

Chapter 52 Knee Arthrodesis

where the limb may be asensate and the patient has very poor control of knee function because of severe spinal cord involvement or a myelopathic process. Other indications for primary arthrodesis include treatment of primary malignant bone tumors using augmentations such as autologous grafts or vascularized fibular transplants, or situations in which inadequate motor function exists to maintain stability in extension, such as in chronic polyomyelitis syndrome. Knee arthrodesis has been shown by numerous authors to be durable in the long term even if interposing grafts are needed. For virtually all other circumstances, primarily arthrodesis has been displaced by TKA. The functional outcome is significantly inferior with arthrodesis. Most older patients will require ambulatory aids such as a cane or crutches, and the lifestyle compromise for some patients may be severe.

Secondary Arthrodesis

The most common current indication for knee arthrodesis is chronic sepsis following TKA in a patient who is not a candidate for reimplantation. Typically, these patients are type B or C hosts. Type A hosts have normal, vascularized soft tissues and normal immune status. Type B hosts have significant local and systemic factors that impair the normal immune processes. Local factors include chronic lymphoedema, major vessel disease, venous

cane or walker for community ambulation.

In general, patients adapt their activity level to the knee fusion. Autotransmission. Most patients avoid sitting in theater seats unless an aisle seat can be reserved. Household chores pose special problems, but most patients are able to bend to reach the floor as a result of stretching of the hamstrings and hypermobility of the lumbar spine. Patients with knee arthrodesis have engaged in virtually every type of sport or recreational activity, including tennis, golf, bowling, baseball, handball, and even horseback riding; however, no patient has been known to attempt snow skiing.

Primary Arthrodesis

With the increasing success rates of TKA, primary arthrodesis of the arthritic knee has become an uncommon operation; however, it remains an attractive or at least a reasonable option in several settings. The first indication is a young patient with severe trauma to the knee joint complicated with chronic sepsis and extensor mechanism loss. The second indication is a neuropathic Charcot joint,

Indications

Knee arthrodesis remains an important salvage technique for complex problems of the knee such as severe trauma, chronic infection, or failed total knee arthroplasty (TKA). Technical advances in intramedullary fixation have increased fusion rates dramatically, to the extent that resection arthroplasty has been eliminated as a long-term solution for chronic problems. Simple resection leaves patients with significant instability that must be splinted or replaced indefinitely; however, temporary resection is still indicated in the setting of two-stage debridement and reconstruction for chronic knee infection. Although late reconstruction with TKA is successful in more than 90% of patients, arthrodesis still may be required in certain cases. The patient should be made aware of the functional expectations following knee arthrodesis. The greatest disadvantage of knee arthrodesis is the resultant complete stiffness. With the knee fused in extension, walking is effective and generally smooth, but sitting can be difficult, especially in areas with limited leg room such as movie theaters, sports stadiums, and airplanes. Most older patients require a

stasis, extensive scarring, and radiation fibrosis. Systemic factors include malnutrition, malignancy, extremes of age, hepatic or renal failure, diabetes mellitus, and alcohol abuse. Type C hosts are sufficiently fragile that they might not survive aggressive treatment. Type B and C hosts have a higher risk of infection recurrence, especially when combined with extensor mechanism problems such as patellar tendon rupture. Patients in whom a periprosthetic infection is unlikely to be cured include those with chronic malnutrition with decreased serum albumin and protein, multiple organism infections, chronic infections with persistent signs of inflammation, or life-threatening infections from methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant *Enterococcus*. A recent study has shown chronic sepsis with resistant organisms is likely to recur in at least 50% of patients following two-stage débridement and reimplantation. Careful judgment is needed when treating each patient, and close consultation with an infectious disease specialist is required to balance the risk of long-term antibiotic treatment or suppressive antibiotic therapy against the surgical choices of fibrous resection arthroplasty, total knee reimplantation, arthrodesis, or, occasionally, amputation.

Contraindications

Contraindications to knee arthrodesis include situations in which healing of the fusion and soft tissues may not occur, such as patients with chronic osteomyelitis, poor soft-tissue coverage, or severely impaired vasculature. In patients with a poor vascular supply, not only may arthrodesis be contraindicated, but the success of flap coverage also may be limited.

