

Traumatic Complete Loss of Knee Extensor Mechanism and Its Reconstruction With a Fresh-frozen Patellar Allograft With Patellar and Quadriceps Tendon

Traumatischer vollständiger Verlust des Kniestreckapparats und dessen Rekonstruktion mittels eines Fresh Frozen Allografts mit anheftender Patella- und Quadrizepssehne



Authors

Johannes Weber¹, Maximilian Kerschbaum¹, Silvan Klein², Florian Hitzenbichler³, Markus Rupp¹, Volker Alt¹

Affiliations

- 1 Unfallchirurgie, Universitätsklinikum Regensburg, Deutschland
- 2 Abteilung für Plastische, Hand- und Wiederherstellungschirurgie, Universitätsklinikum Regensburg, Deutschland
- 3 Krankenhaushygiene und Infektiologie, Universitätsklinikum Regensburg, Deutschland

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Correspondence

Dr. Johannes Weber


Unfallchirurgie

Universitätsklinikum Regensburg

Franz-Josef-Strauß-Allee 11

93053 Regensburg, Deutschland

johannes1.weber@ukr.de

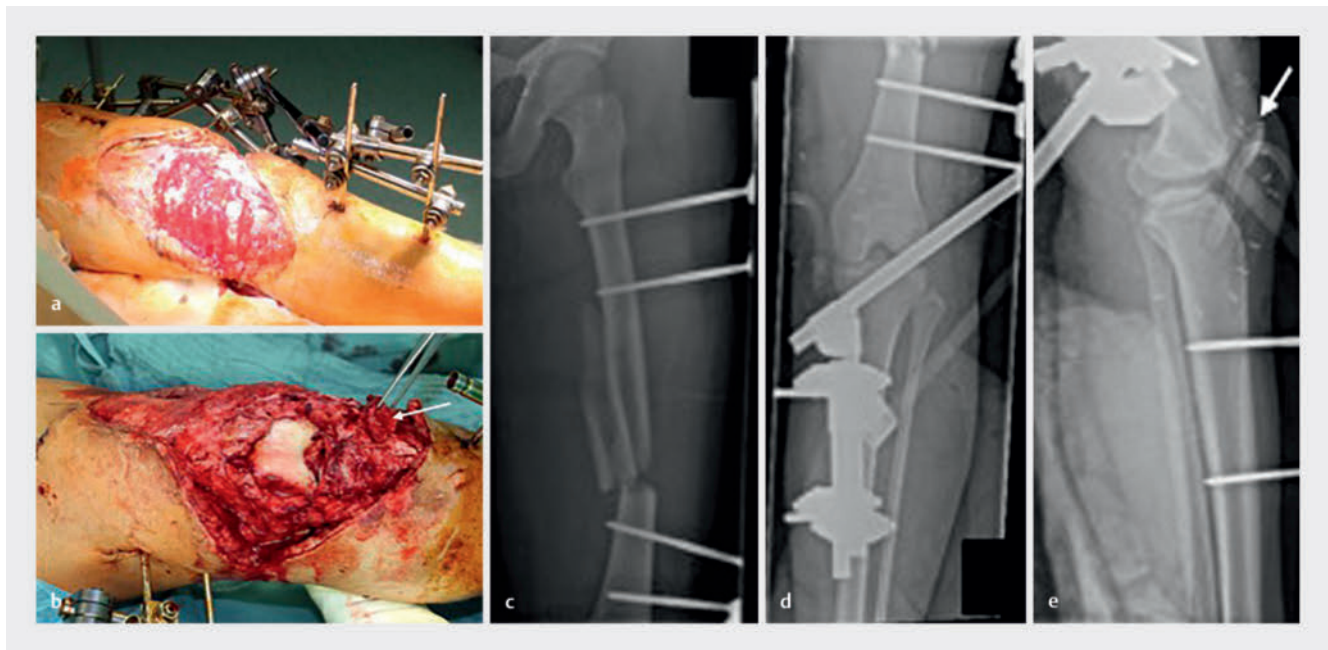
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ABSTRACT

We report on an 18-year-old female who sustained complete loss of her knee extensor mechanism (patella, quadriceps and patellar tendon) due to a motorbike injury with severe soft tissue loss of the ventral aspect of the knee and subsequent infection. After infection control and successful latissimus dorsi free flap surgery, reconstruction of the knee extensor mechanism was performed using a fresh frozen extensor mechanism allograft with patella, quadriceps- and patellar tendon and integrated tibia tuberosity fragment. After a follow-up of 18 months, there was infection free integration of the allograft with a range of motion 0–90° (extension/flexion) and pain free gait.

