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Knee Arthrodesis with the Ilizarov External Fixator as Treatment for Septic Failure of Knee Arthroplasty

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1. Introduction

Femoral–tibial fusion remains one of the last treatment choices for recurrent septic failure of knee prostheses. It can be achieved by different surgical techniques, such as intramedullary nailing, mono/biaxial or circular external fixators, and fixation with long plates and screws. In other studies, the rate of knee fusion following septic prosthetic loosening has been reported to range from 27% [1] up to 31–33% [2, 3] and even 41–42% [4, 5]. However, authors often do not report the way that fusion is achieved; others use an unspecified external fixation with a success rate ranging from 67 to 90% [6–9], and with a mean fusion time that ranges from 4.4 to 6 months.

More precisely, other authors report that fusion rates with the Ilizarov circular external fixator range from 64–75% [10, 11] to 83–93% [12, 13] and even up to 100% [14]. Mean fusion times range from 6.8 to 13 months.

Among our series of 58 septic knee prostheses treated in our ward from 1990 to 2007, 17 (29.3%) underwent femoral–tibial fusion. The fusions were attempted in all cases with the Ilizarov circular external fixator. The choice of fusion was dictated by bad local conditions of the knee (Fig. 1), the precarious general health status of the patient, and his determination to



Fig. 1. Precarious local condition of the right knee in a septic prosthesis loosening

find a definitive solution to the problem. Another important factor was the number of failed prosthetic revision procedures due to septic loosening (Fig. 2).

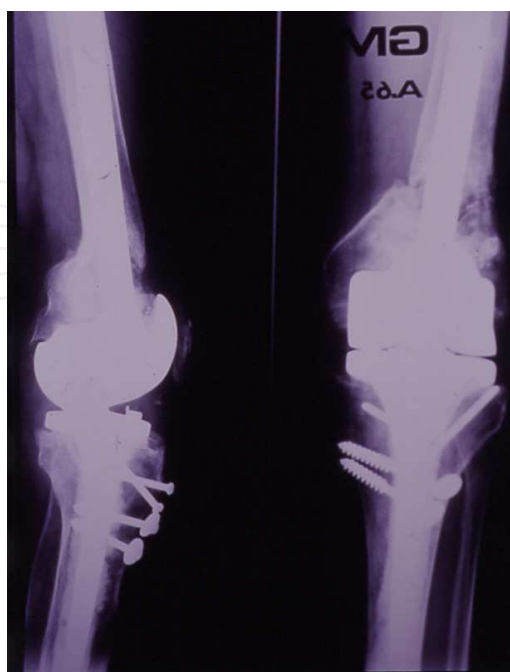


Fig. 2. A/P and L X-ray of a septic knee revision prosthesis loosening

The objective of our study was to evaluate the reliability of the Ilizarov circular external fixator as a surgical technique for knee arthrodesis, and to compare it to other fusion procedures.

2. Materials and methods

The data for this investigation were collected and analyzed in compliance with the procedures and policies set forth by the Helsinki Declaration, and all patients gave their informed consent. The study was authorized by the local ethical committee.

The series included 17 femoral-tibial fusions, representing 29.3% of all septic knee prosthetic loosening (58) treated on the First Ward of the Rizzoli Orthopedic Institute from 1990 to 2007 (Table 1). Nine patients were women (53%) and eight were men (47%); the mean age at the time of fusion was 62.9 years (women 68.3 and men 56.8), ranging from 26 to 80 years. Eleven patients had a secreting fistula. The microbiological culture examination was positive for *Staphylococcus epidermidis* in eight cases, *Staphylococcus aureus* in four cases, *Enterococcus* in four cases, and other bacterial species to lesser degrees (Fig. 3). The culture examination was negative in four patients (23.5%), even when there were local conditions, and laboratory (ESR and CRP elevated) and radiological (locally increased uptake in total body scintigraphy with marked granulocytes) evaluations were positive for infection. Ten patients had previously been surgically treated for primary arthritis (58.8%), four for posttraumatic arthritis (23.5%), one for sequelae of tuberculous arthritis (5.9%), one for rheumatic arthropathy (5.9%), and one for arthropathy following pigmented villonodular synovitis (5.9%). Five patients were treated at our institute from the implantation of the primary prosthesis, whereas the remaining 12 patients were initially treated at other

institutes. The Cierny–Mader classification was used for clinical and anatomopathological assessment [15], while the Engh classification was used to evaluate bone defects [16]. According to the Cierny–Mader system, ten patients (58.8%) belonged to group IV Bls, four patients (23.6%) to group IV Bs, and the remaining patients (17.6%) to group IV Bl.

