Interlocking nailing without imaging: the challenges of locating distal slots and how to overcome them in SIGN intramedullary nailing

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Received: 17 July 2009 / Revised: 14 September 2009 / Accepted: 15 September 2009 / Published online: 8 October 2009
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Abstract Placement of the distal interlocking screw is the most difficult part in all intramedullary nail interlocking screw systems and the Surgical Implant Generation Network (SIGN) interlocking system is not an exception. SIGN nails are interlocking implants designed with a precision instrumentation set for use in treatment of long bone fractures without an image intensifier. Locating the distal slots of SIGN nails could be challenging for young SIGN surgeons when treating very complex comminuted fractures and in obese patients. This study was stimulated by a patient who presented one year after surgery with knee pain due to a migrating nail because of missed distal screws. A total of 48 patients divided into two groups of 24 were studied retrospectively and prospectively. The retrospective studies revealed that failure to locate distal locking slots in ten antegrade nailing procedures was due to wrong entry point and comminution of the fracture. The challenges encountered led us to innovating methods to overcome the difficulties of placement of distal screws in a prospective study. Application of methods A and B made location of the distal slots easier in the prospective study even though there were more complex comminuted fractures. The methods also reduced the antegrade operation time by 1 hour 11 minutes. We concluded that SIGN nailing could be challenging and frustrating at the early learning stage. Application of the two innovative methods will make distal slot location easier. They will also make SIGN interlocking nailing less difficult for young SIGN surgeons as they journey through the learning curves.

Introduction

Surgical Implant Generation Network (SIGN) nails are interlocking intramedullary implants designed for use in the treatment of long bone fractures without image intensifier [5]. It has a precision instrumentation set that allows easy location of the slots and placement of the locking screws without radiological assistance. This avoids intraoperative exposure to ionising radiation from image intensifiers. These image intensifiers are expensive and not readily available in many countries and centres, thus making SIGN nailing ideal for most resource-poor countries of the world [1]. Over 4,500 SIGN operations in 150 programmes spread over 51 countries in Africa, Asia, Europe, North America and South America are using this rapidly spreading SIGN interlocking nailing system for the treatment of humerus, tibia and femur fractures [4, 5]. Placement of the distal interlocking screw is the most difficult part in all intramedullary nail interlocking screw systems [2, 3, 6] and the SIGN interlocking nail is not an exception. There could be challenges encountered during the SIGN nailing procedure despite the precision of the instrumentation. The challenges can be quite frustrating and also be the cause of prolonged operation time with its associated surgical and anaesthetic complications. Locating the distal slots of the SIGN nail can be quite challenging for young SIGN surgeons worldwide when fixing very complex comminuted fractures and in obese patients.

The challenges encountered led us to some innovations to overcome the difficulties in locating the distal slots and placement of the distal screws. This study was particularly stimulated by one of our patients whose SIGN nail migrated to the knee one year after surgery. The distal screws missed the slots and this was not noticed even postoperatively until the time when the patient presented with knee pain one year after surgery.

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Methods

This study is a combination of retrospective and prospective studies. Forty-eight SIGN intramedullary nailing procedures in 47 patients were done within two years. The 48 cases were divided into equal halves.

The first 24 cases were studied retrospectively to identify reason(s) for the difficulty in locating the distal slots despite the precision of the instrumentation. The parameters studied were gender of the patients, pre- and postoperative X-rays, operation time and type of surgery.

The second 24 cases were studied prospectively to look at simple way(s) of locating the distal slots and placing the interlocking screws through the slots. The parameters considered in the retrospective study were also examined in this group.

The original “SIGN” intramedullary nailing technique

The detailed technique of SIGN intramedullary nailing is well described in the “Technique Manual of SIGN IM Nail & Interlocking Screw System Insertion & Extraction Guide, revision # TM-2008.11.15”, but this is a summary of the steps:

1. The assemblage of the L-handle and the nail is shown in Fig. 1.
2. This is coupled with the target arm. The alignment pins are placed through the holes in the end of the target arm to align the slots in the nail to the holes on the target arm.

The alignment pins are removed and the cap screws are tightened firmly (Fig. 2).

Fig. 1 Locking bolt, L-handle and standard SIGN nail

Fig. 2 Target arm aligned with the standard SIGN nail with alignment pins

3. The target arm is removed from the L-handle and nail.
4. The nail is introduced into the reamed medulla of the bone with the help of the L-handle and by gently tapping on the locking bolt.
5. The target arm is realigned to the L-handle and secured with a shoulder screw.
6. The alignment pins are used to mark the site of the skin that corresponds with the SIGN nail slots in the medulla of the bone.
7. The skin is dissected to the outer bone cortex which is drilled with a 3.5 drill bit, through a cannula and small drill bit guide.
8. A step drill is used to enlarge the drilled hole and a solid slot finder is used to confirm the slot with the classic “SIGN sign”, which is the inability to rotate the solid slot finder more than 10° because of the engagement of the finder in the SIGN nail slot. The outer cortex is drilled through a cannulated slot finder.
9. The length of the screw required is determined and placed in the slot.
10. Upon failure to locate the slot in the nail with the above steps, a curved slot finder is used to locate the slot; the curved slot finder is then removed and replaced with a cannulated slot finder through which the far cortex is drilled.

