reported in the literature (4).

Early postoperative infections in the setting of open reduction internal fixation (ORIF) of tibial plateau fractures present a devastating complication and remain a challenge due to the risk of severe bone, soft-tissue and skin defects. In the literature there are numerous reports regarding an increased incidence of infections after proximal tibial ORIF, with rates ranging between 3% and 45% in various studies, while a recent systematic review by Henkelmann *et al* (5) reported an incidence of 12.3% and a meta-analysis by Norris *et al* an incidence of 6.4% (6). Several risk factors for postoperative tibial plateau infections have been identified, including open fractures, smoking, previous fasciotomies for the management of compartment syndrome and bicondylar fractures requiring double plating (7-9).

The orthoplastic approach in the management of such entities enables the surgeon to address both the soft tissue damage and the fixation of the fracture (10). Extensive debridement of necrotic bone and soft tissues is required in the setting of osteomyelitis, while stabilization with external fixation along and flap coverage optimize the healing process and distribution of antibiotics (11).

The aim of the present study was to report the results of patients who received an orthoplastic treatment for early postoperative infection after osteosynthesis of tibial plateau fractures. □

PATIENTS AND METHODS

From 2012 to 2018, 17 patients underwent orthoplastic surgery for early (< three months)

postoperative infection after ORIF of tibial plateau fractures in our center. All patients provided a written informed consent.

All patients had active and persistent drainage from the surgical site. Intraoperatively, meticulous debridement of necrotic bone and soft tissues was performed and the implants were removed. Tissue cultures and sonication fluid cultures of the explanted implants were obtained. In all cases, circular external fixation was used and flap coverage was performed.

After surgery, antibiotics were administered based on intraoperative antimicrobial susceptibility testing for at least six weeks. The wound was closely inspected for signs of necrosis or infection until suture removal. Full blood count, CRP and ESR were obtained weekly to monitor possible infection resurgence as well as serum panels for the renal (creatinine, blood urea nitrogen – BUN) and hepatic (alanine amino transferase – ALT, aspartate amino transferase – AST, alkaline phosphatase – ALP) function to evaluate possible adverse effects of antibiotic administration.

Radiological evaluation was performed monthly until fracture union and annually thereafter. Measurement of knee range of motion (ROM) and SF-36 (12, 13) was performed at three years to evaluate patient satisfaction. Data were expressed as mean $\pm$ standard deviation (SD) for continuous variables and as percentages for categorical data. □

RESULTS

The 17 patients (14 males and three females) had a mean age of 43 years and a mean BMI of 24.23 kg/m². The mean time from the ORIF to re-operation was seven weeks (4-10 weeks). The Oestern and Tscherné classification was used to classify the initial fractures that underwent ORIF, with 11 cases being classified as grade 2, four cases as grade 1 and two cases as grade 0. Demographics and patients' characteristics are detailed in Table 1.

Tissue and sonication cultures identified several causative microbial agents, including *Staphylococcus aureus* (five cases), *Klebsiella pneumoniae* (three cases), *Pseudomonas aeruginosa* (three cases), *Enterobacter cloacae* (two cases) and polymicrobial infections (four cases), as shown in Table 1. There was 100% concor-

TABLE 1. Patients' characteristics and results of tissue and sonication fluid cultures

Variable	N =17
Gender (males/females)	14 (82.35%) /3 (17.65%)
Age (years) (mean[range])	43.71 [19-62]
BMI (kg/m ²) (mean[range])	24.23[19.32-35.41]
Active smokers (%)	12 (70.59%)
Follow-up (years) (mean ± SD)	5.3±1.96
Time from ORIF to surgery (mean[range]) in weeks	7 [4-10]
Oestern and Tscherne classification (for closed fractures)	
Grade 0	2 (11.76%)
Grade 1	4 (23.53%)
Grade 2	11 (64.71%)
Results of tissue and sonication fluid cultures	
Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	5 (29.41%)
<i>Klebsiella pneumoniae</i>	3 (17.65%)
<i>Pseudomonas aeruginosa</i>	3 (17.65%)
<i>Enterobacter cloacae</i>	2 (11.76%)
Polymicrobial infections	4 (23.53%)

SD=standard deviation; ORIF=open reduction internal fixation

TABLE 2. Orthoplastic management

Treatment	N (%)
Flap coverage	
Medial head of gastrocnemius	13 (76.47%)
Local advancement flaps	4 (23.53%)
Bone procedure (with the use of circular external fixation)	
Fracture stabilization	14 (77.78%)
Knee arthrodesis	2 (11.76%)
Bone transport	1 (5.56%)

dance between tissue and sonication fluid cultures. Three months postoperatively, no sign of inflammation or necrosis was encountered, as measured by the blood indices, and no adverse reaction to the antibiotics were recorded.

