Acta Orthop. Belg., 2008, **74**, 809-815

ORIGINAL STUDY

Knee arthrodesis with the Vari-Wall nail for treatment of infected total knee arthroplasty

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We reviewed 20 patients who had undergone one-stage (7 cases) or two-stage (13 cases) knee arthrodesis using the Vari-Wall intramedullary nail, as a salvage operation following infection of a total knee arthroplasty. The procedure was followed by systemic antibiotic administration and early rehabilitation. Intraoperative microbiological cultures were taken. The average period of follow-up was 20 months. Solid union was achieved in 80% ; mean time to fusion was 9 months. There was no recurrence of infection. The average limb length discrepancy was 2.45 cm. A walking aid was needed by 95% of the patients. The complication rate was 30% including 4 pseudarthroses, one intraoperative fracture and one peroneal nerve palsy. The Vari-Wall intramedullary nail is a good option when an arthrodesis is indicated for salvage of an infected total knee arthroplasty. It can be performed in one or two stages depending on several factors such as microbiologic culture results. It achieved good pain relief and acceptable functional results in this study.

Keywords : total knee arthroplasty ; infection ; arthrodesis.

INTRODUCTION

Infection is one of the major complications of total knee arthroplasty (TKA), and TKA infection is currently the major indication for knee arthrodesis. In performing knee fusion, the surgeon aims to achieve solid union, deformity correction and control of infection. Arthrodesis may lead to an acceptable functional outcome, with elimination of pain.

Reduced bone mass, severe ligament instability, loss of soft tissue cover, and the presence of antibiotic-resistant organisms represent severe risks to revision arthroplasty. The risk of a recurrence of the infection and failure after TKA revision in these circumstances is substantial, and the functional outcome may be very poor. These cases are better managed with arthrodesis (*9*).

A number of techniques are recommended for knee arthrodesis. External fixation, whilst ensuring solid union, may require long non-weight-bearing periods and is of limited value in cases with massive bone loss ; moreover, pin-tract infection is common, and the fixator may hinder ambulation.

Plate and screws fixation entails long non-weight-bearing periods and possibly a second operation to remove the implant once union has been achieved. The often inadequate quality of fixation

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No benefits or funds were received in support of this study