A	B	C	D	E	F	G	H	I	L	M	N	O	P	Q
67	F	Rheumatoid Arthritis	SX	NO	Staphylococcus Aureous	YES	4B L-S	2	NO	3	Healed	8	None	-4 cm
57	F	Osteoarthritis	DX	YES (one revision TKA)	Staphylococcus Epidermidis and Aureous. Enterococcus	YES	4B L-S	2	NO	8	Healed	24	Small fistula (after 16 months)	-6 cm
51	M	Tubercular arthropathy	SX	YES (one revision TKA)	Staphylococcus Agalactiae, Epidermidis, Haemoliticus	NO	4B L-S	2	NO	8	Healed	6	Thrombo-phlebitis	-2 cm
80	F	Osteoarthritis	DX	YES (one revision TKA)	Pseudomonas Aeruginosa	NO	4B S	2	NO	3	Healed	50	None	-4 cm
55	M	Osteoarthritis	DX	NO	Not isolated	NO	4B S	2	NO	5	Not healed	6	Intolerance	/
70	F	Osteoarthritis	SX	NO	Staphylococcus Epidermidis	YES	4B L-S	3	YES	7	Not healed	†	Nonunion	/
64	F	Posttraumatic osteoarthritis	DX	NO	Staphylococcus Aureous	YES	4B L-S	2	NO	5	Healed	8	None	-4 cm
48	M	Posttraumatic osteoarthritis	SX	NO	Staphylococcus Epidermidis	YES	4B L	2	NO	8	Healed	28	None	-3 cm
70	F	Osteoarthritis	SX	YES (one revision TKA)	Not isolated	NO	4B S	2	NO	2	Not healed	6	Intolerance	/
74	M	Osteoarthritis	DX	NO	Not isolated	YES	4B L-S	3	YES	16	Healed	15	None	-3 cm
70	F	Osteoarthritis	DX	NO	Not isolated	YES	4B L-S	3	YES	6	Healed	66	None	-5 cm
65	M	Posttraumatic osteoarthritis	DX	NO	Staphylococcus Epidermidis, Pseudomonas Aeruginosa	YES	4B L-S	3	YES	14	Healed	101	None	-6 cm
64	F	Osteoarthritis	SX	NO	Enterococcus Fecalis	YES	4B L	3	YES	12	Healed	17	None	-6 cm
73	F	Osteoarthritis	DX	YES (two revisions TKA)	Streptococcus, Staphylococcus Epidermidis	YES	4B L-S	3	YES	20 (2 attempt)	Not healed	24	Nonunion	/
26	M	Posttraumatic osteoarthritis	SX	NO	Staphylococcus Epidermidis	NO	4B L	3	NO	18	Healed	32	None	0 cm
66	M	Osteoarthritis	SX	NO	Enterococcus, Pseudomonas Aeruginosa	NO	4B S	2	NO	4	Healed	8	None	-3 cm
70	M	Pigmented villinodular synovitis arthropathy	SX	NO	Staphylococcus Aureous, Epidermidis, Enterococcus	YES	4B L-S	2	NO	16	Healed	82	None	-4 cm

A Age at fusion, B Sex, C Initial diagnosis, D Side, E Revision, F Bacteria, G Fistula, H Cierny-Mader Classification, I Engh Classification, L Cement spacer, M Mean Time to Fusion (months), N Result, O Follow up (months), P Problems/Obstacles/Complications, Q Limb shortness (centimeters)