Circular external fixation was used for continuation of fracture stabilization in 15 patients and for knee arthrodesis due to severely damaged articular surfaces in two patients. In one patient with severe anterior tibial bone and patellar tendon loss, partial distal corticotomy after debriding the exposed tibia was performed to transport the healthy distal anterior aspect of the tibia proximally, so reattachment of the patellar tendon could be possible. Both corticotomy and docking sites were autografted in this case. Spanning of the joint was avoided in cases with fracture stabilization; in patients with high comminution, a half-ring was placed above the joint for three weeks. Flap coverage was performed with the medial head of gastrocnemius along with split-skin graft in 13 cases and local advancement flaps in four cases (Table 2). Figures 1 and 2 show two cases treated with the orthoplastic approach. Figure 3 illustrates the bone transport case.

In all cases, bone union was achieved by three months and skin was healed completely, without signs of inflammation or necrosis. Passive knee ROM exercises were initiated immediately after surgery. Non weight bearing exercises were allowed for the first three months, while weight bearing started at three months postoperatively based on the radiologic follow-up. The external fixators were removed when bone union was complete.

SF-36 results were 61.29 ± 12.38 for the physical health component and 68.15 ± 13.34 for the mental health component at three years postoperatively. Mean flexion was 117.67 ± 14.13

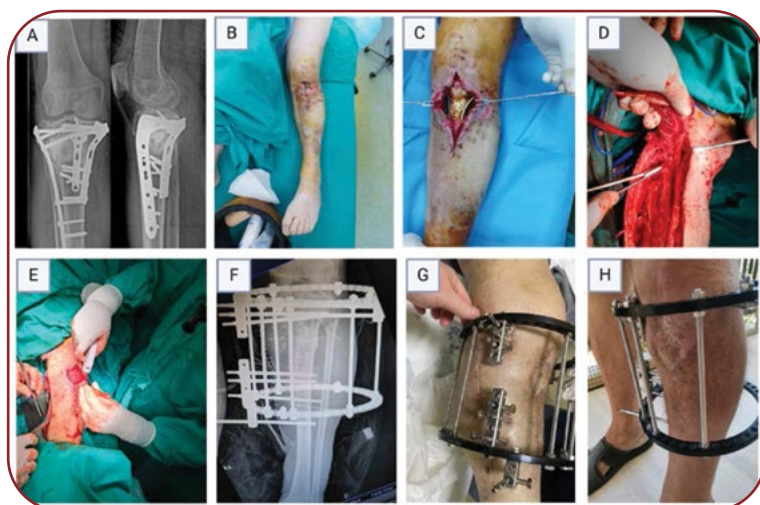


FIGURE 1. Case 1: A) X-ray of tibial plateau fracture treated with ORIF; three plates were used for anatomic reconstruction of the articular surface and bone cement was employed to address bone loss and to support the osteosynthesis process; B) the patient presented with wound dehiscence, severe soft tissue envelope compromise and exposed bone; C) the plates were directly exposed under the skin; D, E) after implant removal and the use of autograft from the ipsilateral iliac crest, flap coverage was achieved with the use of the medial head of gastrocnemius; split-skin graft harvested from the ipsilateral thigh was placed on top of the muscle; F, G) postoperative X-rays and clinical photo with the presence of the circular frame; three half-pins were placed proximally and four distally; H) the patient is full weight-bearing with the circular frame (three months postoperatively).

