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Knee arthrodesis following infected fractures around the knee joint: Case report and literature review

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Abstract
Introduction: Infected fractures around the knee joint may result in chronic osteomyelitis and joint destruction. Knee arthrodesis serves as definitive limb-salvage procedure when reconstruction is no longer viable.
Materials and Methods: We present a case of knee arthrodesis for a complex knee fracture complicated by persistent infection refractory to antibiotics therapy and surgical debridement.
Results: The fracture was initially treated with internal fixation and soft tissue coverage procedures. However, this was complicated by recurrent infection and bone loss necessitating a limb salvage procedure. Knee arthrodesis with a Ilizarov ring fixator followed by long internal fusion nail was performed. The patient achieved infection-free and stable bony union. A thorough review of the literature yield 10 similar studies showing good functional outcomes with knee arthrodesis.
Conclusion: The management of chronically infected fractures around knee joint is challenging. We illustrated a case example of the successful use of knee arthrodesis to achieve bony fusion and infection control with good functional outcomes. Balancing the risk of complications, knee arthrodesis should be discussed as a limb salvage option for complex infected knee fractures.

Keywords: Knee arthrodesis, knee fusion, ilizarov ring fixator, chronic infection

Introduction
Infected fractures around the knee joint represent a complex orthopaedic challenge due to the risk of chronic osteomyelitis, joint destruction and prolonged morbidity. These infections usually arise from high-energy trauma, open fractures, or as complications of surgical procedures such as internal fixation. When the infection is refractory to debridement, antibiotics therapy or staged reconstruction, knee arthrodesis may serve as a definitive limb salvage procedure. While it results in permanent loss of joint mobility, it aids the eradication of infection and allows for a stable and pain-free limb. Indications for knee arthrodesis include significant metaphyseal bone loss, ligamentous instability, resistant infection and previous failed revisions [1]. Herein, we present a case report of knee arthrodesis as a limb-salvage procedure in a debilitating case of persistently infected distal femur fracture with joint involvement.

Case report
A 27-year-old gentleman was involved in a road traffic accident (cyclist versus car). He suffered a left open distal femur fracture (Gustilo 3c), left open tibial fracture (Gustilo 3b), and complete thrombosis of left distal superficial femoral artery and popliteal artery (Figure 1). He underwent initial debridement, revascularization, fasciotomy and left lower limb external fixation. Following multiple debridements, the wound was clean and pulses well felt. A decision was made for internal fixation with wound coverage a week later. Preoperative computed tomography (CT) imaging showed significant articular bone loss especially involving the trochlear and medial femoral condyle (Figure 2). He underwent left distal femur shortening and dual plating together with tibial shortening and nailing and left lower limb free flap procedure (Figure 3).
Unfortunately, the postoperative process was complicated by multiple failed wound coverage procedures coupled with persistent soft tissue infection and osteomyelitis. Initially, the choice of wound coverage was a free latissimus dorsi flap recon with split thickness skin graft. However, the flap became ischemic and was taken down resulting in exposed implants (Figure 4). After multiple debridements and negative tissue cultures, wound coverage was re-attempted with cross-leg latissimus dorsi myocutaneous flap for the knee defect and a

proximally based hemisoleus flap for the distal tibial defect (Figure 5). Part of the cross-leg flap became ischemic and there was underlying osteomyelitis of the distal femur (Figure 6). A decision was made to debride the flap, remove the femur implants and shorten the femur further (by approximately 6 cm). Bone cement was used to fill the void in the anterior aspect of the distal femur. An external fixator was applied while waiting for bony union. After almost 8 weeks from the removal of implants, he underwent division of the flap pedicle followed by sequential advancement of the hemisoleus flap proximally and then a rotational advancement flap to cover the wound defect entirely (Figure 7). A split thickness skin graft was applied a week later for complete coverage (Figure 8).

A month later, the wounds have healed and infection was under control. However, there were a few issues limiting his mobility. There was varus deformity at distal femur, limb length discrepancy of 6cm, stiff knee, and foot drop with cavus likely post compartment syndrome. A limb and foot ring fixator were applied to correct the supracondylar varus malalignment and foot drop respectively (Figure 9). He was able to ambulate with a walking frame and hence discharged with the ring fixator at 7 months post-injury from the hospital.