ZUSAMMENFASSUNG

Der vorliegende Case Report handelt von einer 18-jährigen Patientin, die infolge eines Motorradunfalls mit schwerem ventralen Weichteilschaden über dem linken Knie und anschließender Infektion einen kompletten Verlust des Streckapparats (Patella, Quadrizeps- und Patellarsehne) des linken Kniegelenks erlitt. Nach Infektsanierung und erfolgreicher Einheilung eines freien Latissimus-dorsi-Lappens erfolgte die Rekonstruktion des Streckapparats mittels eines Fresh Frozen Streckapparat-Allografts mit Patella, Quadrizeps- und Patellarsehne mit integriertem knöchernem Tuberositas-tibia-Fragment. Nach einer Beobachtungszeit von 24 Monaten zeigt sich eine infektfreie Einheilung des Transplantates bei einer aktiven Beweglichkeit von Extension/Flexion von 0–90° und schmerzfreiem, nahezu normalem Gangbild.



► **Fig. 1** Clinical (a, b) and radiological (c, d, e) images following transfer of the patient to our department.

Medical History

An 18-year-old female suffered a serious motorcycle injury in 2021 when she collided with an oncoming vehicle at high speed out of town. Among other injuries, the motorcyclist sustained a severe type 3 extremity trauma (Gustilo-Anderson type IIIB) on the left side from the accident which included a multi-fragment femoral shaft fracture, open knee joint injury with the loss of anteromedial soft-tissue coverage of the joint, subtotal loss of the knee extensor mechanism with partial loss of the quadriceps and patellar tendons, parts of the patella and anterior tibial head fracture. After receiving initial care in another hospital including placement of a VAC device and an external fixation device extending beyond the knee joint, a second-look procedure was carried out prior to the necessary reconstruction surgery, which also confirmed multibacterial wound infection (*Bacillus cereus*, *Enterococcus faecalis*, *Kluyvera intermedia*). The patient was then transferred to our department for further treatment.

Findings

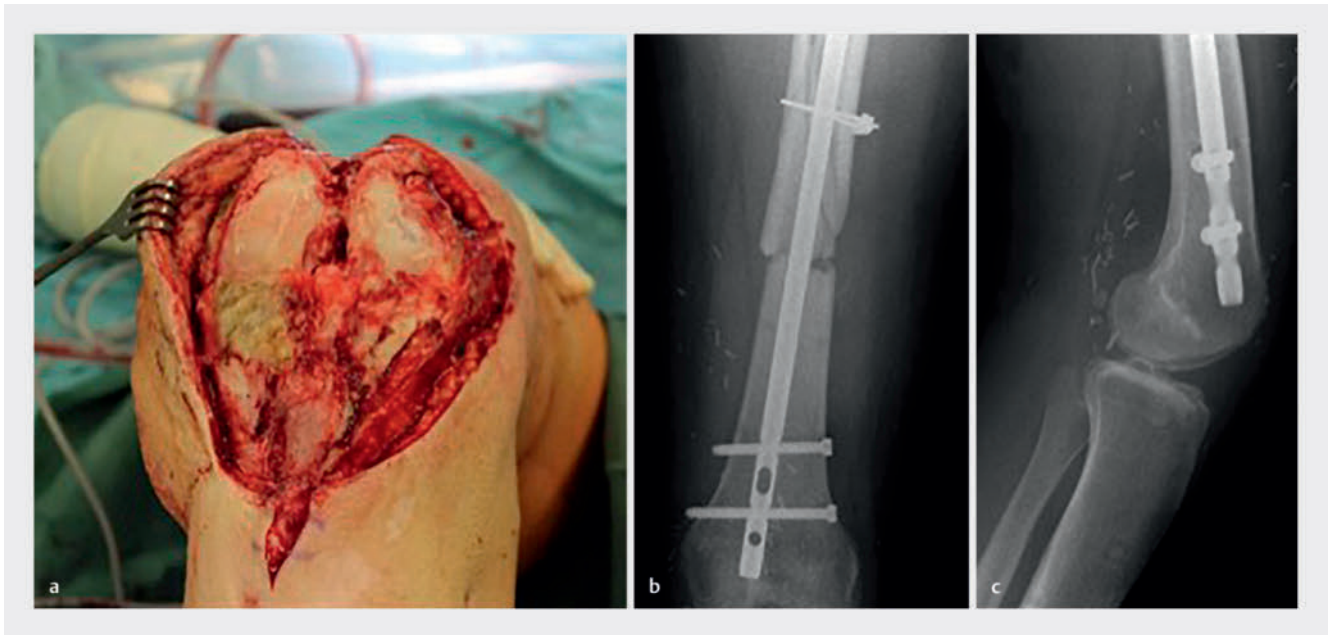
On transfer to our department, examination showed pronounced ventral soft-tissue defect of about 25 × 15 cm in the area of the anteromedial thigh and knee covered by a vacuum-assisted wound dressing, previously confirmed trauma-related knee joint infection, and an external fixation device extending beyond the knee joint (s. ► **Fig. 1**). Imaging confirmed the diagnosed bony defects mentioned above. Duplex sonography and CT angiography performed in the context of emergency vascular surgery found no further accident-related vascular damage except for complete left popliteal vein thrombosis. There were no peripheral sensorimotor losses with the exception of defect-related failures.

