KNEE FUSION USING SIGN NAIL, AN ADDITION TO THE ARMAMENTARIUM: TECHNIQUE AND OUTCOME

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ABSTRACT

Background: Knee arthrodesis still has indications in this modern era of arthroplasty and ranges from failed total knee arthroplasty, advanced tuberculous infection to severe contractures. Of the implants that can be used for knee fusion, intramedullary devices have the lowest rates of major complications, shortest time to fusion and the highest fusion rates.
Objective: To describe the results and technique of a case series of knee fusions performed using SIGN nails at AIC Kijabe Hospital, Kenya.
Design: A retrospective case series.
Methods: This case series describes a novel implant choice for knee fusion in eight patients. Of the eight patients, six were male and two were female. The average age was 40 years. They were followed up for an average of 13 months. All the surgeries were performed by a single surgeon and utilised the same technique. Outcome was based on assessment for clinical and radiologic union.
Results: Four (50%) of the arthrodeses were secondary to advanced tuberculous infection, one was due to chronic knee dislocation and three were due to failed total knee replacement. Seven (87.5%) went on to primary union. One (12.5%) patient needed bone grafting and dynamization and 2(25%) sustained a peri-prosthetic fracture. All patients are ambulant with no weight-bearing restrictions.
Conclusion: The SIGN intramedullary nail system allows an easy and reproducible knee fusion technique in resource and equipment limited settings. Our case series demonstrated that the knee fusion with the SIGN nail lead to successful union in majority of our patients. In addition, 25% of our patients developed a periprosthetic fracture at the nail insertion site which has not been reported in other similar studies.

Key words: Knee, Arthrodesis, Fusion, SIGN nail, Infection

INTRODUCTION

Knee arthrodesis has been performed for more than 100 years (1), albeit with a decline in its use especially in developed countries, due to various arthroplasty options (1,2). It is currently a limb salvage option in failed Total Knee Arthroplasty (TKA), advanced tuberculosis, serious bacterial infections with bone destruction, fixed flexion contractures due to polio, reconstruction after tumour resection, and unreconstructible knee joints after severe trauma (1,2).

Various techniques and implants have been used in knee arthrodesis with varying union rates. Intramedullary devices are popular due to their higher fusion rates, fewer complications and better patient tolerance (3,4).

This study was undertaken to describe our technique of knee arthrodesis using the SIGN nail (Surgical Implant Generation Network, Fracture Care International, Richland, Washington, USA), which is a simple, inexpensive, non-cannulated stainless steel nail, that does not require fluoroscopic guidance for placement of interlocking screws. Ethics approval was obtained from the Institutional Review Board of Kijabe Hospital.

MATERIALS AND METHODS

This was a retrospective review of eight patients (8 knees) who underwent knee arthrodesis using a SIGN nail. Six males and two females with an average age of 40 years were treated with arthrodesis using a SIGN nail. The average follow-up period was 13 months. The medical records were reviewed and the data was stratified under various parameters (Table 1). The preoperative diagnoses entailed knee tuberculosis in four (50%) patients, failed total knee replacement in three

Table 1
Demographics and diagnoses of the patients

Patient	Age (years)	Sex	Diagnosis
1	25	F	Advanced Tuberculosis (TB)
2	42	F	Chronic dislocation
3	30	M	Advanced TB
4	26	M	Mal-aligned-Post-TB knee ankylosis
5	65	M	Failed total knee arthroplasty (due to infection)
6	35	M	Advanced TB
7	55	M	Failed total knee arthroplasty (due to infection)
8	41	M	Failed total knee arthroplasty (due to infection)

(37.5%) patients and chronic post-traumatic knee dislocation in one (12.5%) patient.

Surgical technique: The patient was placed supine on the operating table with the tourniquet *in situ*. A midline longitudinal skin incision extending from the distal third of the thigh to just distal to the tibial tuberosity was made. Deeper, a medial parapatellar approach was utilized (Figure 1). The bone cuts were performed using an oscillating saw with the aid of a total knee instrumentation set (Depuy, Johnson & Johnson) or free hand, with the aim of restoring the neutral mechanical axis alignment (confirmed intraoperatively using the electrocautery cord from the centre of the hip to the middle of the ankle joint).