Results

Several fixation techniques have been shown to result in a successful knee arthrodesis, including standard external fixation frames, Ilizarov technique with small-wire fixation, double-plate fixation, and intramedullary nailing. In severe cases, allografts or vascularized fibular grafts have been used to treat bone defects to promote fusion (Table 1).

External Fixation

One report has shown 100% solid fusion using an anterior unilateral frame for arthrodesis. Another series demonstrated fusion in 20 of 21 knees when an Ilizarov-type fixation was used. This contrasts with the 40% to 80% success rate of earlier methods that used the Charnley compression technique. Inadequate stability probably explained these high failure rates.

Complications of arthrodesis reported in the literature include delayed union, recurrence of infection, wound healing problems, stress fracture, reflex sympathetic dystrophy, and partial peroneal nerve palsy. Complication rates have ranged from 38% to 50% in selected series. Peroneal nerve palsy has been noted by multiple authors, and no obvious explanation is offered other than that stretching of the peroneal nerve may result from positioning of the knee during the surgical procedure. Most of the reported peroneal nerve palsies resolved over time, and in no case was direct surgical trauma identified as the cause.

Intramedullary Nail

The Wichita Fusion Nail (Stryker Orthopaedics, Rutherford, NJ) is a significant improvement over older methods. Compression at the fusion site is optimal with the turnbuckle bolt, and midterm experience has been excellent, with a 100% fusion rate in a recent series.

Techniques

Setup/Patient Positioning

For all methods of knee arthrodesis, the patient is positioned supine on the operating table or with a pelvic bump if anterograde intramedullary nail insertion is planned. The entire lower extremity is prepared and draped in standard fashion; if a proximal nail entry site is chosen, draping should include the hip joint. A sterile tourniquet is used during the initial exposure to minimize blood loss. The surgeon must plan in advance for the chosen fixation method, which may include an external fixation system, compression bone plates, or various intramedullary nailing systems.

Procedure

EXPOSURE

The standard exposure is an anterior midline incision or an incision that follows an older incision. Flaps are made that avoid undermining subcutaneous tissues. Typically, the extensor mechanism, including the patella and patellar tendon, is removed. During exposure, the surgeon must be wary of dissection that will damage neurovascular structures. As with total knee revision, a safe margin is the posterior cortex of the proximal tibia. A sharp bone instrument such as a pointed Hohmann retractor may be used to define this junction for posterior exposure (Figure 1). The posterior surface of the distal femoral condyles is relatively safe and may be stripped under direct visualization. The lateral fibula and lateral collateral ligament of the knee define the position of the peroneal nerve at the knee joint. Adequate soft-tissue mobilization allows the joint surfaces to be positioned for fixation.

GENERAL PRINCIPLES

To obtain successful fusion, standard concepts of primary bone healing apply. The ends of the distal femur and proximal tibia should be flat, with

Table 1 Results of Knee Arthrodesis

Authors (Year)	Number of Knees	Technique	Etiology	Fusion Rate (%)	Complications
Siehl and Hanel (1993)	8	IM nail with dynamic compression plate	Chronic knee infection	100	1 rod perforation 1 peroneal nerve palsy 1 nonunion 1 reinfection
Wick et al (1995)	36	EXFix	Infected TKAs, loose TKA	75	14 nonunions 6 pin-tract infections 5 delayed unions 1 stress fracture through pin tract 1 amputation for persistent infection
Arino et al (1997)	21	IM nail	16 knee tumors 5 failed TKAs	90	3 stress fractures 3 peroneal nerve palsy 1 superficial wound infection 1 reflex sympathetic dystrophy
Wu et al (2005)	3	Dual locking compression plates	Infected TKAs	100	None noted
Strogatz et al (2006)	12	IM nail	Infected TKAs	83	1 amputation 1 nail breakage
McQueen et al (2006)	44	IM nail (Wichita Fusion Nail, Stryker)	Failed TKAs	100	20% major: 6 delayed unions 3 deep infections 2 fractures
Shem et al (2006)	21	Iliizarov frame	Chronic knee infection	95	9 (43%): 3 required redebridement
Leary et al (2007)	85	61 EXFix 24 IM rods	Infected TKA	EXFix: 67 IM rod: 96	EXFix: 3 infections IM rod: 2 infections

IM = intramedullary; EXFix = external fixator; TKA = total knee arthroplasty.