Prospective study

The aim was to find simple way(s) of locating the distal slots and placing the interlocking screws in difficult fractures.

Fig. 3 Standard SIGN nail: the proximal and distal slots are labelled

Method A

This is for antegrade femoral nailing. The SIGN Technique Manual must be read and followed.

The fracture site must be reduced anatomically as much as possible. When the distal slots are difficult to locate, the following steps should be followed:

1. The curved slot finder is passed through the target arm directly (without the cannula and the guide) to locate the more proximal of the two distal slots. The finder is left in the slot (1a in Figs. 3 and 4). This is not removed and replaced with a cannulated slot finder as in the original technique.
 2. The more distal screw is placed (2 in Figs. 3 and 4).
 3. The trochanteric screw(s) is placed, usually easy to locate (3 in Figs. 3 and 5).
- Lastly the first (proximal) of the two distal slots is located. This is done as follows:
4. The curved slot finder is removed from the proximal slot of the two distal slots, redrilling may be necessary, and the screw is placed (1b in Figs. 3 and 4; Fig. 6).

This method is very useful when encountering difficulty in locating the distal slots in antegrade femoral SIGN nailing and the target arm is required for this procedure.

Method B

This option of overdrilling the outer cortex is to be considered if the method in the SIGN manual and the above method did not result in location of the slot.

1. The outer cortex is slightly overdrilled with a 3.5 drill bit.
2. This is carefully widened with the step drill.
3. Suctioning of the enlarged hole is done with a fine tip suction; the tip can be unscrewed if a metallic one is used. Gauze on artery forceps into the drilled hole will do where there is no suction. This helps to directly visualise the slot.

Fig. 4 The distal slots of the standard SIGN nail are labelled

4. It might be necessary to drill the other cortex with a 3.5 drill bit.
5. The appropriate screw length is placed.

This is done without the target arm.

This method should only be used in strong bone and not in osteoporotic bone.

Results

Forty-eight SIGN intramedullary nailing procedures were done in 47 patients within two years. The male to female ratio of the 47 patients was 5.7:1. All operations were by open method; femur: antegrade=34, retrograde=8 and tibia=6.

It was noted that difficulties were encountered in locating distal slots in ten antegrade femoral nailing procedures (Table 1). In seven of these ten, the entry point was obtained by reaming the proximal fragment retrogradely from the fracture site. The fractures were comminuted fracture of the proximal one half of the femur ($n=5$), transverse midshaft ($n=2$), distal one third ($n=1$) and 9-month-old fractures ($n=2$). The average operating time for antegrade femoral SIGN nailing was 2 hours 30 minutes.

There were 15 very complex comminuted fractures of the femur and one segmental femur fracture that were treated by antegrade or retrograde intramedullary nailing. The average operation time for antegrade femoral nailing was 1 hour 21 minutes and 1 hour 2 minutes for retrograde femoral nailing. True anteroposterior and lateral postoperative X-rays were ensured for all of the 24 cases. Methods A and B were used to locate and place screws in distal slots in nine cases in this prospective study (Table 2). Neither use of a C-arm nor revision surgery were needed in any of the cases.

Discussion

The use of interlocking nails for fractures of long bones has increased and indeed has become the gold standard for care of unstable long bone fractures [1]. Procedures using

Fig. 5 The proximal hole and proximal slot of a standard SIGN nail are labelled

Fig. 6 Curved slot finder in the proximal of two distal slots

interlocking nails are commonly performed using an image intensifier, but SIGN nailing is primarily designed to be used without an image intensifier which might not be affordable in many centres and countries.

The study generally showed that interlocking was not difficult with tibia intramedullary SIGN nailing in both the retrospective and prospective studies even though the number might be small at six. The inability to hit the SIGN slots in the early stage of the project could be due to the fact that the procedure had not been well mastered. In seven of the ten difficult cases in the retrospective study, the entry point was obtained by reaming the proximal fragment retrogradely from the fracture site. This could explain why the entry point was very close, in the piriformis fossa or in the anterior one third of the greater trochanter in five cases in the retrospective study. This could have also accounted for our failure to locate the distal slots in these cases because the increased stress on the nail, bends it. The outcome of the antegrade SIGN nailing depends greatly on locating the precise entry point at the juncture of the posterior one third and anterior two thirds of the greater trochanter as indicated in the manual. This was carefully followed in the prospective study. Locating the entry point and reaming the femur in antegrade nailing can be a problem, especially in obese patients, but can be solved by placing an inverted T incision ($\perp$) on the greater trochanter. The vertical component of the incision should lie along the line of the reaming. This incision was used in three of our patients who were obese, and locating and reaming of the entry point were done with noticeably less difficulty. In [method A](#) the curved slot finder was not removed and replaced with a cannulated slot finder; this is to avoid losing the slot after it has been located. The prospective study had more comminuted fractures than the retrospective study, but the application of [methods A](#) and [B](#) made it possible for easy and quicker locking to be done especially in nine cases where locating the distal slots was initially difficult. A C-arm was not needed in any of the cases, thus avoiding radiation to both surgeons and patients as opposed to the retrospective study where in seven cases the distal slots were located with the aid of a C-arm. It was also noted that the average operation time decreased from