Treatment and Course

The interdisciplinary extremity board of our institution decided to start treatment by resolving the infection and repairing the soft-tissue defect by carrying out a free latissimus dorsi flap-plasty together with a split-thickness skin graft. This would then be followed by temporary reconstruction of the extensor mechanism by performing hamstring tendon plasty.

During the third-look operation (s. ► **Fig. 2**), foreign bodies still present in the wound were entirely removed, and local antibiotics were administered after repeat debridement and the taking of bony and soft-tissue samples. The above-described flap reconstruction with screw osteosynthesis of the tibial head and reconstruction of the extensor mechanism using a semitendinosus tendon was carried out 9 days after transfer of the patient to our department. Surgery was done under antibiotic therapy consisting of piperacillin/tazobactam to combat antibiotic-resistant bacteria and with repeat temporary placement of a vacuum-assisted wound closure system. Macroscopic examination showed no signs of infection and preservation of the cranial superior pole of the patella. This subsequently healed well, allowing the remaining superficial skin defects to be covered with split skin grafts. Treatment of the femoral fracture was changed from an external fixation device to osteosynthesis surgery with placement of an antegrade intramedullary femoral locking nail. As healing continued to progress well and partial loading of the left lower extremity became possible, the patient was discharged home on crutches with oral antibiotic therapy consisting of amoxicillin/clavulanic acid at 5 weeks after admission to our department.

A wound healing disorder with prolonged wound secretions developed around the area of the knee joint covered by the flap, making repeat revision surgery necessary at 3 weeks after dis-



► **Fig. 2** Clinical (a) and radiological (b, c) images taken during third-look surgery following osteosynthesis of the accompanying femoral fracture.

