An Original Study

Wichita Fusion Nail for Patients With Failed Total Knee Arthroplasty and Active Infection

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Abstract

In the study reported here, we retrospectively evaluated short-term results of knee arthrodesis using the Wichita® fusion nail (WFN) in patients with active infection. Clinical examinations, x-rays, time to union, knee pain after fusion, and ambulatory status were compared in 7 patients who received the WFN. Mean fusion rate was 86%, mean time to fusion was 9.8 months, and mean complication rate was 57%. Complication rates were high, but clinical outcomes were acceptable, supporting use of WFN as a reasonable way to salvage failed total knee arthroplasty in patients with active infection.

Few treatments are available for patients with a failed total knee arthroplasty (TKA) and active infection. Knee arthrodesis is the method of choice for salvaging the unrevisable knee with chronic prosthetic infections (especially infections with highly virulent, antibiotic-resistant microbes), polymicrobial infections, soft-tissue coverage problems, or deficient extensor mechanism.[1,2] Successful knee fusion provides patients with a stable limb for ambulation, one with more efficiency and lower energy cost[3-7] than above-knee amputation or resection arthroplasty provides. Approximately 25% to 30% of patients who undergo above-knee amputation, and fewer than 50% of the patients with resection arthroplasty, are ambulatory.[8,9] Knee arthrodesis usually relieves the patient's pain and has been associated with a low reinfection rate.[5,6,10-13]

External fixation, compression plating, and long intramedullary devices are well-established options for knee fusion. Modular nails, such as the Wichita® fusion nail (WFN; Stryker Orthopaedics, Mahwah, NJ) and the Neff nail (Zimmer, Warsaw, Ind), are alternatives with advantages over long intramedullary nails. Modular nails are available in multiple sizes and are placed through a single incision, and the fusion site is compressed during surgery. The WFN is made of Vitallium alloy (Dentsply, York, Pa) and has femoral and tibial intramedullary components, 4 transverse locking screws, and a split compression screw. The nail, inserted through a single knee incision, allows for both intraoperative and postoperative compression. The modularity of the system can be used to adjust for different femoral and tibial anatomies.

The primary objective of this study was to address whether use of the WFN is an effective treatment for patients with active infection. Another objective was to determine if these outcomes were comparable with those of other modular nail systems as reported in the literature.

Methods

Eighteen fusions were performed between July 1999 and May 2004 for patients with failed TKA. Nine of these 18 fusions were performed with the WFN. All 7 patients with active infection (7/18) were treated with the WFN. Mean age of the 4 women and 3 men with active infection was 63.3 years (range, 50-79 years) (Table I). These patients had a mean of 6.6 previous surgeries (range, 4-10) and a mean follow-up of 41.9 months (range, 29-63 months).

The active infections were polymicrobial or involved highly virulent and antibiotic-resistant microorganisms (Table I). All 7 patients received oral antibiotic suppression. Five (71%) of the 7 had soft-tissue deficiencies that required either gastrocnemius muscle rotational flaps or rectus abdominus free flaps; the other 2 (29%) had a disrupted extensor mechanism consisting of necrotic patellar tendons. One patient had a failed arthrodesis with an external fixator, complicated by pin-tract infections and diagnosed as an infected nonunion.

Surgical Technique

In all cases, an active infection was present, and the knee arthrodesis was performed as a 2-stage fusion involving an explantation of hardware with placement of an antibiotic spacer followed by a second-stage WFN implantation. WFN implantation was done with an anterior approach to the knee through a single incision. Transverse and parallel

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Table I. Patient Demographics and Preoperative Data

Pt	Sex	Age (y)	No. Previous Surgeries	No. Previous Fusions	Soft-Tissue Flap	Extensor Mechanism	Bacteria
1	M	65	5	1	None	Intact	MSSA, GNB
2	M	69	10	0	GMRF	Intact	MRSA, VRE, PA
3	F	63	9	0	GMRF	Disrupted	MRSE, VRE, PA
4	F	79	6	0	GMRF	Intact	VRE
5	F	53	7	0	GMRF	Disrupted	MRSA, VRE, PM
6	F	50	5	0	RAFF	Intact	VRE, CA
7	M	64	4	0	None	Intact	MSSA, EC