Table 1 Retrospective study of the first 24 SIGN cases

Location of distal slots	Number	Type of SIGN surgery	Remark	Total number
Located	2	Tibia =1; antegrade femur =1	For SIGN training	14
	12	Tibia=2; retrograde femur =1; antegrade femur=9	Proximal and distal screws located	
Could not be located	1	Antegrade femur	Unable to fix both the distal and proximal screws	10
	2	Antegrade femur	Postoperative X-rays appeared to show the distal screws in place. In one of the patients the nail migrated to the knee. Lateral postoperative X-rays were inadequate in these patients	
	7	Antegrade femur	Distal slots could not be located but were found with the aid of a C-arm. Entry point was in the piriformis fossa, very close or in the anterior 1/3 of the greater trochanter in 5 cases	

Table 2 Outcome of the 24 prospective SIGN surgeries

Locating distal slots	Type of operation	Number	Remark	Total number
Located	Tibia	3	Screws placed easily	3
Not attempted	Retrograde femur	1	Distal screw not placed in 1 deliberately because the nail was felt to be rigidly tight in the canal. This was confirmed on postoperative X-rays	1
Located	Retrograde femur	2	Method B was used to find and place the distal screws in 2	7
		5	Screws placed easily in 5	
	Antegrade femur	7	Distal slots and placement of screws by method A in 4 and method B in 3	13
		6	Screws placed easily in 6	

2 hours 30 minutes to 1 hour 21 minutes for antegrade nailing even though there were more complex and comminuted fractures than in the retrospective study. We also found that the average operation time for retrograde femoral nailing was 1 hour 2 minutes in the prospective study. This could be because of the roomy nature of the distal one third of the femur that does not lead to the bending of the proximal part of the SIGN nail as was encountered in the antegrade SIGN nailing. True lateral and anteroposterior postoperative X-rays were obtained to confirm the placement of the screws in the distal slots in the prospective study. All of the 24 cases in the prospective study had correctly placed screws in the distal slots except in one case where the distal slots were deliberately not locked because the nail was felt to be rigidly tight in the canal. This shows that the application of methods A and B and thorough understanding of the procedure manual can greatly help in locating the distal slots and placing the screws. It is very important that two true postoperative X-ray views be done for every patient in order to avoid a situation where the screws are assumed to be in the slot when they are not place.

In conclusion we found that SIGN interlocking nailing could be quite simple when the instructions in the manual are followed. It could also be a challenging and frustrating experience at the early learning stage. When the manual instructions have been followed to the letter and difficulties are encountered in locating the slots, the application of methods A and B will make it easier to locate the distal slots, thus reducing the operation time. Good understanding of the Technique Manual of SIGN nailing and application of the methods will also make SIGN interlocking nailing

easier, especially for young SIGN surgeons as they journey through the learning curves of intramedullary SIGN nailing. Retrograde reaming of the proximal fragment with the aim of finding the entry point should be discouraged because it increases the chances of bending the nail and creating problems in locating the distal slots.

Acknowledgment The authors acknowledge Dr. Lewis G Zirkle M.D. and Dr. Jeffrey Tamborlane M.D. (of blessed memory) for donating the SIGN set. Many thanks go to Dr. Robert Schultz M.D. for his special interest in the St. Lucia SIGN project. We also acknowledge Robert J. Schmitt and Michael J. Edwards of SIGN for the graphics. SIGN (Surgical Implant Generation Network) is a humanitarian organisation in Richland, WA, USA that provides SIGN nails for treatment of long bones in many parts of the world. It is founded and funded mainly by Dr. Lewis G Zirkle M.D.

References

- Ikem IC, Ogunlusi JD, Ine HR (2007) Achieving interlocking nails without using an image intensifier. *Int Orthop* 31(4):487–490
- Rabin SI, Naeni F, Robledo SL, Rabin DN (1993) Inserting distal screws into interlocking IM nails—revisited. Methods to make it easier. *Orthop Rev* 22(9):1059, 1062–3, 1068
- Whatling GM, Nokes LD (2006) Literature review of current techniques for the insertion of distal screws into intramedullary locking nails. *Injury* 37(2):109–119 Epub 2005 Nov 28
- www.sign-post.org
- Zirkle LG Jr (2008) Injuries in developing counties—how can we help? The role of orthopaedic surgeons. *Clin Orthop Relat Res* 466(10):2443–2450 Epub 2008 Aug 7
- Zirkle LG (2008) Technique Manual of SIGN IM Nail & Interlocking Screw System Insertion & Extraction Guide. Revision # TM-2008.11.15, p 33. www.sign-post.org