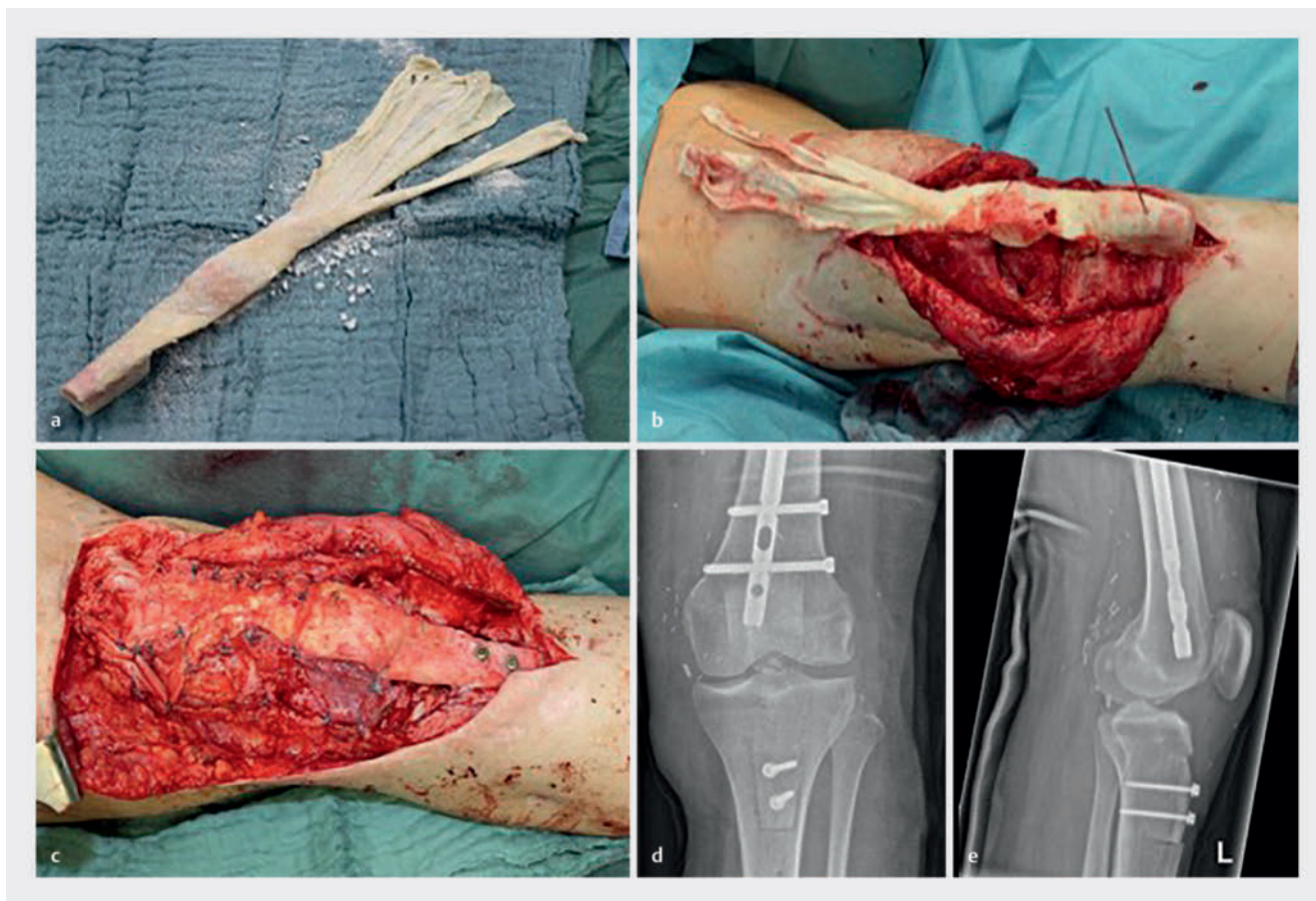
charge. Massive re-infection of the knee was detected after lifting of the knee flap, with fracture-associated infection of the tibial head accompanied by septic arthritis of the knee. Treatment necessitated carrying out extensive debridement of the knee joint and complete resection of the bony remnant of the patella and the remnants of the quadriceps and patellar tendons including the semitendinosus plasty and the removal of both screws at the tibial head (s. ► **Fig. 2**). Antibiotic-loaded ceramic bone replacement material was inserted. No microorganisms were detectable while the patient was still taking antibiotics and she received further antibiotics administered intravenously. The complete loss of the knee extensor mechanism including the patella and its adjoining quadriceps and patellar tendons made it necessary to decide on the further approach to treat the knee joint in this young female patient. In consultation with the patient, the decision was made in the interdisciplinary extremity conference to implant a fresh frozen extensor mechanism allograft which included a patella with adherent quadriceps and patellar tendons and a tibial tuberosity bone block after controlling for infection.

After switching to ampicillin/sulbactam, antibiotic therapy was changed again to oral therapy with amoxicillin/clavulanic acid. The infection was fully resolved after a total of 14 weeks of antibiotic therapy with only partial loading of the leg permitted and the knee joint immobilized with a thigh splint.