If the knee arthrodesis was performed for a failed infected total knee arthroplasty, it was done in two stages; The first stage entailed implant removal, debridement, biopsy and antibiotic cement spacer placement with an external splinting orthosis. Follow up with serial infection work up was done to confirm control of infection prior to the second stage procedure. During the second stage procedure, the antibiotic cement spacer was removed, repeat microscopy and culture specimens taken, then definitive bone cuts fashioned. The decision to proceed with definitive bone cuts was based on the surgeons assessment of the presence of gross infection intraoperatively.

An oblique hole was made in the anterior aspect of the femur, approximately 10-15cm above the medial joint line (Figure 2a). The entry hole was enlarged sequentially, initially with a power drill and subsequently with hand reamers to fit the selected nail size. The femur and tibia canals were hand reamed after which the nail was inserted with the Herzog curve facing posteriorly ('apex posterior'). Using the SIGN nail locking target arm, which does not require fluoroscopy, the nail was locked proximally first with a lateral to medial placement of two interlocking screws. After confirming apposition of the bone ends and alignment, two distal interlocks were placed via the target arm with a medial to lateral placement of the screws (Figure 2b). To aid in placing the distal screws, the target arm was loosened proximally and rotated to align the target arm on the medial side. Ideally, arthrodesis should be done with neutral coronal alignment and 10 degrees of flexion.

Finally, the patella articular surface was denuded of all the cartilage with an oscillating saw or rongeur and then the soft tissues closed over a closed drainage system with absorbable monofilament sutures (PDS [Ethicon, Johnson & Johnson]) and skin staples or non-absorbable sutures (Nylon [Ethicon, Johnson & Johnson]) for skin closure.

Figure 1

The medical parapatellar incision is shown by the blue arrow with the patella being retracted laterally by the rake retractor