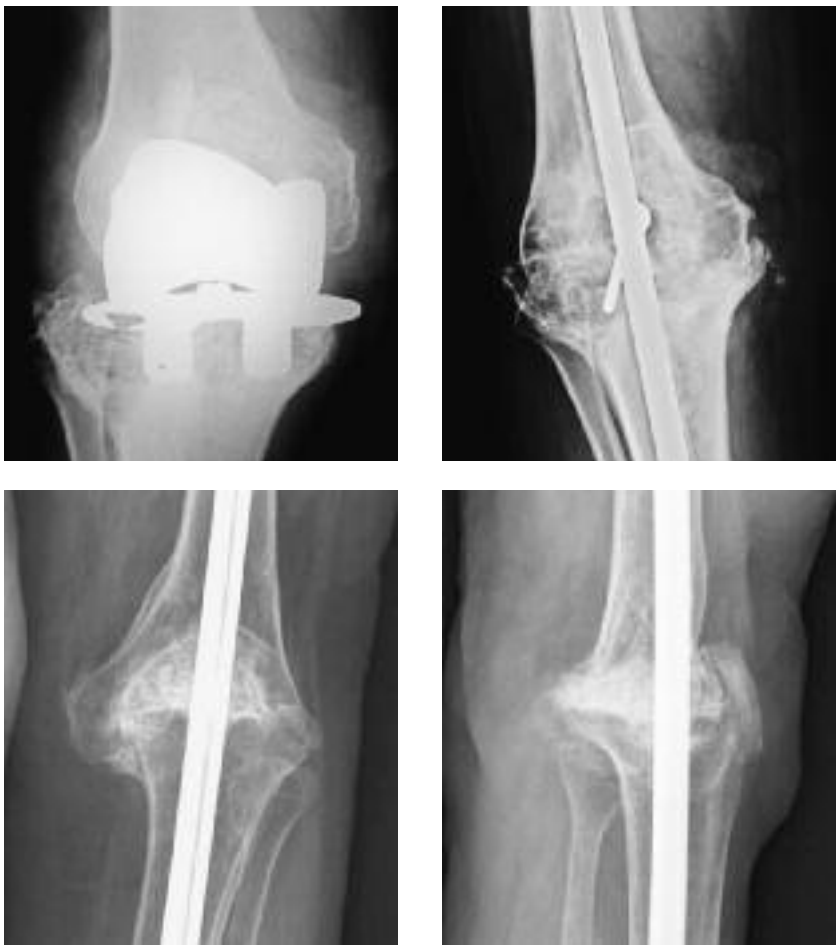

Fig. 1. — Vari-Wall intramedullary nailing. Note visible trabeculation over the arthrodesis site

and compression at the arthrodesis site is associated with a high risk of nonunion or malunion.

Of the techniques most widely used at present, intramedullary nailing is associated with the highest percentage of union, largely because the longitudinal fixation and compression achieved allow for prompt weight bearing and early rehabilitation (*11*). Healing time is also reported to be shorter when a two-stage procedure is used, eliminating infection prior to performing arthrodesis (fig 1).

Achieving stability of the arthrodesis site and large contact between viable bone surfaces are the key factors in obtaining a satisfactory solid union (*1*).

MATERIAL AND METHODS

The clinical and radiological results were retrospectively studied in 20 patients, who underwent knee arthrodesis with intramedullary nailing as a salvage operation for an infected knee arthroplasty. Revision arthroplasty was deemed unsuitable due to lack of soft tissue coverage, infection by multiresistant microorganisms (MRSA), rupture of the extensor apparatus, massive bone loss, or failure of a previous revision arthroplasty. The patients (14 women, 6 men) had a mean age of 75.2 years (range : 58 to 83).

Where TKA infection was caused by virulent or multiresistant pathogens, a classical two-stage protocol was used, with implant removal, cleansing, debridement and

insertion of tobramycin cement spacers during the first step, followed by removal of the cement spacer and knee arthrodesis. Standard Vari-Wall intramedullary nails (Biomet®) of varying length (60 to 80 cm) and diameter (10-14 mm) were used. In the second surgery, after removal of the infected implant, the knee was cleansed and systemic antibiotics were administered ; at the same time, clinical, radiological and laboratory evaluations were performed ; arthrodesis was carried out once clinical, laboratory, imaging and scintigraphic data showed eradication of the infection.

A single-stage approach was used in the remaining cases.

During surgical removal of the infected implant, samples of synovial fluid, synovial tissue, joint capsule, and both femoral and tibial intramedullary canals were taken for culturing. Antibiotic therapy following implant removal consisted in initial interim empirical treatment with vancomycin pending the arrival of microbiology results, subsequently adjusted in the light of results : patients with negative cultures received vancomycin over a 3-week period, followed by oral levofloxacin 500 mg/24 hours + rifampicin 600 mg/24 hours for 3 months.

After insertion of antibiotic cement spacers, clinical, laboratory and radiological follow-up continued for 3-4 months. If the results obtained over this period suggested that the infection had been eradicated, knee arthrodesis was carried out using a Vari-Wall intramedullary nail. One patient presented a major skin defect, which was treated by transposition of the gastrocnemius muscle. The patella was used for grafting a bone defect if present. Where the bone defect was less marked, the anatomical position was respected and bones were secured by a screw over the femorotibial contact surface. Bone defects were treated with allografts or autologous patellar bone grafts, depending on the size of the defect. Mean limb-length discrepancy was 2.45 cm (range : 0 to 5). Antibiotic prophylaxis at the second stage was vancomycin 1 gr/12 hours for 48 hours. Patients were kept in bed for the first 48 hours post-surgery, with compression dressings and suction drains. Thereafter, they were allowed to sit with the affected leg raised, and were encouraged to regularly exercise ankle flexion/extension. Patients who did not have bone grafts were allowed to start aided walking and partial weight-bearing from day 3 onwards. In patients with bone-graft, (4 allografts and 1 autograft) weight-bearing and aided walking were delayed until the third week. Walkers/crutches were gradually abandoned, depending on the functional capacity of the patient.