During follow-up, lab tests for infection parameters were unremarkable; wound and skin lesions continued to heal as expected, the flapplasty healed, and joint puncture found no suspicion of infection, even after antibiotic therapy was discontinued. These positive developments meant that finally, 5 months after the accident, the planned reconstruction of the extensor mechanism using a previously carefully measured fresh frozen extensor mechanism allograft (Cells + Tissuebank Austria, CTBA, Krems an der

Donau, Austria; s. ► **Fig. 3**) could be carried out. During the procedure, the flap was raised again and the knee joint was inspected. The site was found to be free of infection, whereupon the extensor mechanism allograft was implanted. As a prophylaxis against infection, the allograft was soaked with vancomycin solution, similar to the procedure recommended for allogeneic tendon allografts. The patella was then positioned under X-ray control at the correct level compared to the contralateral side to match the Insall-Salvati ratio of the opposite leg, and a bony bed was created at the tibial tuberosity for press-fit implantation of the tuberosity bone graft at the transplant using an oscillating saw. The bone graft was positioned in an anatomically correct position and additionally fixed with 2 parallel 3.5-mm cortical screws using the lag screw technique. This was then followed by careful alignment of the patella to the femoral trochlear groove with the knee joint in an extended position, and stitching of the quadriceps tendon into the remnant of the quadriceps tendon stump or the distal muscular part of the quadriceps muscle was carried out using the onlay technique and slow-resorption sutures. The operation was completed by primary wound closure which included the raised edges of the flap. The knee joint was immobilized again with a dorsal splint. Postoperative X-ray images show correct positioning of the patellofemoral joint with anatomical repositioning of the tibial bone graft in the region of the tibial tuberosity using screw osteosynthesis.

After an uneventful course in hospital (s. ► **Fig. 4**) which included 14-day prophylactic i.v. antibiotic coverage with ampicillin/sulbactam, prophylactic antibiotic therapy was switched to oral amoxicillin/clavulanic acid after intraoperative samples were found to be negative. The patient was discharged home with instructions to keep the operated extremity immobile for 4 weeks and for partial loading not to exceed 20 kg.



► **Fig. 3** Standard X-ray images of the allograft before (a after additional coating with vancomycin powder), during (b, c) and after transplantation (d, e).

At regular follow-up visits, the patient was gradually approved for increased loading and movement: 6 weeks of passive loading and movement were followed by a further 4 weeks of active loading and movement. Antibiotic therapy was discontinued after a total of 12 weeks of prophylactic antibiotic therapy following transplantation of the allograft. Active mobility of the left knee joint was now 0–5–45° (max. extension/flexion).

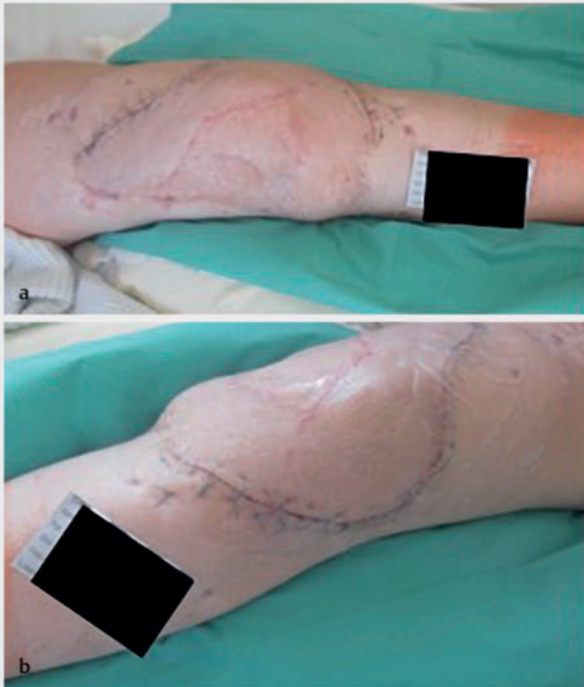
After the patient successfully returned to work as a bank clerk and continued physiotherapeutic exercise, her mobility increased to 0–0–65° (extension/flexion). The patient was now fully mobile and no longer required crutches, the knee was fully weight-bearing and only a slight limp was still apparent. Control X-ray imaging after 4 months showed continued correct positioning of the patellofemoral joint and implanted extensor mechanism allograft, and good centering of the patella on axial imaging of the patella at 30° flexion with good bony integration of the tibial bone block in the proximal tibial metaphysis (s. ► **Fig. 5**).