Abbreviations: GMRF, gastrocnemius muscle rotational flap; RAFF, rectus abdominus free flap; MSSA, methicillin-sensitive *Staphylococcus aureus*; GNB, Gram-negative bacteria; MRSA, methicillin-resistant *S aureus*; VRE, vancomycin-resistant *Enterococcus*; PA, *Pseudomonas aeruginosa*; MRSE, methicillin-resistant *Staphylococcus epidermidis*; PM, *Proteus mirabilis*; CA, *Candida albicans*; EC, *Enterobacter cloacae*.

Table II. Outcomes for Actively Infected Patients (N = 7)

Pt	Follow-Up (mo)	Time to Union (mo)	Complications	Pain	Ambulation
1	46	9	Persistent infection, tibial fracture	None	Yes
2	63	—	Nonunion	Moderate	Yes
3	35	10	Persistent infection	None	Yes
4	36	12	None	None	No
5	29	12	None	Mild	Yes
6	39	12	None	None	Yes
7	45	4	Peroneal nerve palsy	None	Yes

Table III. Recent Studies of Modular Nail Systems

Study	No. Patients (Infected)	Fusion Rate (%)	Mean Fusion Time (mo)	Mean No. Previous Surgeries
Present study	7 (7	86	9.8	6.6
McQueen et al (2006)[6]	44 (26)	100	3.6	2.8
McQueen et al (2005)[20]	12 (7)	100	4.3	3.8
Domingo et al (2004)[1]	11 (8)	91	4.4	N/A
Waldman et al (1999)[28]	21 (21)	95	6.3	4.0
Arroyo et al (1997)[24]	21 (3)	90	8.4	N/A
Mean (literature)		95.2	5.4	3.5

Abbreviations: N/A, data not available.

osteotomies were prepared at the distal femur and proximal tibia with the goal of creating a fusion in full extension and a straight limb. This is in contradiction to the normal recommendation of slight flexion, because of the inherent shortening of the limb after resection of the knee replacement.

All clinical charts and x-rays were assessed by a blinded reviewer. Serial x-rays were used to determine time to fusion, defined as bony bridging of the bone gap on both anteroposterior and lateral views. Fusion rate, time to union, knee pain after fusion, and ambulatory status were compared with results published in the literature.

Results

A solid knee arthrodesis occurred in 6 (86%) of the 7 knees. Mean time to radiographic union was 9.8 months (range, 4-12 months) (Table II). Five (71%) of the 7 patients reported no pain after solid arthrodesis (Table II). One patient, who was morbidly obese, had mild pain despite successful fusion. One patient had moderate pain when ambulating and was diagnosed with an atrophic nonunion.

Six (86%) of the 7 patients were ambulatory; the exception was a patient (Table II) with a solid fusion at 1 year and a leg length 9 cm short on the fused side. This patient developed a significant equinovarus deformity of the foot and ankle secondary to the limb shortening. In addition, she had flexion contractures of a hand because of untreated trigger fingers and was not able to hold on to a walker.

Four (57%) of the 7 patients experienced at least 1 complication (Table II). Of these 4 patients, 2 had a persistent infection that required rod removal. The first had a solid fusion at 9 months, but osteomyelitis of his distal femur never resolved with antibiotic treatment, and he later developed a deep abscess in the popliteal space that required irrigation and débridement 2 years 8 months after WFN implantation. Failure to eradicate this infection approximately 3 months after irrigation and débridement required nail removal. The nail was removed, without disrupting the fusion, through an anterior cortical window created in the proximal tibia. Two months after nail removal, the patient was diagnosed with a nondisplaced transverse fracture of the proximal tibial diaphysis propagated from the corticotomy. He was treated conservatively with a cast and fracture brace, and he healed slowly over 1 year. Almost 4 years after implantation, the fusion remained well healed and solid, and the patient was ambulatory, had no pain, and was wearing a functional brace that allowed him to remain relatively active.