Evaluation of the results was based on the following parameters : limb length discrepancy, radiological evidence of union (good trabeculation at the arthrodesis site), mean time to radiological union, complications such as deep vein thrombosis (DVT) or pseudarthrosis, the number of positive cultures and microorganisms isolated and WOMAC scale to assess pain and functional capacity. Section B of the scale referring to stiffness was omitted, giving scores ranging from 0 to 88 (2).

In two allogenic bone-graft patients, one gram of powdered vancomycin was administered *in situ* together with the bone graft.

Eight patients had a posterior cruciate retaining (CR) TKA, eight had a posterior stabilised (PS) TKA and the remaining 4 had a constrained TKA. Surgery was performed following a one-stage protocol in 7 cases (35%), and following a two-stage protocol in the remaining 13 (65%). Two patients had previously undergone revision arthroplasty. A proximally locked nail was used in 11 of cases, and a statically locked nail in the other 9.

Microbiological examination was carried out systematically for all patients, taking 5 samples for culturing.

RESULTS

The mean follow-up duration for these 20 patients was 20.6 months (range : 11 to 29). Radiological and clinical union was achieved in 16 patients (80%) in a mean time of 9 months (range : 5 to 12). All patients with allogenic bone graft displayed solid union, with a mean time to union of 8 months. The single patient who received autologous patellar bone-graft developed pseudarthrosis (table I).

The mean number of positive cultures per patients was 1.3 (range : 0 to 5). Cultures were all negative in 8 patients (40%), who continued with the initial empirical treatment. Six patients (30%) were positive for coagulase-negative staphylococci (CNS), two patients (10%) for methicillin-resistant S*taphylococcus aureus* (MRSA), two (10%) for Gram-negative species, one (5%) for Gram-positive species (*Enteroccocus faecalis*) and one (5%) for fungi (table II).

During follow-up, 70% of patients displayed no complications. One patient presenting paralysis of the peroneal nerve was treated conservatively by rehabilitation and an equinovarus splint, and started to recover after the 6th month. Another patient

Table I. — Graft type vs. time to union and pseudarthrosis

Patients	Bone Graft type	Time to union (Months)	Pseudarthrosis
1	Allogenic	8	NO
2	Without graft	10	NO
3	Without graft	6	NO
4	Allogenic	5	NO
5	Without graft	12	NO
6	Without graft	7	NO
7	Without graft	–	YES
8	Without graft	–	YES
9	Without graft	10	NO
10	Without graft	–	YES
11	Allogenic	12	NO
12	Allogenic	10	NO
13	Without graft	9	NO
14	Without graft	8	NO
15	Without graft	12	NO
16	Autologous	–	YES
17	Without graft	12	NO
18	Without graft	8	NO
19	Without graft	8	NO
20	Without graft	7	NO

Table II. — Microbiological findings and number of positive cultures

Patients	Number of positive cultures	Microorganisms isolated
1	0	–
2	1	S. Epidermidis
3	3	S. Epidermidis
4	0	–
5	2	MRSA
6	4	S. Epidermidis
7	1	S.Epidermidis
8	1	Enterococcus Faecalis
9	3	Gram negative
10	0	Gram negative
11	0	–
12	0	–
13	1	S. Epidermidis
14	0	–
15	0	–
16	5	S. Epidermidis
17	0	–
18	2	Fungi
19	0	–
20	3	MRSA

sustained an intraoperative subtrochanteric fracture, treated intra-operatively with no further complications. There were 4 cases (20%) of pseudarthrosis, (2 in one-stage arthrodesis and another 2 in two-stage arthrodesis) only one of which required treatment due to poor clinical progression : the patient underwent surgery 18 months after the first operation ; the bone surfaces were refreshed and allogenic bone grafts were applied. Finally, one patient died two years post-surgery for reasons unrelated to surgery.