14 days after her last presentation as an outpatient and just 15 weeks after transplantation of the extensor mechanism allograft, the patient participated in a car race as a co-driver on part of the race circuit. During a collision she sustained a proximal lower leg fracture near the bony bed of the implanted tibial bone block. Surgical treatment of the fracture consisted of closed re-

sitioning and LISS plate osteosynthesis using a minimally invasive technique and prophylactic antibiotic therapy (s. ► **Fig. 6**).

Axial alignment with good bony consolidation of the fracture were already present 3 months after carrying out osteosynthesis. Active mobility of the left knee joint at the time was already 0–0–60° (extension/flexion).

At 24 and 19 months, respectively, after implantation of the extensor mechanism allograft and osteosynthesis of the proximal tibial fracture, active mobility (extension/flexion) was 0–0–80°. Contrast-enhanced ultrasonography carried out 2 years after transplantation of the extensor mechanism implant showed periosteal perfusion of the bony components of the allograft (s. ► **Fig. 7**). The patient currently has no symptoms and is very satisfied with the functional and clinical results (s. ► **Fig. 4**, ► **Video 1**). Her KOOS symptom score (KOOS: Knee Osteoarthritis Outcome Score) is 68, KOOS pain score is 83, and KOOS-ADL score (Activities of Daily Living) is 91. Her EQ-5 D quality of life score is 0.788 and her IKDC score is 56.3% (IKDC: International Knee Documentation Committee). The patient was also advised to request extended antibiotic prophylaxis if she had any dental or other surgical procedures.



► **Fig. 4** Clinical image (a, b) 14 days after latissimus dorsi flap-plasty.

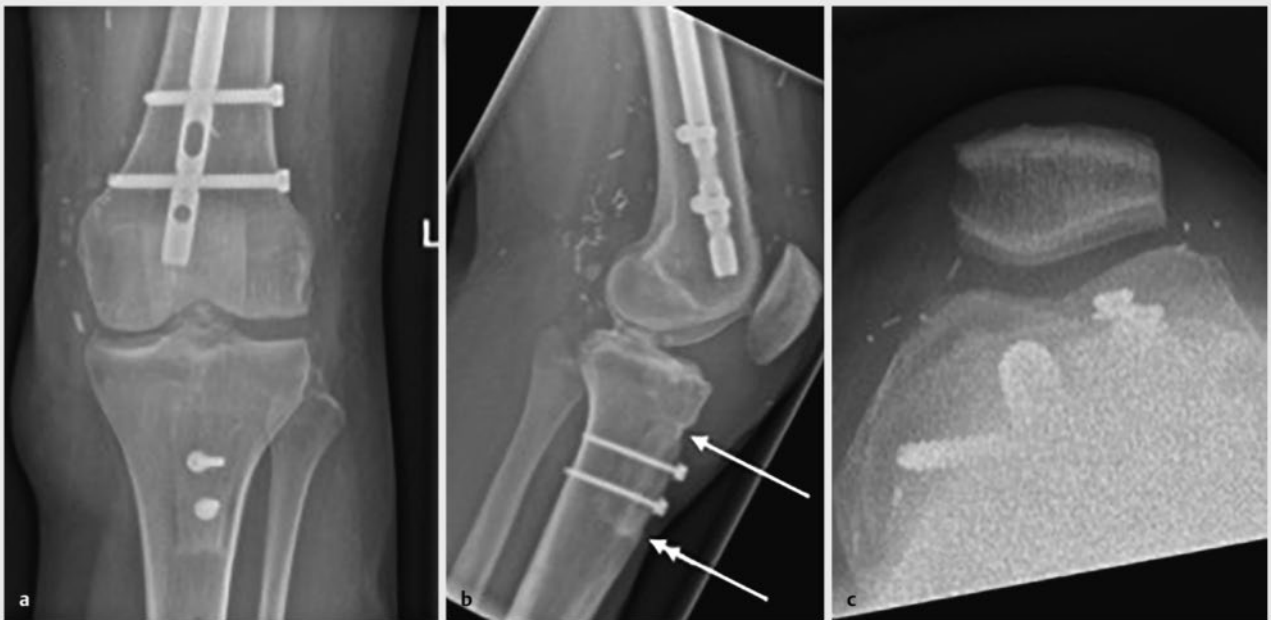


► **Video 1** Gait two years after transplantation of the allograft.