Table 1. Summary of the data on the patients included in this study

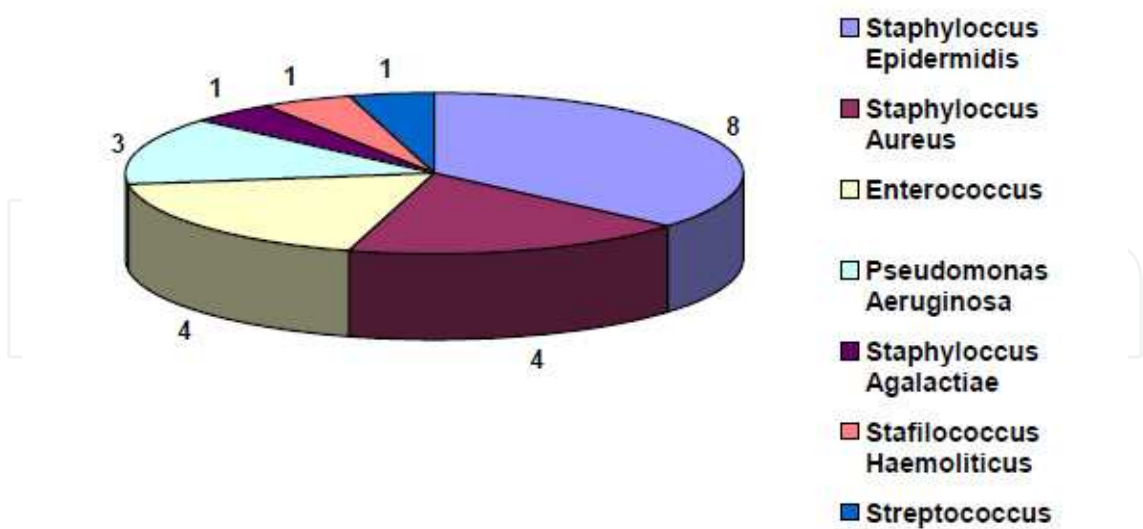


Fig. 3. Type and distribution of the isolated microbes

According to the Engh classification, ten patients (58.8%) were considered type II, and the remaining (41.2%) were considered type III. Different surgical treatments were performed depending on the Engh classification.

For type II Engh patients the treatment involved:

- Injection of the fistulous tract, when present, with methylene blue dye;
- Removal of prosthetic components and cement mantle, samples taken for microbiological culture testing, than surgical debridement and regularization of the femoral and tibial bone surfaces;
- Femoral–tibial stabilization under compression with the Ilizarov external fixator, applying 5–6 mm diameter percutaneous half-pins with a hydroxyapatite coating for femoral arches, a distal femoral ring, and a pair of tibial rings stabilized with Kirschner wires;
- Specific or wide-ranging antibiotic therapy for four/six weeks.

For Engh type III patients (except in one case) the treatment involved:

- Injection of the fistulous tract, when present, with methylene blue dye
- Removal of prosthetic components cement mantle, samples taken for microbiological culture testing, than surgical debridement and regularization of the femoral and tibial bone surfaces
- Application of antibiotic-loaded cement spacer stained with methylene blue (Fig. 4)
- Hinged brace and specific or wide-ranging antibiotic therapy for four/six weeks
- Assessment of infection indices and clinical condition, then further surgical debridement followed by femoral–tibial fusion with the external fixator
- Specific or wide-ranging antibiotic therapy for four/six weeks if the culture exam is positive at the time of fusion.

An additional surgical stage with the application of an antibiotic-loaded cement spacer is used for 4–6 weeks in patients belonging to Engh group III, because in our experience surgical debridement alone may not be sufficient to eradicate the infection in cases with large bone defects.

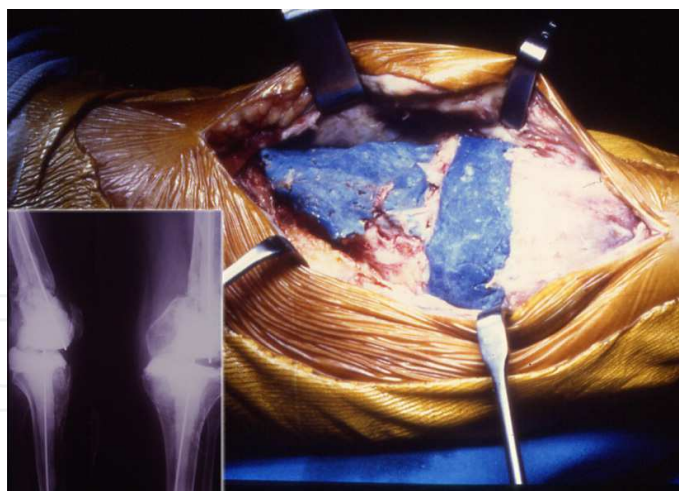


Fig. 4. a Antibiotic-loaded cement spacer stained with methylene blue following knee prosthesis removal. b A/P and L X-ray of a knee with cement spacer in situ

The type of antibiotic used in the spacer depended on the result of the microbiological test performed previously. In our series, in most cases we used vancomycin at a dose of 2–4 g of antibiotic per 40 g of cement.