This is particularly true when intercalated allograft is used, as union relies on incorporation from the host side only. Maximum bone apposition is sought. In the case of chronic sepsis or osteomyelitis, all necrotic or nonviable tissues must be excised.

Siehl and Hanel noted that an optimal amount of shortening for clearance of the shoe on gait swing through articulation was 1.5 to 2.5 cm. Patients would choose shoe lift adjustments to this level.

Several fixation methods are preferred here. For most, some form of well-vascularized bone. This is particularly true when intercalated allograft is used, as union relies on incorporation from the host side only. Maximum bone apposition is sought. In the case of chronic sepsis or osteomyelitis, all necrotic or nonviable tissues must be excised.

EXTERNAL FIXATION

compression arthrodesis is applied, threaded pin groups are applied proximally and distally in sound cortical bone of the femur and tibia. Optimum apposition with a degree of compression is desired. Meticulous pin-site care is necessary, and the development of foci of osteomyelitis may be associated with long-term pin use. Patients are best kept non-weight bearing or partial weight bearing for 3 to 5 months.

The most stable construct is a double-frame technique in which two or three

DOUBLE-PLATE FIXATION

This technique uses two broad AODynamic compression plates with 10 to 18 holes (average, 12 holes). Bone

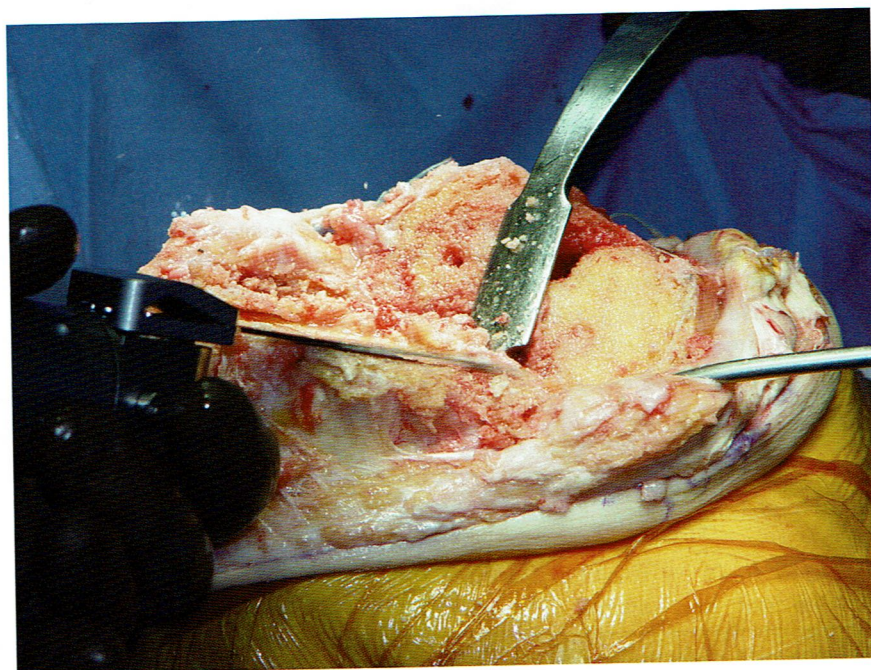


Figure 1 Standard technique is used to cut the proximal tibial surface perpendicular to the axis of the tibial shaft.

cuts are made such that the normal femorotibial valgus of 7° is restored. One plate is placed anteromedially, and the other is placed anterolaterally. Careful contouring of the plates is usually needed. The patella may be osteotomized and applied to the anterior surface of the femur and tibia as a graft. In the presence of sepsis, a two-stage technique is required, with arthrodesis performed after 8 weeks of antibiotic treatment. Postoperative management includes a long-leg cast until the fusion is solid, which may take 5 to 6 months. Recently, authors have reported using this method with a locking compression plate in difficult cases.