At the 1-year mark, the patient developed purulent discharge from a small left medial knee wound along with mild fever. X-ray and CT imaging showed a medial sinus communicating with the bone cement (left in the anterior part of distal femur), extensive Heterotopic Ossification (HO) on the medial side, and healed tibial fracture with nail in-situ (Figure 10). He underwent multiple debridements, excision of medial HO and removal of the tibial nail. A antibiotic coated nail was left inside the tibia. Given the extensive bone loss and destruction of the knee joint, the left lower limb was deemed unreconstructable. The patient was counselled for a knee arthrodesis as a limb salvage procedure. He was informed about the expected loss of range of motion, gait changes, and difficulties with certain daily activities. Knee arthrodesis was performed with a Ilizarov ring fixator compressed in slight valgus and external rotation (Figure 11). After 2 months, the frame was removed and long fusion nail inserted (Figure 12). At 2 years follow-up, he was ambulating well with a shoe raise and has returned back to his profession as a driver and achieved complete knee fusion. (Figure 13). At 3 years, X-rays showed good consolidation across the arthrodesis site with stable alignment (Figure 14).

Discussion

Knee arthrodesis serves as a vital salvage option in the treatment of chronically infected fractures around the knee joint, particularly when previous surgical interventions have failed and joint preservation is no longer viable. Although it results in permanent loss of knee movement, arthrodesis offers a stable, pain-free limb and restores ambulatory function. It is typically considered when infection persists despite aggressive debridement, antibiotic therapy, and reconstructive efforts. As compared to above-knee amputation, knee arthrodesis has been proven to be superior in terms of energy expenditure and limb function [2]. It is classically described as salvage procedure after failed knee arthroplasty with favourable outcomes [3]. Fewer case reports are published regarding the use of knee arthrodesis for septic post traumatic sequalae. Our case study demonstrates the successful use of knee arthrodesis in a complex case of distal femur fracture complicated by recurrent infection, bone loss and poor soft tissue and skin coverage. Despite a lengthy postoperative course, our patient regained functional use of the affected limb and returned to daily activities eventually.

We performed a literature review of 2 electronic databases (Pubmed and Embase) with search keywords “knee arthrodesis”, “knee fusion”, “knee fracture”, “distal femur fracture”, and “chronic infection”. We identified 10 studies consisting of 39 patients that reported knee arthrodesis as a salvage technique for complex fractures around knee joint (Table 1) [4-13]. These included distal femur, proximal tibial, tibial plateau or patella fractures. The mean age was 41.8 years old and 71.8% was male. In 5 studies, the initial injury was a high-energy open fracture [4, 6, 7, 10, 11], while the remaining studies did not specify [5, 8, 9, 12, 13]. In 8 studies, the indication for knee arthrodesis was resistant infection (soft tissue infection/septic arthritis/osteomyelitis) and significant bone loss [4-9, 12, 13]. In the other 2 studies, the decision for knee arthrodesis was due to multi-ligamentous instability with poor skin integrity [10], and advanced age with osteoporosis and friable soft tissue [11]. In 5 studies, patients had prior internal fixation before the eventual knee arthrodesis [5, 6, 8, 9, 13].

Achieving bony union is a principal goal of knee arthrodesis. For our case report, a hybrid method of Ilizarov ring fixator followed by long femoral-tibial nail was utilized. The ring fixator was kept in place until radiographic osteogenesis and satisfactory alignment was obtained at the 2 months interval. Subsequently when the infection was under control, the frame was removed and a long nail was inserted to achieve complete fusion at the 1-year interval. The removal of the fixator provided the patient with more convenience and comfort when mobilizing. Similarly, the literature supports the efficacy of knee arthrodesis in achieving union and eradicating infection, depending on the fusion technique. Across the included studies, some reported time to union while others reported time in external fixator as an outcome measure. Time to union ranged from 7-13 months for circular external fixator and 4-8 months for intramedullary nail. Time spent in external fixator ranged from 5-11 months. Except for 1 patient with septic non-union and knee amputation [5], all achieved the eventual goal of knee fusion.