In a 26-year-old patient with a final limb shortening of 11 cm, femoral and tibial lengthening were performed at same time as the fusion.

Patients who were considered healed showed a continuous cancellous trabecular pattern from femur to tibia at standard radiographs (Fig. 5) and no clinical and instrumental signs of an active infection. Stability at the fusion site was evaluated with the varus-valgus stress test. The femoral–tibial fusion was assessed both radiographically and clinically.

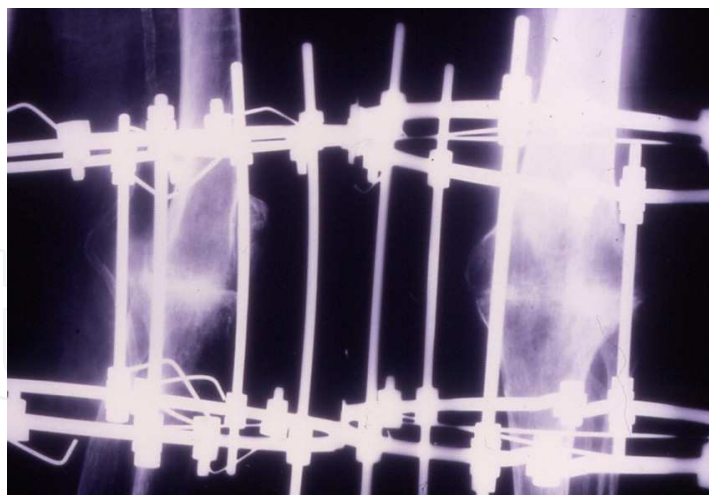


Fig. 5. A/P and L X-ray showing continuity of the trabecular-medullary pattern in a patient treated with Ilizarov's external fixator

3. Technical notes for assembling the external fixator

3.1 Femoral component

The fixator is anchored to the femoral diaphysis by three or four 5–6-mm percutaneous half-pins coated in hydroxyapatite and fixed to two Ilizarov arches of the same diameter but

different lengths (the distal one is longer). The arches are positioned perpendicular to the long axis of the femur. Four screws are recommended for patients over 60 kg in body weight. The distal arch is connected to a ring with a size proportional to the diameter of the knee and anchored to the distal femur by two Ilizarov wires.

3.2 Tibial component

The femoral distal ring is connected by three hinged rods to two rings of the same diameter that are anchored to the proximal tibial diaphysis by Ilizarov wires. For good fusion it is important that the fixator is connected to bone by Ilizarov wires on both sides of the subsequent fusion. In this setup the circular external fixator is bulky but effective. The hinged connection allows compression at the fusion site with deviations in flexion, external rotation and valgus of the tibia with respect to the femur. Proximal percutaneous screws and Ilizarov wires often cause local swelling of the skin. This is the most uncomfortable aspect for the patient (Figs. 6, 7).

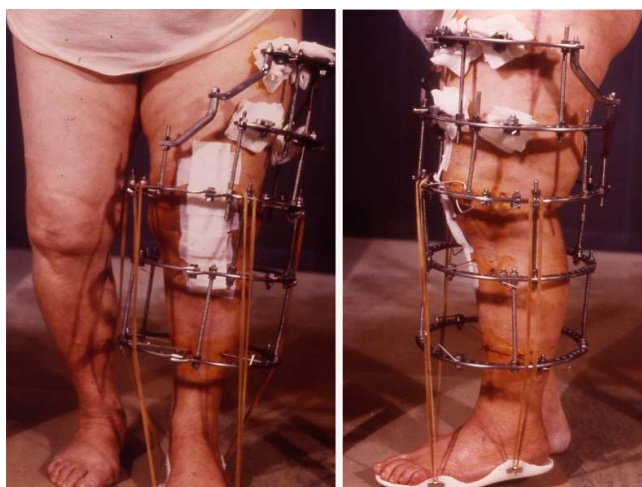


Fig. 6. Left knee in a patient treated by fusion using an Ilizarov circular external fixator. A splint is present to support the foot