INTRAMEDULLARY NAIL FIXATION

Several different rod configurations have been developed, with particular advantages noted for each. This technique is particularly valuable if a long interposing allograft is required, as rigid fixation of the graft is essential for union. The procedure is done using fluoroscopic guidance, and it is important to have the imaging ma-

chine placed such that the nail insertion can be visualized all the way down the leg, to be sure that the distal aspect of the rod remains within the bone. After exposure, the knee implant is removed or the previously debrided infected knee is assessed, and the fusion site is prepared. At this point, an incision is made over the greater trochanter and the gluteus medius muscle is split to expose the piriformis fossa. An entry site is created in the piriformis fossa, and a guidewire is passed into the proximal femur down to the knee joint. The bone surfaces may then be cut, using the axis of the guide pin to create maximally abutting surfaces. Anterograde reaming of the femur is done over the guidewire. Generally, this can be done to 12 or 13 mm, which is the nominal size of the tibial reaming and provides a suitable nail size for strength. The guide pin is passed down the tibia under fluoroscopic control to make certain that the center of the ankle joint is reached. Depending on the nail used, one may overream 0.5 mm on the tibial side and 1 mm on the femoral side. The

dimensions of the nail are determined on the basis of the tibial size. The length of the nail is based on guide pin measurement from the tip of the greater trochanter to a point 2 cm above the ankle joint. The bowed insertion nail is then carefully inserted over the guide pin down to the knee joint and passed across to the tibia while an assistant holds the bone ends in apposition. The anterior bow of the femoral shaft determines the position of the nail and tends to direct the nail out the most anterior cortex of the distal femur. Insertion into the tibia must be assessed carefully to prevent perforation and to ensure distal positioning about 2 cm above the ankle joint. The proximal end of the nail should be within 1 cm of the tip of the greater trochanter. At this point, adjunct fixation may be considered. A 10-hole medial AO neutralization plate, cross-cancellous screws, or proximal and distal locking screws in the nail may be considered. Additional bone graft or bone graft substitutes may be added to the fusion site. Postoperatively, no external splints or casts are needed, but the patient must be non-weight-bearing for 6 to 10 weeks, depending on the progression of healing. The shortened immobilization period is considered an advantage over distal plating or external fixators.



Video 52.1 Arthrodesis of the Knee Utilizing Intramedullary Nailing. Steven Hawkins, MD; Todd Havener, MD, FRC

AUTHOR'S PREFERRED TECHNIQUE: INTRAMEDULLARY NAIL (MCQUEEN TECHNIQUE)

Although other devices may be used, my preference is to use the Watson Fusion Nail (Figure 2), a unique intramedullary nail that can be assembled and compressed in situ. This nail has relatively short femoral and tibi-

ment allows for eventual engagement of the tibial locking segment with a tibial locking segment with a pressure on tightening (Figure 4). The particular advantage of this system is that excellent compression of the femoral nail, secured by a turnbuckle nut that secures adjustment of tibial placement (Figure 3). Adjustment of tibial placement using fixed-dimension reamers done using matching female side in the femoral nail, secured by a turnbuckle nut that secures adjustment of tibial placement (Figure 3).

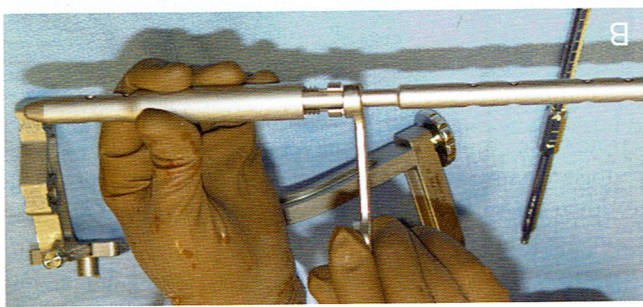
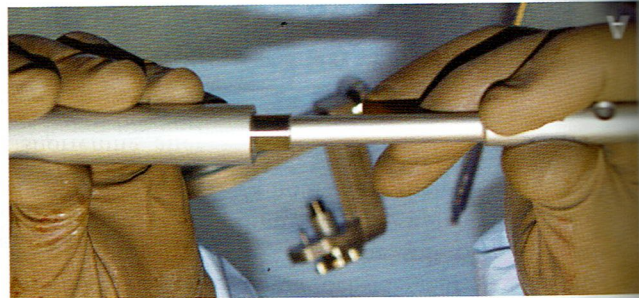