Several surgical techniques exist for performing knee arthrodesis, including intramedullary nailing, plate fixation, and external fixation with uniplanar or multiplanar frames. Intramedullary nailing offers high fusion rate between 80-100% [14-16]. However, the use of internal fixation in the setting of active infection remained controversial. Even with a 2-stage procedure, internal fixation still carries the risk of intramedullary dissemination of infection [17]. External fixation with a Ilizarov ring fixator provides stabilization while awaiting the eradication of infection. Other benefits include gradual and dynamic axial compression across the arthrodesis site, correction of malalignment to restore mechanical axis, and incorporation of limb lengthening procedures. Current studies have reported favourable results with Ilizarov fixator for infected TKA [18-20]. Much less is known regarding its efficacy for post-traumatic infection. Based on our literature review, 8 studies utilized the Ilizarov ring fixator [4-6, 8-10, 12, 13], while 2 studies utilized intramedullary nailing due to the absence of infection [7, 11].

As described earlier, the reported time to fusion was slightly shorter for intramedullary nailing as compared to Ilizarov ring fixator. Otherwise, both methods achieved the primary aim of infection-free union.

Limb length discrepancy (LLD) may result from knee arthrodesis, particularly when extensive bone resection is necessary for infection control. Bone defects may be managed with vascularized fibular grafts, structural allografts, or bone cement [21]. Minor cases of LLD are often well tolerated with orthotic support. In our case report, the patient had a LLD of 6 cm but he managed to ambulate independently with the aid of a shoe raise and thus did not proceed with limb lengthening. More significant shortening may require additional interventions such as staged limb lengthening. One advantage of circular fixators is their ability to simultaneously manage both arthrodesis and limb length restoration. 6 included studies reported the use of limb lengthening procedures such as bone transport or distraction osteogenesis [4-6, 8, 9, 13]. The mean bone defect was 10.2 cm and decreased to 2.2 cm with limb lengthening procedures, thus allowing for improved function [22]. There was no significant increase in union time or time spent in external fixation with the use of simultaneous limb lengthening procedures.

Even though knee arthrodesis is a valuable option for limb salvage, its use is associated with distinct complications. While there were no complications in our case report, based on the literature review, pin-site infection is the most common complication (75.7%). Majority were treated conservatively with oral antibiotics or pin care (64.9%), but deep-seated infection required pin/wire revision (10.8%). There were 4 cases of peri-implant fracture due to minor trauma (10.8%), whereby 1 was treated conservatively and 3 was treated with plate osteosynthesis and fixator repositioning. There were 3 cases of equinus deformity (8.1%), whereby 2 was treated with a foot frame and 1 treated with posteromedial release. There were 3 cases of deep vein thrombosis (8.1%) treated with warfarin resulting in a delay of bone transport. The rest of the complications included septic non-union (5.4%), wound abscess (2.7%), and pseudoarthrosis (2.7%). Despite these challenges, knee arthrodesis offers the advantage of infection control and adjustability. Patients should be counselled on the risk of pin-site infection and advised on proper local pin care.

In summary, knee arthrodesis remains a viable option in the management of chronically infected knee fractures when reconstruction is no longer feasible. With proper technique and postoperative care, it can lead to durable infection control, bony union, and restoration of ambulatory function. Although gait is inherently altered by the loss of knee flexion, most patients regain the ability to ambulate independently or with minimal support. Based on the literature review, 63.2% were ambulant without aid, 35.6% ambulant with aid, 5.3% wheelchair-bound (due to non-related reasons). Many are able to return to daily activities, though returning to physically demanding occupations is less predictable and may require vocational adjustment. However, knee arthrodesis with ring fixator does demand a high level of patient compliance e.g. regular appointments to adjust the fixator and also significantly reduced patient comfort due to the prolonged fixator use [23]. The choice of knee arthrodesis should be deliberated based on clinical indications and patient profile in order to maximise functional outcomes.