Discussion

The case history presented here shows a special reconstruction procedure in a patient with complete loss of the extensor mechanism following initial severe soft-tissue trauma followed by infection. Initial treatment required coverage of the soft-tissue defect and control of the infection. To manage such complex cases as well as bone and joint infections and bony defect situations, our institution set up an interdisciplinary “muskuloskeletal board” in which both periprosthetic [1] and fracture-associated infections [2] are discussed.

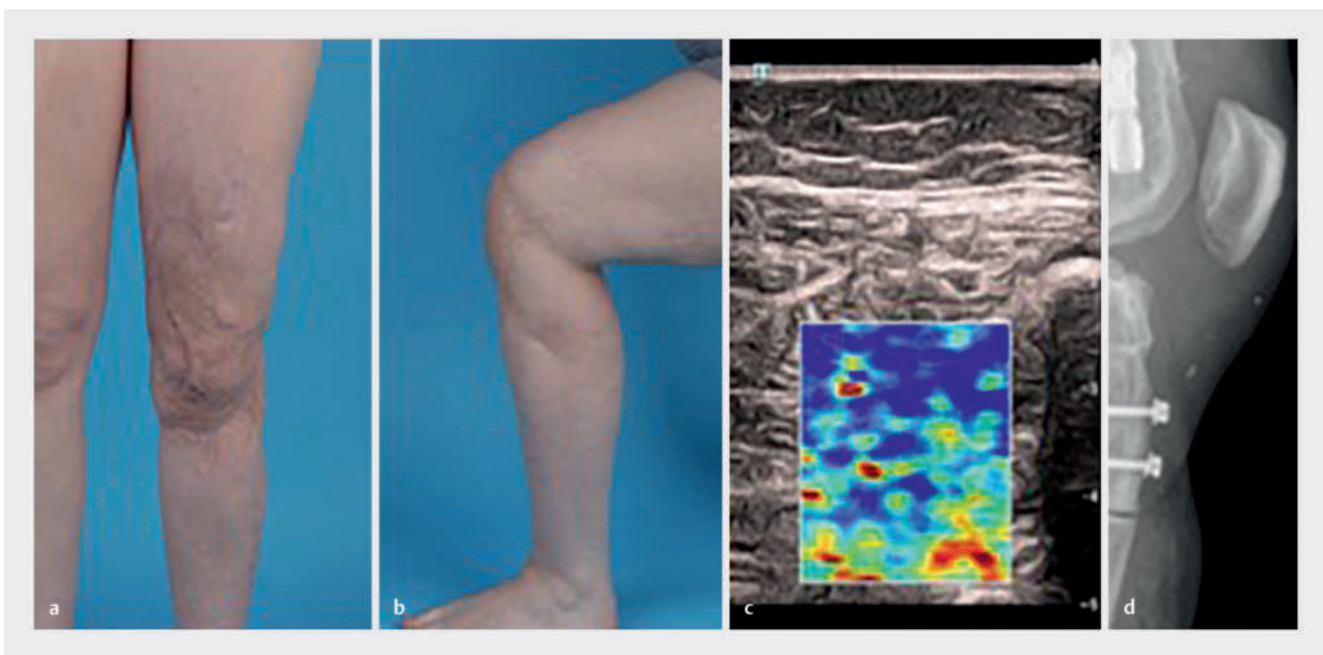
After successful soft-tissue coverage and elimination of the infection, the question arose about the further treatment options



► **Fig. 5** Control X-ray imaging carried out 4 months after transplantation with adequate integration of the tibial bone graft (a, b) and good centering of the patella (c).



► **Fig. 6** Conventional X-ray imaging before (a, b) and after (c, d) surgical treatment of a traumatic peri-implant proximal tibial fracture.



► **Fig. 7** Clinical imaging (a, b) and sonographic confirmation of the integration (c) of the tibial implant 24 months after transplantation. Lateral X-ray shows no signs of patellar necrosis (d).

due to the loss of the extensor mechanism. Leaving the situation “as is” without a further surgical intervention as would be the case for a “classic” patellectomy was not appropriate in this case, as the additional loss of the quadriceps and patellar tendons meant that the patient would have no extensor function in that knee, which would probably result in gait instability. The alternatives were ar-

throdesis of the knee or implantation of an extensor mechanism allograft. In view of the young age of the patient who was just 18 years old, her high level of compliance, and her wish for knee mobility, we decided to attempt an individual curative approach and carry out extensor mechanism allograft surgery using a fresh frozen transplant.