Figure 2 Photographs of the Wichita Fusion Nail. **A**, Engagement of the tibial and femoral components of the Wichita Fusion Nail require insertion of the tibial bolt into the femoral side. **B**, Note placement of the "turnbuckle" nut that secures and provides compression of the fusion

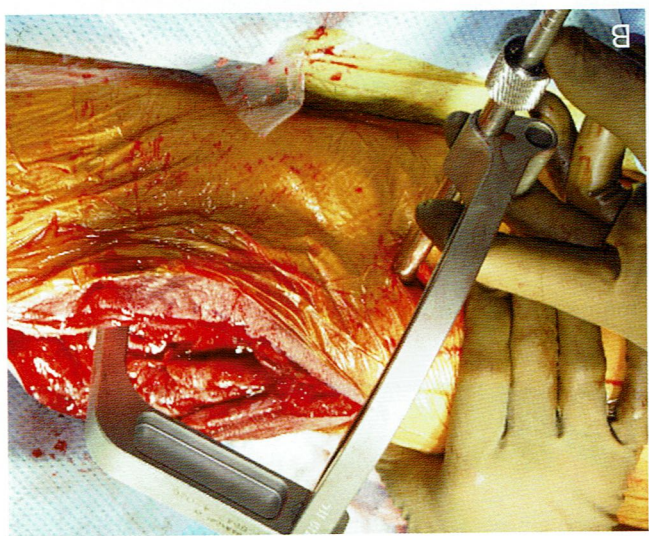
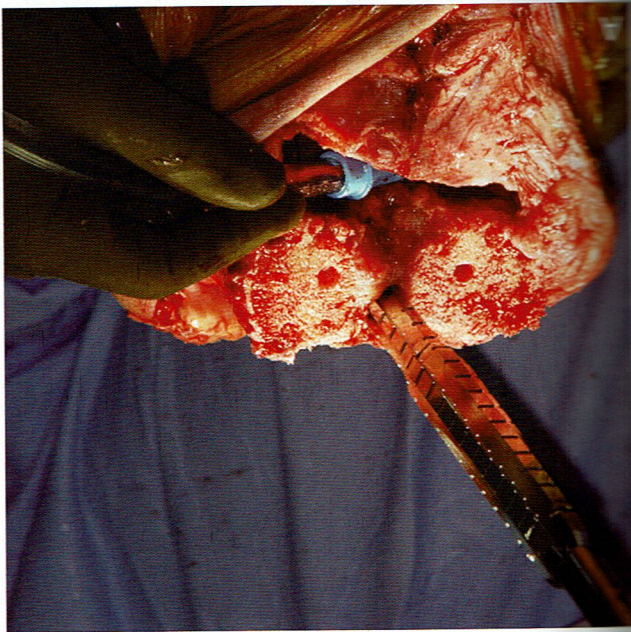


Figure 3 Femoral preparation for knee arthrodesis using the Wichita Fusion Nail. **A**, An intramedullary reamer is used. **B**, An outrigger applied to the Wichita femoral rod allows for lateral percutaneous insertion of the proximal interlocking screws. **C**, Fluoroscopic view shows optimal positioning of the femoral rod before placement of fusion compression. The screws extend through the nail and engage both cortices of the bone.

sion site is possible and blood loss is minimal, which can be a problem if intramedullary reaming is needed. Another important advantage is that the Wichita Fusion Nail is relatively short compared with other intramedullary nails and therefore can be removed without taking down the fusion. McQueen and associates advise cutting the tibial component at the smaller dimension through a window

for removal and state that the femoral component is short enough that removal can be done in a straightforward manner without disturbing the fusion site (Figure 5).

Wound Closure

Wound closure requires that soft tissues be reapproximated without excessive tension. This may be problematic, as typical leg shortening after

failed TKA creates significant redundant tissue. Debulking of soft tissues and removal of the patella may be helpful. Wound healing problems are rare, however, because the wound is held rigidly in one position. Because wound débridement may lead to ooze from the soft tissues, a wound drain may be preferable for the first 24 hours after the procedure.