Fig 1: Initial X-rays of the left distal femur and tibial open fractures

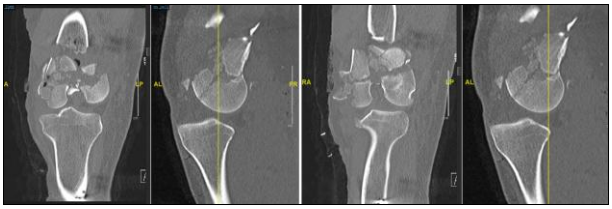

Fig 2: Initial CT imaging showing significant articular bone loss

Fig 3: Left femur dual plating and left tibial intramedullary nailing

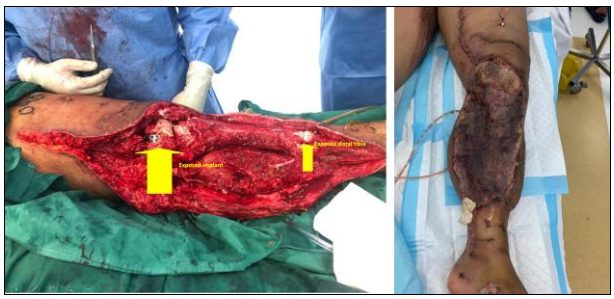

Fig 4: Flap ischemia and exposed implants

Fig 5: Cross-leg latissimus dorsi flap for knee defect and proximally-based hemisoleus flap for distal tibial defect

Fig 6: Ischemia of the cross-leg flap and underlying osteomyelitis of distal femur

Fig 7: Division of flap pedicle of the cross-leg flap

Fig 8: Split thickness skin graft for complete coverage

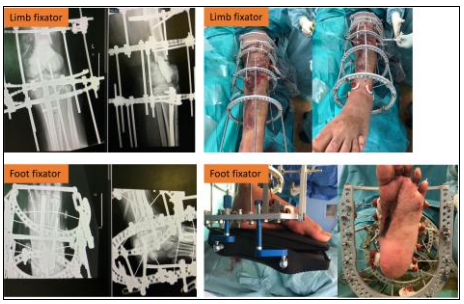

Fig 9: Application of limb fixator to correct varus deformity and foot fixator to correct equinus

Fig 10: Medial distal femoral sinus communicating with bone cement and extensive heterotopic ossification

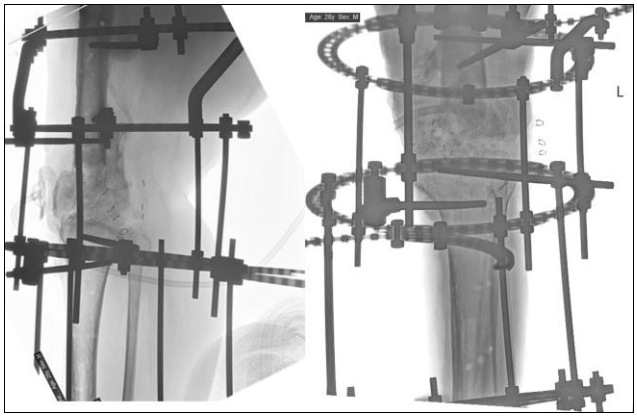

Fig 11: Knee arthrodesis with Ilizarov ring fixator compressed in neutral to valgus in slight external rotation