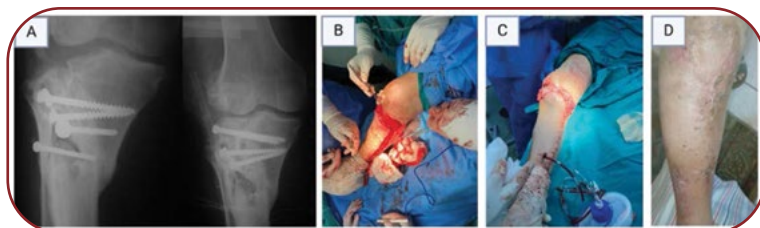


FIGURE 2. Case 2: A) X-rays of a patient treated with screw fixation (partially threaded screws were used); B) after implant removal, the medial head of the gastrocnemius was used to cover the defect; C) split-skin graft of the ipsilateral thigh was used to cover the muscular flap; D) complete wound healing was achieved (photo was taken after removal of the external fixator)

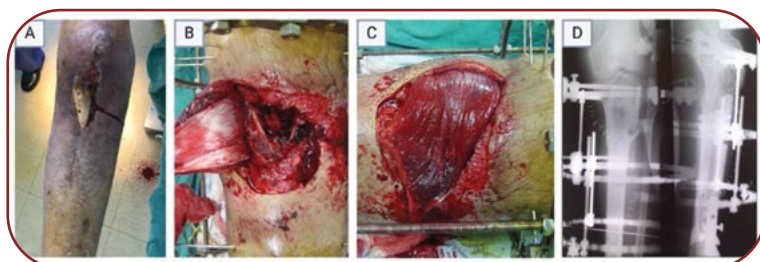


FIGURE 3. Case 3: A) wound dehiscence with deep infection, skin necrosis, exposed tibia and detached patellar tendon; B, C) severe bone loss was evident after meticulous debridement of the necrotic bone; the medial head of the gastrocnemius was used for soft-tissue coverage; D) partial distal corticotomy and bone transport was performed in this case.

TABLE 3. Functional outcomes three years postoperatively

SF-36 domains	Mean $\pm$ standard deviation (SD)
Physical health component	61.29 $\pm$ 12.38
Physical functioning	59.12 $\pm$ 20.93
General health	58.82 $\pm$ 14.42
Bodily pain	83.09 $\pm$ 16.38
Role physical	44.12 $\pm$ 25.81
Mental health component	68.15 $\pm$ 13.34
Role emotional	66.68 $\pm$ 20.42
Emotional health	74.59 $\pm$ 13.92
Social functioning	63.97 $\pm$ 17.05
Vitality (energy/fatigue)	67.35 $\pm$ 13.36
Knee range of motion	Mean degrees $\pm$ SD
Flexion	117.67 $\pm$ 14.13
Extension deficit	12 $\pm$ 7.51

degrees and mean extension deficit was 12 $\pm$ 7.51 degrees (the arthrodesis cases were excluded from these measurements). Patients' results regarding ROM and detailed quality of life assessment as measured with SF-36 are summarized in Table 3. $\square$

DISCUSSION

Infections after tibial plateau ORIF are potentially disastrous complications that could lead to articular destruction and negative effects to the physical and emotional health of the affected individuals. These cases can progress rapidly and lead to articular surface destruction, segmental bone defects, soft tissue defects and chronic osteomyelitis. Several treatment options have been described in the literature, including debridement with implant retention, implant removal, the use of vacuum-assisted drainage, flap coverage, external fixation, bone cement and the use of local antibiotics (14, 15). All the above-mentioned options are combined with prolonged intravenous antibiotics to control the infection.

Early onset infections enable the surgeon to perform minimal bone debridement and single-stage treatment. Several single-stage treatment options have been described in the literature, including debridement with implant retention, implant removal, use of vacuum-assisted drainage, muscle-flap coverage, external fixation, bone cement and the use of local antibiotics (14). In our series, the implants were removed in all cases and fracture stabilization was performed, with the use of circular external fixator as a means of definitive fixation method. Circular external fixators have been shown comparable results to ORIF in the setting of complex tibial plateau fractures (16, 17). We generally avoided spanning of the knee joint to reduce stiffness, but in cases of high comminution a half-ring was placed above the joint for three weeks. A decision to proceed with knee arthrodesis was made in two cases with severe articular damage with extension to the diaphysis in patients with polymicrobial infections.

In all cases, debridement of dead bone was performed until viable bleeding bone was encountered. In patients with bone defect, the dead space was filled with autologous cancellous bone graft, harvested from the iliac crest or the concomitant femoral metaphysis or both. Several ways to manage the dead space after debridement have been described in the literature, including antibiotic beads, bioactive glass, bone allograft, bone graft substitute pellets, antibiotic loaded hydroxyapatite and bone matrix (18). However, autologous bone grafting has been shown to be superior to other methods in terms

of histocompatibility and osteogenic potential (19). In one case, we chose to transport the anterior distal tibia proximally due to severe bone loss and detachment of the patellar tendon. A similar technique was recently described for the treatment of chronic osteomyelitis involving the anterior tibial cortex (20).