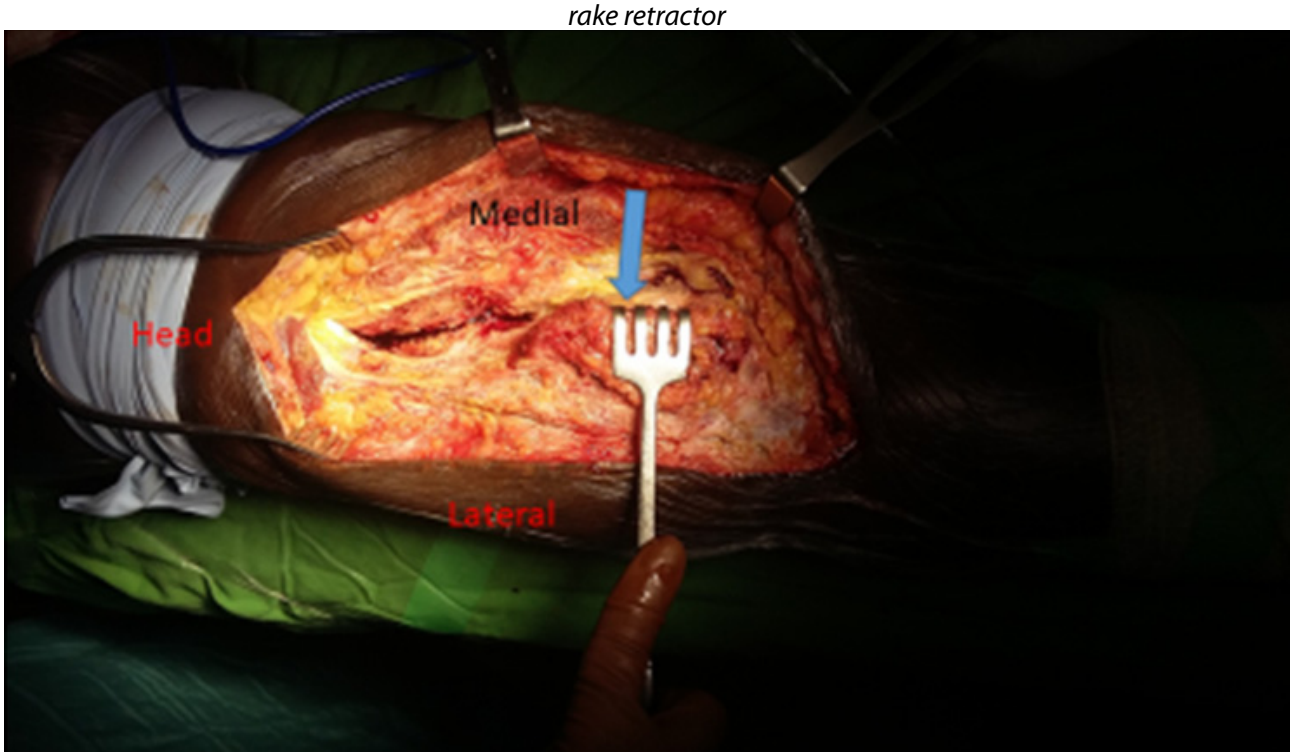
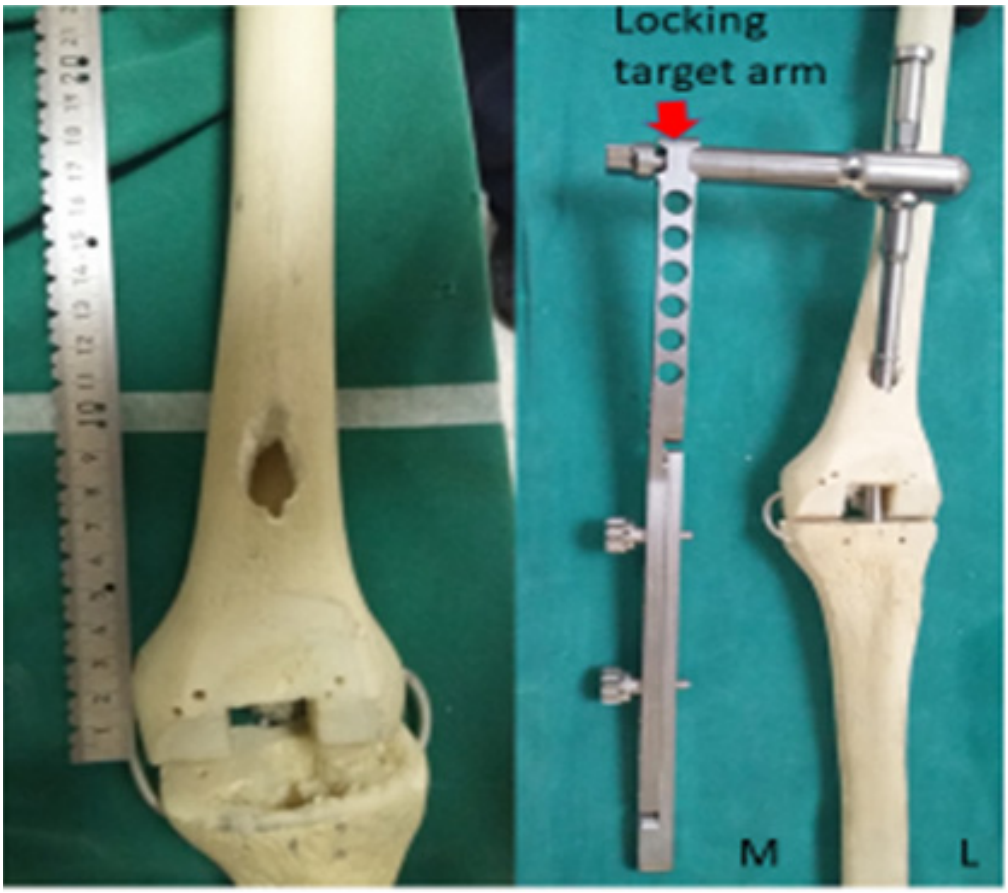


Figure 2

(a) Sawbone model (previously used to demonstrate total knee replacement) showing the femoral entry is 10-12 cm from the joint line (b) Sawbone model showing the target arm turned to the medical side (M) to insert the distal 2 interlocks