For the other patient who required rod removal, the persistent infection was secondary to unresolved osteomyelitis. The nail was removed 5 months after implantation through an anterior cortical window created in the distal femur without disrupting the fusion site. After nail removal, a gastrocnemius muscle flap was performed secondary to skin breakdown. The patient, placed on a restricted weight-bearing regimen, showed complete fusion 10 months after WFN implantation. At the 3-year postoperative visit, the patient was ambulatory and had no pain, and the fusion remained solid.

A third patient was diagnosed with an atrophic nonunion at 1 year and was lost to follow-up, and the fourth developed permanent peroneal nerve palsy from the procedure.

Discussion

Failed TKA presents a unique set of problems for knee arthrodesis, including persistent infection, severe bone loss, poor bone apposition, lack of soft-tissue coverage, and loss of extensor mechanism. Patients with a failed TKA have lower fusion rates because of impaired bone quality, decalcification, and bone deficiency after removal of the prosthesis and cement.[14] Significant bone loss results in limb shortening when the knee is fused.

Use of external fixators in cases of active infection has several advantages. These temporary devices do not act as a nidus for infection and allow for repeat débridement if necessary in cases of 1-stage fusions or difficult-to-control infections.[5,7,10,11,13,15-22] The major disadvantages are pin-tract infection, pin loosening, neurovascular injury resulting from improper pin placement, and stress fractures.[5,7,10,11,13,15-22] In addition, patients are partial weight-bearing, and fusion rates are lower, especially in cases of failed TKA, in comparison to other fusion methods.[5,7,10,11,15-21]

Plate fixation offers rigid internal fixation with compression, and patients are weight-bearing as tolerated with external immobilization. However, compression plating has been reported to be less reliable in cases of failed TKA caused by deficient bone stock.[5,23]

Long intramedullary rod fixation is a familiar surgical technique that can be used in cases of severe bone loss and for salvaging failed external fixators.[5,11,13,14,17,20,24-29] Disadvantages are use of a second incision at the hip, which places the hip at risk for infection; longer surgical time; increased blood loss; compression of fusion site with weight-bearing; and canal diameter differences.[5,11,13,14,17,20,24-29] Use of a long intramedullary device has the potential to contaminate healthy bone in cases of failed TKA and sepsis,[10] although this risk has been shown to be low for knee arthrodesis.[13,30,31] It is important to control the infection before nailing. Donley and colleagues[25] reported that mean time to clear an infection after prosthesis removal was 12 months.

The long fusion nail offers dynamic compression during ambulation and may be easier to remove than a modular nail. Ideally, however, the nail will not need to be removed. The WFN offers additional advantages over long nails, including 1 versus 2 incisions, modularity for different canal diameters to accommodate the anatomy of the patient, and intraoperative compression. We believe that these advantages make the WFN, on the whole, another option for this subset of patients and a useful one for surgeons to consider.

Modular intramedullary nails can obtain solid fusion in the face of an active infection.[13] Use of intramedullary rods in cases of infected TKA has an unresolved infection rate comparable with that of external fixation and a better union rate,[4,16,18,21-23,27,31-33] suggesting superiority over external fixators. Modular nails have advantages over long nails, including use of a single incision at the knee, modularity for different canal diameters, and intraoperative compression.[1,6,20,24,28] However, modular nails are difficult to remove in cases of solid fusion with persistent or recurring infections.