There are only a few descriptions of extensor mechanism allograft implantations in the literature, usually presented in the context of case reports or individual case-control studies [3, 4, 5, 6, 7]. Transplantation of an entire extensor mechanism is a known procedure primarily carried out in the context of managing complications of knee endoprosthesis surgery [3, 4, 5] and performed as a last resort in cases where other reconstruction options have either been exhausted or are otherwise no longer possible. There are some known, small, very much location-dependent case series in the field of tumor orthopedics [6].

Even though the reported satisfaction rates are adequate, a decreased range of movement, muscular weakness, and restricted activities of daily life are often present, even in cases where healing proceeds as expected. Complication rates of up to 50% have been reported with follow-up periods of more than 5 years in some cases [3, 6]. Combined extensor and flexor deficits often coincide with limitations in the total range of movement of about 80°, although better clinical results have been observed for knee joint prostheses [3, 4]. There are no data on quality-of-life scores for these patients.

In our case, the clinical result after a follow-up of 24 months was very satisfactory for the patient, despite her sustaining another traumatic fracture of the proximal tibia after transplantation following a car accident on a race track. Overall, integration and healing of the transplant without infection was remarkable; it followed implementation of appropriate measures such as excluding persistent infection by carrying out joint puncture shortly before implanting the extensor mechanism allograft and repeat post-operative antibiotic therapy for several weeks. Good bony integration of the bony tibial allografts was observed in the metaphyseal tibial area after just 3 months. The subsequent fracture occurred in the context of direct violent impact trauma and should therefore not be classed as a “pathological” fracture or a typical complication of allograft surgery. The relatively young age of the patient and her good state of health certainly contributed to the currently very positive result of treatment. Nevertheless, potential re-infection of the graft, graft necrosis and cartilage lesions in the femoral sulcus with subsequent arthrosis may develop at a later stage. Im-

munosuppression, which is used for classic organ donations, was and is not necessary as HLA sensitization has not been reported in the context of fresh frozen allograft transplantations. This is because the manner by which fresh frozen allografts are prepared prevents HLA sensitization and includes different chemical wash steps to clean cancellous bone and mechanical preparation of the tendinous parts of the transplant to free them from extra-tendinous components prior to cryopreservation, as was done to the allograft used in this patient.

Conflict of Interest

The authors declare that they have no conflict of interest.

Literatur

- [1] Sain A, Bansal H, Pattabiraman K et al. Extensor Mechanism Reconstruction Using Allograft Following Total Knee Arthroplasty: A Review of Current Practice. *Cureus* 2021; 13: e12803. DOI: 10.7759/cureus.12803
- [2] Rupp M, Walter N, Popp D et al. Multidisciplinary Treatment of Fracture-Related Infection Has a Positive Impact on Clinical Outcome-A Retrospective Case Control Study at a Tertiary Referral Center. *Antibiotics (Basel)* 2023; 12: 230. DOI: 10.3390/antibiotics12020230
- [3] Bürde C, Sweeney P. Die Behandlung der Streckapparatsuffizienz nach Knieprothetik durch allogene Transplantation. *Orthopade* 2007; 36: 372–378. DOI: 10.1007/s00132-007-1045-z
- [4] Burnett RS, Berger RA, Della Valle CJ et al. Extensor mechanism allograft reconstruction after total knee arthroplasty. *J Bone Joint Surg Am* 2005; 87 (Suppl 1): 175–194. DOI: 10.2106/JBJS.E.00442
- [5] Krockner D, Matziolis G, Pruss A et al. Rekonstruktion des Streckapparats mittels freiem, allogenen, gefriergetrocknetem Patellatransplantat. *Unfallchirurg* 2007; 110: 563–566
- [6] Müller DA, Beltrami G, Scocciati G et al. Allograft Reconstruction of the Extensor Mechanism after Resection of Soft Tissue Sarcoma. *Adv Orthop* 2018; 2018: 6275861. DOI: 10.1155/2018/6275861
- [7] Walter N, Rupp M, Baertl S et al. Periprosthetic joint infection: patients benefit from a multidisciplinary team approach. *Bone Joint Res* 2022; 11: 8–9