Fig 12: Ilizarov ring fixator removed and long fusion nail inserted

Fig 13: Independent ambulation with shoe raise on affected left side

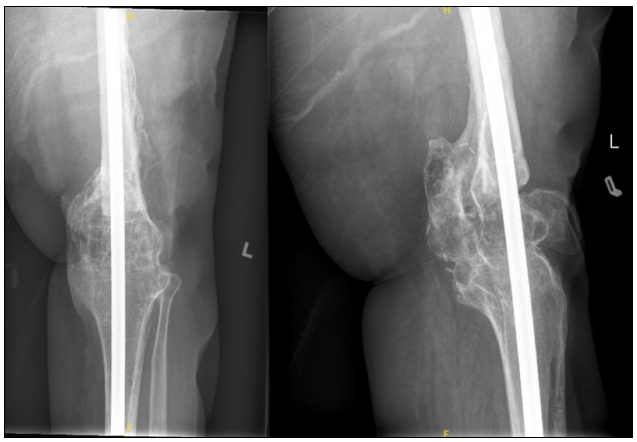

Fig 14: Postoperative X-rays at 3 years follow-up

Table 1: Case Studies on knee arthrodesis for traumatic knee fractures

Author	No. of patients	Age	Sex	Index injury and surgery	Indication	Bone defect (cm)	Type of knee arthrosis	Time in EF[#]	Time to union	Additional procedures	Final LLD[#] (cm)	Complications	Functional outcomes
Rozbruch 2005	3	33-43	M	Open proximal tibial fracture	Infection and bone loss	4-14.5	Ilizarov external fixator	11mths[#] (6-17)	NR[#]	Bone transport in 1 patient	0.6-3.7	3 pin-site infections	Ambulant without aid
Salem 2006	12	39.7 (21-75)	9M 3W	Complex knee fractures (distal femur, tibial plateau, proximal tibial, patella) s/p ORIF[#]	Septic arthritis/osteomyelitis	NR	Ilizarov external fixator	22.7 (11-47) weeks	NR	Bone transport in 2 patients	NR	5 pin-site infections, 1 resection and frame application, 1 septic non-union	NR
Lai 2007	2	18 21	2M	Right open distal femur fracture s/p ORIF	Infected non union	14-15	Ilizarov external fixator	NR	10-13 mths	Distraction osteogenesis + vascular fibular bone graft	0	2 pin-site infection	Ambulant without aid
Mack 2008	1	21	M	Left gustilo IIIB periarticular knee fracture with patellectomy	Extensive bone loss	11	Standard length Wichita Fusion Nail (Stryker, Inc., Kalamazoo, MI)	NR	8 mths	Contralateral femoral structural autograft Rotational flap with overlying split skin graft	NR	Wound abscess requiring I&D and prolonged abx	Community ambulant with cane
Kinik 2009	1	33	M	Left intra-articular distal femoral and tibial plateau fracture s/p ORIF	Osteomyelitis and draining sinuses Infective nonunion	11	Ilizarov external fixator	32 weeks	NR	Bone transport	1	Pin-site infection, equinovarus	Ambulate independently without aid
Barwick 2013	4	36-57	3M 1W	Proximal tibial/distal femur fracture s/p ORIF	Osteomyelitis/septic arthritis	6-10	2 Ilizarov external fixator 2 Taylor-Spatial Frame	NR	NR	Bone transport	3-4	4 pin-site infection, 3 deep vein thrombosis, 2 equinus contracture	NR
Waszczykowski 2016	1	18	M	Left open lateral femoral and tibial condyle fracture with popliteal artery injury and peroneal nerve palsy	Mult-ligamentous instability, chronic pain and poor skin integrity	NR	Arthroscopic-assisted Ilizarov external fixator	42 weeks	54 weeks	NR	NR	No infections noted	Return to work as taxi driver after 2 years
Batta 2017	1	90	F	Left gustilo IIIA displaced tibial plateau fracture (Schatzker Type 4)	Advanced age, osteoporosis, friable soft tissue, patient preference	NR	Long femoral-tibial nail	NR	4 mths	NR	NR	NR	Able to mobilize comfortably by 4 mths
Reinke 2020	13	19-80	9M 4F	Varies knee fractures	Active florid knee and soft tissue infection with destruction of structures	NR	Ilizarov External Fixator	27 (13-68) weeks	NR	5 needed soft tissue procedures including graft/skin flaps	3 (2-3.5)	13 pin-site infections 2 peri-implant fractures 1 pseudoarthrosis	6 mobile without aid, 5 mobile with aid, 1 wheelchair-bound due to spinal condition
Chalak 2023	1	52	M	Right distal femur and patella fracture s/p ORIF	Infected non-union of distal femur with discharging sinus. Severely arthritic and stiff knee	7.62	Ilizarov External Fixator	NR	7 mths	Distraction osteogenesis with tibial osteotomy to overcome LLD	2.54	NR	Independent in all basic ADLs[#] except public transport and toileting

[#]Abbreviations: EF=external fixation, LLD=limb length discrepancy, mths=months, NR=not reported, s/p=status post, ORIF=open reduction internal fixation, ADLs=activities of daily living

Conclusion

The management of chronically infected fractures around knee joint is challenging. We illustrated a case example of the successful use of knee arthrodesis as a limb salvage procedure for distal femur fracture with persistent deep-seated infection and bone loss. Knee arthrodesis achieved bony fusion and infection control with good functional outcomes. The option of knee arthrodesis should be discussed with patients when reconstructive efforts have failed, considering their lifestyle preferences, comorbidities and compliance.

Declaration

There are no conflicts of interest to declare. This case series has no funding.

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