Removal of modular nails is difficult but possible. The locking screws are first removed from the tibial and femoral components. Then a rectangular corticotomy at the femur and fusion site is created to allow for visualization of the femoral component and the compression screw at the joint. The rectangle is approximately 1.5 cm wide by 10 to 15 cm long. It is made in the femoral cortex anteriorly, and the fusion does not have to be taken down to remove the nail. The nail is cut with a carbide hip burr. Taking the nail apart is an option after the cross-linking screws are removed, but cutting the nail is easier. The femoral component is extracted first. Then, the tibial stem is gently removed by tapping the component out proximally, along with the compression nut.

Overall, in cases of failed TKA, the intramedullary nail has a higher fusion rate compared with that of other fusion methods, despite bone loss, poor apposition, short limb, and persistent infection.[11,15,16,18,21,25,31] Decreased fusion rate and longer time to union have been found in patients with infections. Rand and colleagues[21] stated that the extent of bone loss is the most important factor influencing knee arthrodesis, and massive bone loss may substantially reduce the prospect of successful arthrodesis.[3,8,21]

In the present study, the mean fusion time of 9.8 months (42.5 weeks) is longer than times previously reported (Table III). Number of prior surgeries (6.6) and use of soft-tissue flap for coverage (71%) correlated with longer fusion time (Table I). In most cases, the infection was difficult to control and often required multiple débridements, antibiotic cement spacer exchanges, and soft-tissue reconstruction. It is important to recognize

Why Bone Graft Was Not Used

Because of the presence of infection, we chose not to use bone graft in these cases. In cases of fusion, use of bone graft potentially has 2 benefits: to lengthen the leg, which would require an interpositional structural graft, and to enhance fusion. We believe that, in the setting of active infection, these grafts would not function to meet either of these aims. In fact, allograft could cover the bony surfaces and theoretically inhibit direct host bone contact. The theoretical advantages of use of allograft would likely not be substantiated in these cases.

that all patients in this series continued to have low-grade infection. They had all failed multiple attempts to eradicate the infection, as illustrated by a mean of almost 7 previous procedures. Because of the presence of infection, bone graft was not used in these cases (See Box above). Other studies on modular intramedullary devices have reported fusion rates comparable with those of the long intramedullary nails.[1,6,20,24,28] For long intramedullary nails, the rate of successful fusion is 80% to 100%,[4,11,13,17,18,25-27,31,34-39] mean time to union is 6 months,[13,17,27,36,37] and the complication rate is 40% to 50%.[13,21,24,26,33,40] Table III summarizes the results of several recent studies using modular nail systems.

WFN offers the advantage of dynamic compression with weight-bearing in addition to intraoperative compression. However, in the case of failed TKA with severe bone loss and osteoporosis, the surgeon may restrict patient weight-bearing for an extended period, which can increase time to union. All our patients were partial weight-bearing after implantation because of significant bone loss and osteoporosis. Their weight-bearing status was considered advanced, on the basis of radiographic evidence of early fusion.

In our study, longer time to fusion was found to be positively associated with number of previous surgeries and with soft-tissue coverage requirements (Tables I, II). Our fusion rate of 86% compares well with those of modular nails (88%-100%). Mean time to fusion was 9.8 months, longer than what has been reported in the literature (3.6-8.4 months). This difference can be explained by the persistent infections that required multiple débridements and by antibiotic cement spacer exchanges that led to increasing bone loss, soft-tissue deficiencies requiring flap coverage, and restricted weight-bearing. Illustrating this fact is the mean of almost 7 previous surgeries in our cohort, which is nearly twice that reported in the literature (Table III). These previous surgeries result in destruction of soft tissues and periosteal stripping, which compromise blood flow to the fusion site.

Conclusions

Our study provides evidence (86% fusion rate) to support use of modular intramedullary nails in the difficult subset of patients with failed TKA and active infection. Although our patients had a high complication rate and longer time to union, their clinical outcome (based on pain after arthrodesis and ability to ambulate) was acceptable. Given that this subset of patients had failed attempts to eradicate the infection and would have faced the possibility of an above-knee amputation as their alternative, we feel that these results support use of WFN as an effective way to salvage an irretrievably failed TKA in patients with active infection.

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