a **b**

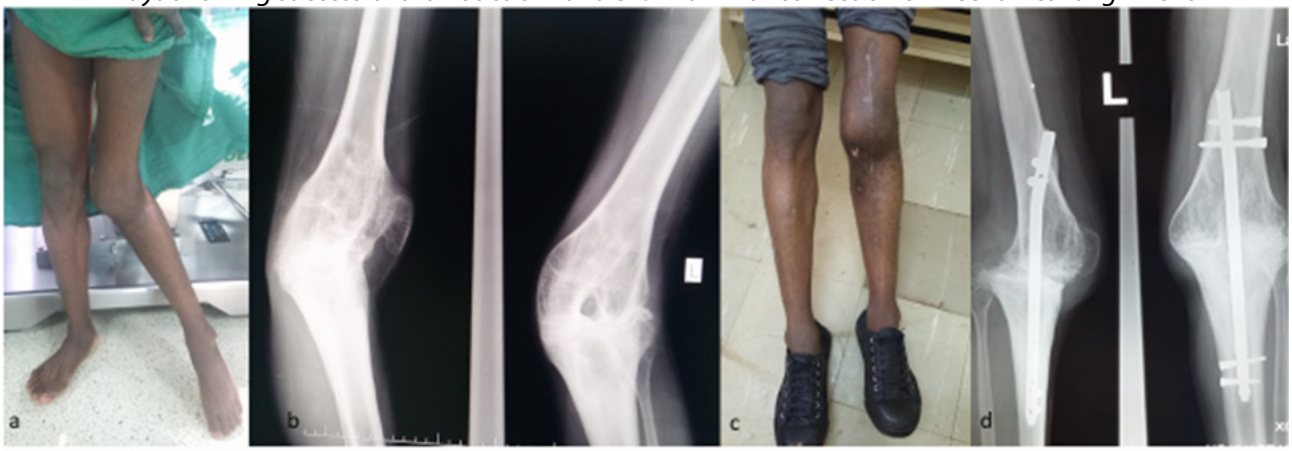
Postoperative regime: All the patients were allowed full weight-bearing as tolerated with axillary or elbow crutches. Supplemental protection with a knee immobilizer was done for 2-3 months. The skin staples or sutures were removed at 2-3 weeks. The Full Haemogram (FHG) and Erythrocyte Sedimentation Rate (ESR) were done serially to monitor for infection recurrence where appropriate.

RESULTS

Seven out of eight (87.5%) patients went on to primary union (Figure 3a & b). All the patients progressed to independent ambulation and were able to independently carry out their Activities of Daily Living (ADLs). There were no postoperative infections.

Figure 3

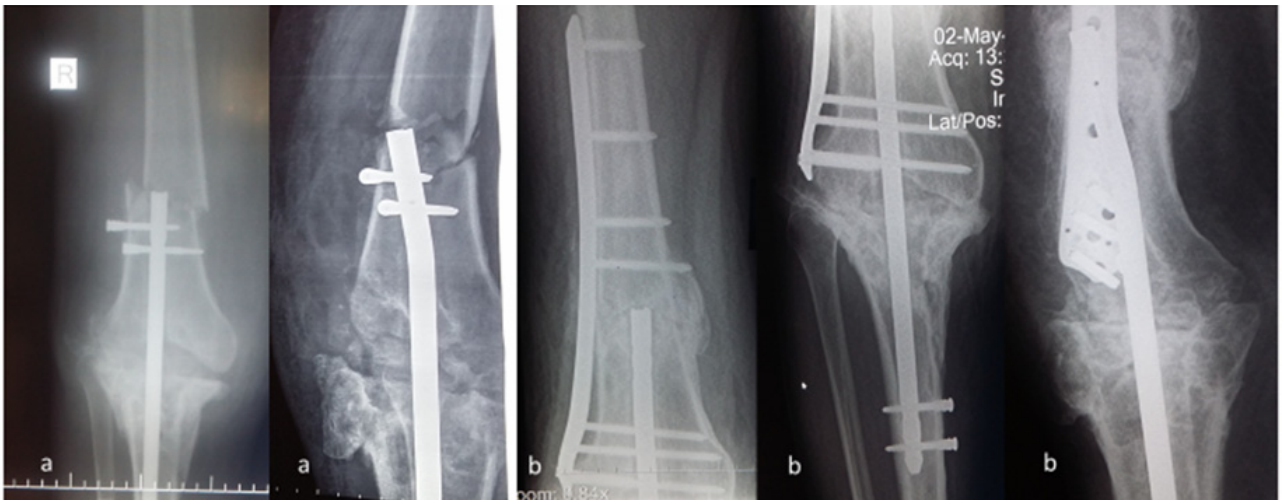
(a) Left knee post tuberculous ankylosis in extreme valgus (b) Pre-op lateral and anteroposterior X-rays showing the ankyloses (c) Post-op leg photo showing restoration of normal mechanical alignment (d) Post-op X-rays showing successful arthrodesis with a SIGN rail with correction of mechanical alignment



Complications: Two (25%) of the patients sustained a femoral peri-prosthetic fracture which was fixed with a distal femur locking plate and went on to successful union (Figure 4a & b). In both cases, the fractures were at the nail entry point. One (12.5%) patient had an aseptic non-union and was treated with bone-grafting and supplemental plate fixation with a narrow 4.5 mm dynamic compression plate.