We have not noted any recurrence of infection during the observation period. There were no cases of nail failure or breakage.

By the end of the follow-up period, only one patient (5%) was able to walk unaided, seven (35%) could walk with one crutch, 4 (20%) with two crutches and 8 (40%) with a walking frame. The mean leg length discrepancy was 24.5 mm (range : 0 to 50). The mean postoperative WOMAC score was 32.26/88 points (range : 8 to 69). A mean score of 4.95/20 points (range : 0 to 14) was obtained for section A (pain assessment) and a mean of 27.32/68 points (range : 0 to 55) was recorded for section C (functional assessment) (table III).

DISCUSSION

The stainless steel Vari-Wall nail features a variable wall thickness which provides increased strength over the screw holes while maintaining optimal flexibility. This is important to facilitate insertion and to minimize stress shielding, while stimulating bone fusion by providing micromotion at the femorotibial interface. It can be extracted easily after fusion should this be necessary, which is not possible with short two-part interlocking tibiofemoral nails introduced through the knee incision. Our results with the Vari-Wall nail are similar to those reported with other intramedullary systems (*7*).

Treatment of total knee arthroplasty infection by arthrodesis is today a widely accepted practice, particularly where there are complications such as rupture of the extensor apparatus, lack of soft tissue coverage, infection by virulent microorganisms,

Table III. — Functional outcome in terms of walking and WOMAC scale

Patients	WOMAC (pain)	WOMAC (functional)	Ambulation
1	3	21	Frame
2	12	36	Frame
3	8	32	Frame
4	0	8	One crutch
5	10	36	Two crutches
6	14	55	Frame
7	10	31	Frame
8	6	27	One crutch
9	4	21	Two crutches
10	0	15	No support
11	0	42	Frame
12	0	17	One crutch
13	5	29	One crutch
14	5	24	Frame
15	5	29	One crutch
16	2	29	Two crutches
17	4	21	Two crutches
18	1	19	One crutch
19	–	–	Frame
20	5	27	One crutch

massive bone loss, failure of previous revisions or comorbidities such as morbid obesity or diabetes mellitus. The aim of arthrodesis is to alleviate pain and achieve an acceptable functional outcome. Every attempt should be made to achieve 0º extension, and a slight varus, to place the foot under the centre of gravity during walking.

Various techniques are used for arthrodesis. External fixation, made popular by Charnley, has been widely used (*4*). It enables adjustment of compression and alignment at the arthrodesis site, but a number of papers report lower rates of successful union than with intramedullary nailing : Hagemann *et al* (*8*) recorded 64% union, Broderson *et al* (*3*) 75.5%. Disadvantages of external fixation include pin tract infection and the need to keep the fixator in place over prolonged periods of time.

Dual-plate internal fixation is less widely used. Lucas and Murray (*10*) reported successful fusion in 17/18 patients, but there was difficulty with wound closure over the anterior plate, and five patients required plate removal because of painful prominent hardware. A postoperative plaster cast was also required, which delayed weight-bearing.

Intramedullary fixation is probably the most widely-used technique, with reported success rates ranging from 60% to 100%. Intramedullary nailing enables early weight-bearing, provides greater stability and is better tolerated than other arthrodesis techniques. Bargiotas *et al* (*1*) reported solid union in 10/12 patients, and stressed that the highest fusion rates were obtained with large contact areas of bleeding bone during arthrodesis. Wilde *et al* (*16*) recorded a fusion rate of 66.6% in patients who had previously undergone surgery on more than one occasion, and highlighted the value of arthrodesis in cases with massive bone loss. Rothacker and Cabanela (*12*) reported a mean time to clinical union of 20.8 weeks (range : 7 to 60) after arthrodesis in patients with an infection at the site of a total knee arthroplasty compared with 11.3 weeks (range : 6 to 16) in those with an aseptic knee, while Woods *et al* (*17*) found that it took on average 2.2 months longer for the fusion to heal in patients who had the arthrodesis at the site of an infection.