In the presented series, flap coverage along with fracture stabilization in one stage was performed after meticulous soft tissue debridement. The goal of early coverage was to enhance regional blood flow in order to ameliorate the distribution of antibiotics and enhance the bone healing process, especially with the use of the medial head of gastrocnemius muscle flap, as reported by previous studies (11, 21, 22). All steps of the procedure, including the flap, were performed by the same attending orthopedic surgeon (senior author) with experience in adult limb reconstruction and limb salvage surgery. Nevertheless, the orthoplastic approach is usually implemented with the cooperation of orthopedic and plastic surgeons in institutions that offer both specialties. The assistance of plastic surgeons in the management of complex soft tissue and skin defects following orthopedic infections is invaluable. In our facility, the cooperation with the plastic surgeons provided us with a plethora of alternate techniques like the gracilis and soleus muscle flaps as well as the anterolateral thigh and latissimus dorsi free flaps, that are crucial in larger defects around the knee and in cases where a gastrocnemius musculocutaneous flap is not available (23).

Functional outcomes were measured at three years postoperatively. Knee ROM was satisfactory in most cases. However, quality of life assessment with SF-36 showed that there were important physical functioning limitations, with a score of 59.12 ± 20.93 for the physical functioning domain and 44.12 ± 25.81 for the role physical, despite minimal reported pain (83.09 ± 16.38). Mental health was also affected to a lesser extent, with an overall score of 68.15 ± 13.34 and similar scores in each domain. However, this is an expected and acceptable outcome in the setting of the detrimental sequelae that follows the postoperative tibial plateau infections. To the best of our knowledge, there has not been a case series of multi-stage treated, tibial plateau fracture infections that were assessed for clinical outcomes with the SF-36 and thus, direct comparison was not

possible. Nonetheless, in a study by Nasser *et al*, the single stage orthoplastic treatment of bone infection was compared to the more traditional two-stage treatment (24). Their research showed comparable clinical outcomes between the two approaches, with less recurrence of infection and lower rates of amputation for the single stage. They also reported a higher average time to bone union for the single stage, which could be attributed to the fact that autologous bone grafting was not standardized in their practice. Successful single stage treatment of bone infection is beneficial for the patient, as it is linked with shorter hospital stay, reduced theater time without multiple surgeries and less time off work. In addition, previous studies have proved that single stage orthoplastic treatment is advantageous for healthcare systems as it correlates with lower medical costs through shortened hospitalization, decreased theater time and reduced antibiotic use (25, 26).

Our study has some limitations. First, it is a retrospective study with a relatively small sample size from a single center and thus, the results should be reasonably interpreted. Additionally, due to the nature of bone infection and the variability of bone and soft tissue defects between cases, the surgical technique and treatment plan were not possible to be standardized. In order to avoid selection bias, all cases with postoperatively infected tibial plateau fractures treated in a single stage in our institution were included. □

CONCLUSION

Early onset infections after open reduction and internal fixation of tibial plateau fractures are complex complications that greatly impact patients' clinical course and quality of life. In the right setting and with the required expertise, single stage orthoplastic treatment is a valid option that spares the patient from the distress of multiple procedures and offers acceptable clinical outcomes. Future studies should focus on comparing clinical outcomes between single stage and multi-stage orthoplastic treatment, including results from different institutions and examining different types of fixation and dead space management. □

Statement of human and animal rights: All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and

with the Helsinki Declaration of 1975, as revised in 2008..

Informed consent: All patients enrolled in this study gave their informed consent to participate and no identifying factors were used.

Authors' contributions: CA and PG equally contributed to data collection, manuscript writing, surgery assistance; AK, CPS and PM: data collection, surgery assistance; DFG: surgery assistance; CG: performance of flap procedures

with VDP; VDP: performance of all surgical procedures, study design, study supervision and coordination. All authors provided critical feedback and approved the final version of the manuscript.

Data availability: The data that support the findings of this study are available from the corresponding author, CA, upon reasonable request.

Conflicts of interest: none declared.

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