Fig. 7. Type IV Bls patient treated using an Ilizarov external fixator for left knee fusion. Functional stable limb bearing was achieved after 101 months

4. Results

Among the 17 patients, 13 fusions were achieved at the first surgical attempt in a mean time of 9.3 months (range 3–18 months) (Figs. 8, 9) the mean follow-up was 30 months (range 6–101 months) (Table 1).

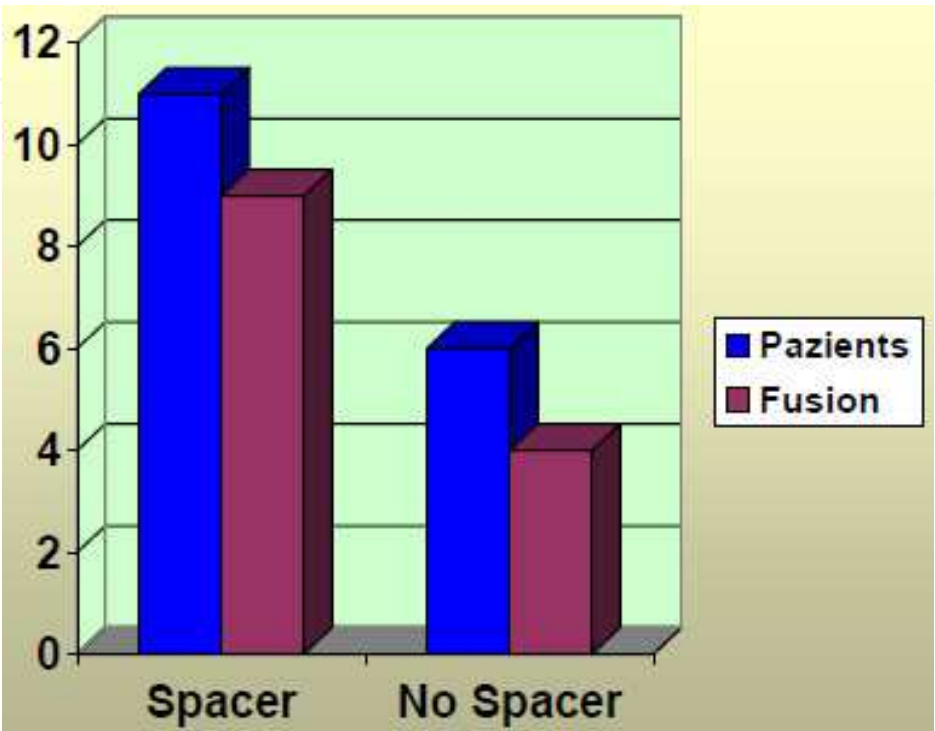


Fig. 8. Comparison of patients according to treatment and fusion rate

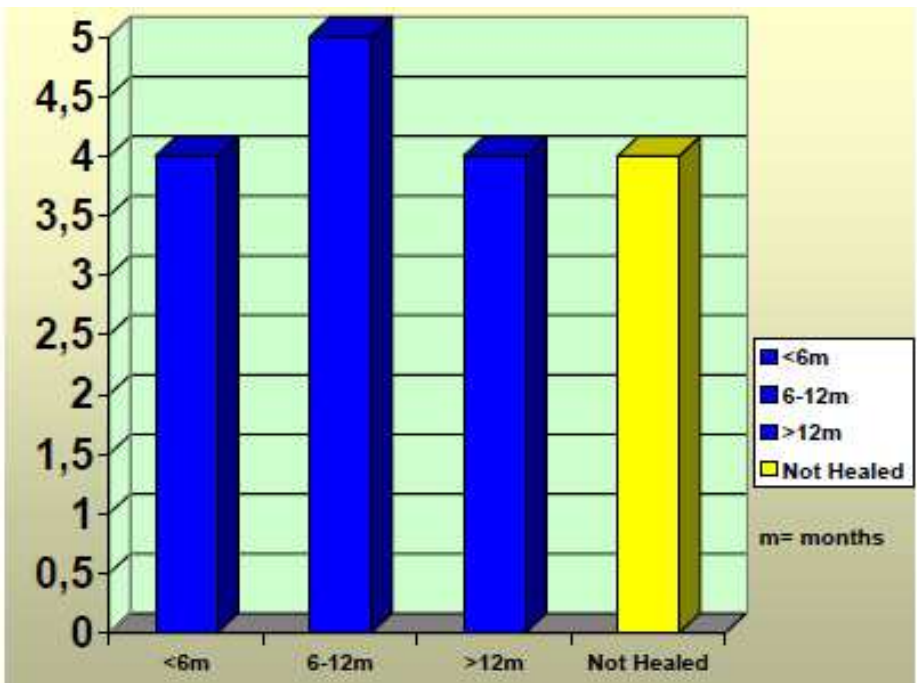


Fig. 9. Duration of treatment with Ilizarov fixator in healed patients

To assess difficulties that occur during treatment with the Ilizarov external fixator, Paley's classification was used [17] to distinguish problems, obstacles and complications. Problems represent difficulties that require no operative intervention to resolve, while obstacles represent difficulties that require an operative intervention. All intraoperative injuries and all problems that are not resolved before the end of treatment are considered true complications. In our cohort there were four complications (23.5%) that were responsible for treatment failure in four patients. Two patients belonging to Cierny-Mader IV Bs and the Engh type III group developed a septic intrarticular nonunion. The other two patients belonging to Cierny-Mader IV Bs and the Engh type II group developed an intolerance to the external fixator that led to its early removal. In all four patients, further attempts at fusion with other surgical techniques were abandoned and a hinged brace was applied. The mean residual limb length discrepancy was 3.8 cm (range 0–6 cm). One obstacle occurred in a 26-year-old patient with a final limb shortening of 11 cm; femoral-tibial fusion and femoral and tibial lengthening using the Ilizarov technique were performed at the same time, thus restoring the original length of the limb.

Problems included a thrombophlebitis in a patient with severe venous insufficiency of the lower limbs and previous deep venous thrombosis; this was treated with pharmacological therapy. Another was a small fistula at a surgical wound that developed in another patient 16 months after the removal of the external fixator, which resolved after specific antibiotic therapy. Among other problems, there were superficial wound infections of percutaneous screws and Ilizarov wire tracts that were never quantified but which always resolved with local disinfection.