In our series successful fusion was recorded in 80% of cases, with a mean time to union of 9 months (8 months in bone-graft patients). No pseudarthrosis was observed in any patients undergoing arthrodesis following a cruciate retaining TKA, with better bone stock. Bone grafts were used in four patients who had previously undergone constrained TKA, and thus displayed greater loss of bone stock ; one of these developed pseudarthrosis. None of the patients with a posterior stabilised TKA – and therefore moderate bone mass – received bone grafts, except for one case in which the autologous patellar graft used was probably insufficient.

Recently, other intramedullary techniques have been tested, using short modular nails introduced through the knee incision. Waldman *et al* (*4*) reported successful fusion in 95% of 21 cases, with a mean time to union of 6.3 months. Walker *et al* (*4,15*) observed solid union in 4 out of 4 cases. In 1999, Sundgren (*13*) reported on two cases using a cemented modular intramedullary nail ; cementing enables antibiotics to be added at the site of infection, and also provides immediate stability, with no need to wait for fusion ; additionally, limb length can be respected.

Bargiotas *et al* (*1*) have reported on a two-stage approach for arthrodesis, obtaining satisfactory results in terms of eradication of infection (11/12 cases), solid union (83.3%) and time to union (5.5 months). In the present study, the surgeon decided whether a one-stage or two-stage approach should be adopted, in the light of microbiology findings, the patient's general health and prior associated pathology. The one-stage approach was used in 35% of patients and the two-stage approach in the remaining 65%. There was no recurrence of infection in either group, largely because the microorganism detected in one-stage patients was not virulent, and this approach was not used in any case presenting MRSA. In Bargiotas' study (*1*), the MRSA infection rate was 50%, compared with 10% in this study. A lower rate of successful fusion was obtained in one-stage patients (71.4%) than in those undergoing two-stage arthrodesis (84.2%), possibly due to the use of bone grafts in the latter. There was no significant difference in time to union between the two groups.

The clinical results obtained here suggest satisfactory elimination of pain, with a mean score of 4.95/20 points for section A of the WOMAC scale (little or no pain in daily activities). Alleviation of pain is a major aim of arthrodesis. The score of 27.32/55 points recorded for section C of the WOMAC scale suggests that most patients experienced an acceptable level of difficulty, when carrying out functions of daily living. Most patients required some sort of walking aid : one or two crutches in 55% of cases, and a walking frame in 40%. Crockarell and Mihalko (*6*) reported better results, with 45% of patients being able to walk unaided. The mean patient age is highly relevant in this respect : in the Crockarell and Mihalko study (*6*) the mean age was 63, compared with 75.2 in our study. Finally, the reported mean leg length discrepancy varies considerably : here, the mean value was 2.45 cm, compared with 3.56 cm in 12 patients reported by Wilde and Stearns, 3-7 cm in the Crockarell and Mihalko study, and up to 5.5 cm in other studies (*1,6,16*).

According to a recent review by Conway (*5*), complication rates following knee arthrodesis range from 20% to 84%, and include recurrent infection, peroneal nerve palsy, pseudarthrosis, DVT, fractures, breakage of screws or nails and lack of soft tissue coverage. Here, the complication rate was 30%. The single case of pseudarthrosis is addressed above. We had no instance of DVT, recurrent infection, breakage of the nail or poor soft-tissue coverage. The single case of neurapraxia – peroneal nerve paralysis – recovered after conservative treatment (rehabilitation and equinovarus splint). There was one intraoperative fracture, treated intraoperatively with favourable progress. One patient died two years post-surgery for reasons unrelated to surgery (acute heart failure).

In view of the results obtained, and although the study involved only a small number of cases, knee arthrodesis using a Vari-Wall intramedullary nail would appear to be suitable for treating TKA infection in cases where arthrodesis is indicated. A one-stage or two-stage approach may be used depending on the virulence of the microorganisms involved and on the previous pathology.

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