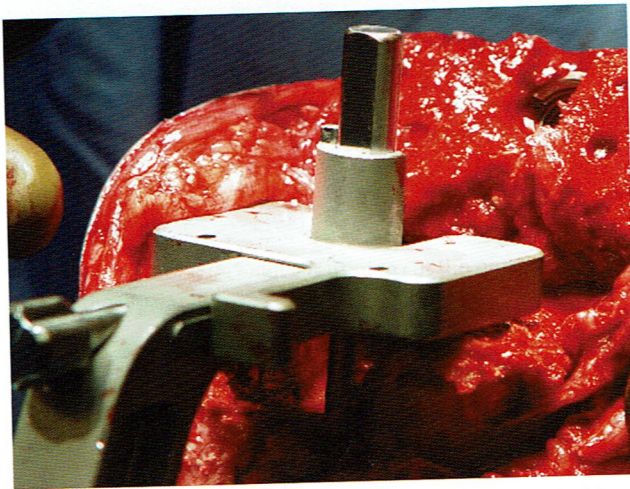


Figure 4 Tibial preparation for knee arthrodesis using the Wichita Fusion Nail. An outrigger applied to the tibial rod places the device at the appropriate position for interlocking. Note the beveled surface of the proximal bolt; this engages a female hole in the femoral nail.

Postoperative Regimen

With any of the compression fusion techniques, the extremity must be kept strictly non-weight bearing for the initial 6 to 12 weeks, or longer for intercalated allografts. Most authors recommend casts or splints with plate fixation. With intramedullary fixation, no external immobilization or splint is needed. For most patients, only sedentary activities with transfer techniques are allowed. Partial weight

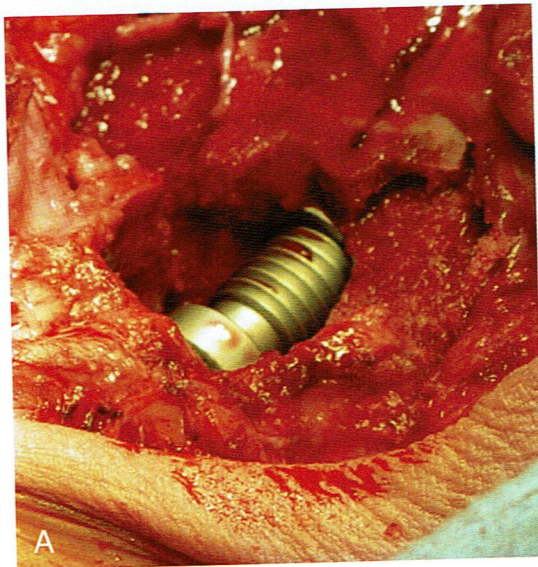


Figure 5 Final placement of the intramedullary fusion nail. **A**, The turnbuckle nut is engaged through a small window that is created when the fusion site is prepared. Postoperative AP (**B**) and lateral (**C**) radiographs show excellent placement of the fusion nail and correct placement of screws in the interlocking holes.

and proximal femoral fracture if reaming is inadequate. Adjunct fixation such as crossed cancellous screws or a neutralization bone plate may be needed at the fusion site. The addition of interlocking screws can add rotational stability at the fusion site. Chronic sepsis before knee arthrodesis remains a controversial topic. Salem and associates noted a high fusion rate with the Ilizarov hybrid fixation but noted several retractions and problems that required additional surgery after TKA, a staged reconstruction seems appropriate, with a delay of 6 to 8 weeks compared with appropriate antibiotic therapy. The choice of nail does not seem to affect fusion rates, but certain advantages and disadvantages are associated with each particular nail. The simple bowed femoral nail allows straightforward anterior-external insertion but carries the possibility of migration, bone perforation, grade insertion but carries the possibility of migration, bone perforation, and proximal femoral fracture if reaming is inadequate. Full weight bearing is allowed when union is confirmed.

Avoiding Pitfalls and Complications

bearing may begin at 6 to 12 weeks depending on the progression of healing and quality of the fixation. Full weight bearing is allowed when union is confirmed.

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CPT Code		Coding	Corresponding ICD-9 Codes	
Knee Arthrodesis				
27580	Arthrodesis, knee, any technique		714.0 733.16 996.66	715.16 905.4

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