5. Discussion

Femoral-tibial fusion is a valid alternative upon septic failure of primary and revision total knee arthroplasty, and is usually well tolerated by patients.

This treatment restores good limb loading, decreasing pain and eliminating infection.

Circular external fixation provides stability at the fusion site and correct femoral-tibial alignment in flexion, external rotation and valgus deviation. Any type of correction is possible without the need to take the patient into the operating room. The circular fixator provides very good stability, so daily load-bearing may be allowed without limitation. It is a low-cost option from a hospital economics perspective, and it ensures a low risk of infection. In particular cases during treatment for femoral-tibial fusion, the fixator can restore severe limb-length discrepancy by applying a distraction osteogenesis technique on the tibial and/or femoral side.

Disadvantages of circular external fixator include:

- A long learning curve
- Objective discomfort for the patient due to the wide field of the device
- Nonrigid fixation due to flexible metal wires and percutaneous screws
- Cutaneous infections frequently occur at wire entry sites
- Loosening and breakage of percutaneous screws
- Long treatment times.

Knee arthrodesis achieved by various types of intramedullary nailing has a success rate ranging from 67 to 100% [6, 18–24] in a mean time of about six months. Using intramedullary nailing in a knee with a periprosthetic infection poses a number of problems, such as the risk of spreading the infection into the medullary canal, the difficulty involved in treating infection recurrence, the possibility of nail migration or breakage, and the

impossibility of performing a compression at the fusion site and clinically assessing its stability during treatment [23, 25].

The technique of femoral-tibial fusion with a monoaxial or biaxial external fixator has a success rate that ranges from 68 [26] to 89% [27] and up to 100% [28, 29]. These fixators, especially monoaxial ones, are fairly well tolerated by patients. However, they do not allow significant changes in the axis, and, due to their structural characteristics, they are rigid and not entirely reliable for complete load-bearing [30].