Figure 4

(a) AP and lateral X-rays showing right peri-prosthetic distal femur fracture (b) AP and lateral X-rays 4 months post fixation of the peri-prosthetic distal femur fracture with a distal femur locking plate and showing successful union across the fracture and the arthrodesis sites



DISCUSSION

Since Albert of Vienna performed the first knee arthrodesis in 1878 for a polio-related pathology, there has been an evolution of techniques (5) in knee arthrodesis. The options available are external fixation, intramedullary nailing, plate fixation or a combination of the aforementioned implants (2).

Traditionally, external fixation has been the workhorse especially for infected cases (3). The advantages include, less soft tissue dissection, decreased blood loss and, with the use a multi-planar fixator, correction of malalignment (2). Unfortunately, it is associated with very low fusion rates, as low as 38% (4), in addition to pin tract infections, restricted weight-bearing, fracture through pin-sites and poor patient satisfaction due to their bulk and prolonged application (2,3,6). Also, neurovascular structures are at risk when multiple pins are deployed (13).

Plating is less popular, due to suboptimal soft tissue cover for some of the multiply operated knees (3). In addition, it is a load bearing device, hence like external fixators, is accompanied by weight-bearing restrictions (2).

Intramedullary fixation is gaining popularity as the better option due to its higher fusion rates that range from 83% to 100% (3). In addition, intramedullary nails provide rigid load-sharing fixation, which allows immediate full weight-bearing. The surgeries require limited exposure and dissection, preserving soft tissue integrity (7,8). In addition, it has low prominence (2) and thus better patient satisfaction. Intramedullary fixation in the setting of sepsis carries a risk of persistent infection with likelihood of intramedullary spread; as noted by Talmo *et al* (3) in their series of 29 failed infected TKAs that were treated with long intramedullary nails and ended up with septic failure in four (14%) of the cases. Although previous studies have demonstrated significant elevation of energy cost with ambulation post knee arthrodesis (9); trans-femoral amputations carry an even greater energy cost for ambulation compared to arthrodesis (7).

In a functional analysis, Benson and colleagues (10) studied a small cohort of age and sex-matched post-knee arthrodesis patients, and found they were comparable to post-TKA patients. That is, compared to post-TKA patients with excellent function, as defined by Hospital for Special Surgery knee scores of greater than 90, the post-knee arthrodesis patients performed equally well in terms of activities of daily living except for moderately decreased mobility levels (4,10).

Most of the described IM-Nails are long and are inserted either antegrade through the piriformis fossa or through the knee for the modular type (2,3,5). They are stable and allow early weight bearing. Their removal, necessitated by recurrent or persistent infection, can be technically challenging especially for the modular type. This may require transecting the nail through the knee and hence jeopardising the arthrodesis (3,5).

In 2016, Anderson and colleagues (2) described a new knee arthrodesis technique using the SIGN nail. The technique described entails an anteromedial entry point in the supracondylar femur region. They achieved 100% fusion and four out of their six patients were able to ambulate without any assistive devices. In contrast, our technique describes a direct anterior entry point to the supracondylar femur region.

In our case series of eight patients, 87.5% went on to fusion and all were able to ambulate without any assistive device. A new finding in our series is the occurrence of peri-prosthetic fractures in two (25%) patients. Both were in the supracondylar femur, one at the most proximal interlock and the other at the proximal junction of the nail and femur. They were both after a slip and fall mechanism while walking. In contrast, Anderson and colleagues (2) did not experience any periprosthetic fractures.

The SIGN nail is affordable and readily available in most developing countries (11) and it has all the attendant aforementioned advantages of a nail. It is also FDA approved and now being embraced by surgeons across North America. Moreover, it does not require any fluoroscopic guidance during proximal and distal interlocking (2).

The limitations of the study entailed its retrospective design and having a small cohort.

CONCLUSION

As initially described by Anderson and colleagues (2), we found that the SIGN intramedullary nail system allows an easy and reproducible knee fusion technique in resource and equipment limited settings. In addition, 25% of our patients developed a periprosthetic fracture at the nail insertion site which has not been reported in other similar studies.

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