Finally, bone fusion with dual compression plates has a success rate ranging from 80 [31] to 100% [32]. The authors, however, report high rates of complications (18.2%) such as stress fractures and persistent infection. Healing in some cases was achieved after repeated surgical attempts. Bone fixation with plates and screws is rigid and enables axial

Author(s)	N° of Knees	Classification Used	Fusion rate	Mean Time to fusion (range) in months	Mean residual limb shortness	Complications	Mean FU in months
Johannsen HG et al (2005) [11]	8	none	75%	3,5 (3-4)	3,5 cm	12,5% (1 chronic osteomyelitis)	10
Manzotti A et al (2001) [12]	6	none	83%	6,8 (10,3-5,1)	-	None	34,2
Garberina MJ et al (2000) [10]	19	none	68%	4,6 (3-6,8)	-	26,3% (2 fractures, 2 valgus angulation, 1 wound infection)	32
Oostenbroek & van Roermund (2001) [13]	15	Mild/Moderate/Severe loss of bone	93%	12 (6-24,7)	4 cm	80% (2 femoral fractures 3 osteitis 3 frame instability 1 non-union 1 femoral angulation 1 heel decubitus 1 pneumonia infection)	52
David R et al (2001) [14]	13	none	100%	6,4 (4,6-8,4)	3,7 cm	7,7% (1 wound infection)	40,8
Spina M et al (2009)	17	Combined Engh/Cierny-Mader	76,5%	9,3 (3-18)	3,8 cm	11,7% (1 Thrombophlebitis, 1 small fistula)	30

Table 2. Literature review of knee arthrodesis with an Ilizarov circular external fixator

compression [33]. It is, however, a complex procedure that is very invasive and at risk of infection. Nichols et al. [32] advise against this technique in the presence of widespread infection.

The existing literature on femoral-tibial fusion with an Ilizarov circular external fixator reports success rates that vary in different studies from 64 [10] to 100% [14] (Table 2). In our series, the rate of complete healing was 76.5% at the first surgical attempt in a mean time of 9.3 months. Failures consisted of four patients (23.5% of the entire group); two of these patients had bad general health conditions; one patient died a few months after removal of the external fixator; another did not heal despite a second attempt at fusion with an Ilizarov external fixator. The other two patients were affected by an anxious-depressive syndrome that contributed to severe intolerance to the external fixator, so its early removal was inevitable. This event accounted for 50% of the failures, so we believe in the importance of carefully assessing the patient's ability to cooperate before treatment.

Our selection of an Ilizarov circular external fixator was dictated by its low cost, versatility, stability under load, possibility to performing modifications during treatment, and low risk of septic dissemination. Nevertheless, in our opinion, careful patient selection is required, as old age and psychological intolerance are generally compromising factors. The treatment time is long and an experienced surgeon is needed to assemble the external fixator and manage it later.

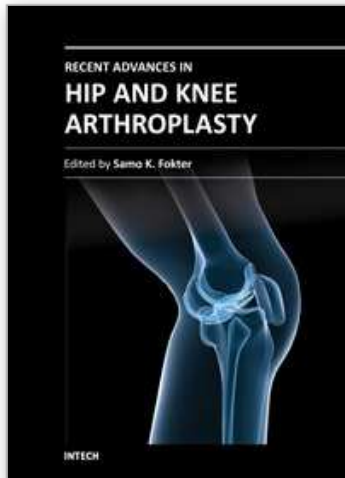
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The purpose of this book is to offer an exhaustive overview of the recent insights into the state-of-the-art in most performed arthroplasties of large joints of lower extremities. The treatment options in degenerative joint disease have evolved very quickly. Many surgical procedures are quite different today than they were only five years ago. In an effort to be comprehensive, this book addresses hip arthroplasty with special emphasis on evolving minimally invasive surgical techniques. Some challenging topics in hip arthroplasty are covered in an additional section. Particular attention is given to different designs of knee endoprostheses and soft tissue balance. Special situations in knee arthroplasty are covered in a special section. Recent advances in computer technology created the possibility for the routine use of navigation in knee arthroplasty and this remarkable success is covered in depth as well. Each chapter includes current philosophies, techniques, and an extensive review of the literature.

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