

# Achieving interlocking nails without using an image intensifier

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**Abstract** Interlocking nails are commonly performed using an image intensifier. These are expensive and are not readily available in most resource-poor countries of the world. The aim of this study was to achieve interlocking nailing without the use of an image intensifier. This is a prospective descriptive analysis of 40 consecutive cases seen with shaft fractures of the humerus, femur, and tibia. Fracture fixation was done using Surgical Implant Generation Network (SIGN) nails. Forty limbs in 34 patients were studied. There were 12 females and 22 males, giving a ratio of 1:2. The mean age (years) was  $35.75 \pm 13.16$  and the range was 17–70 years. The studied bones were: humerus 10%, femur 65%, and tibia 25%. The fracture lines were: transverse 40%, oblique 15%, and comminuted 45%. Fracture grades were: closed 90%, grade I, 5%, grade II, 2.5%, and grade IIIA, 2.5%. Surgical approaches were: antegrade 62.5% and retrograde 37.5%. Indications for fixation were: recent fracture 92.5%, non-union 5%, and malunion 3%. Methods of reductions were: open 85% and closed 15%. The mean follow-up period (years) was

$1.50 \pm 0.78$ . The union time averaged 3 months. Complication was mainly screw loosening due to severe osteoporoses in one case. It is, therefore, concluded that, with the aid of external jigs and slot finders, interlocking can be achieved without an image intensifier.

**Résumé** Les clous verrouillés sont d'utilisation commode mais demande une imagerie dans leur utilisation. Cette imagerie est chère et ne peut être réalisée de façon valable dans les pays pauvres. Le but de cette étude est de montrer que le verrouillage des clous peut se faire sans l'utilisation d'une imagerie. Il s'agit d'une étude prospective de 40 cas de fracture de la diaphyse humérale, fémorale ou tibiale, la fixation de ces fractures étant réalisée par un clou de type SIGN. 40 membres chez 34 patients ont été étudiés, 12 femmes, 22 hommes (ratio de 12). L'âge moyen a été de  $35,75 \pm 13,16$  s'échelonnant de 17 à 70 ans. Les fractures affectaient l'humérus dans 10% des cas, le fémur dans 65% des cas et le tibia dans 25% des cas. La fracture était transverse dans 40% des cas, oblique dans 15% et communitive dans 45% des cas. Il s'agissait d'une fracture fermée dans 9 cas sur 10. Lorsqu'elle était ouverte, de grade I dans 5%, de grade II dans 2,5% et de grade IIIA dans 2,5%. L'approche chirurgicale a été antérieure dans 62,5% des cas et postérieure dans 37,5% des cas. Il s'agissait d'enclouage pour fixer une fracture fraîche dans 92,5% des cas, après pseudarthrose dans 5% des cas et cal vicieux dans 3% des cas. La réduction a été réalisée par voie sanglante dans 85% des cas, à foyer fermé dans 5% des cas. Le suivi moyen a été de  $1,50 \pm 0,78$ , la consolidation a été obtenue en moyenne en 3 mois. Une seule complication avec mobilisation d'une vis après une ostéoporose sévère a été observée dans un seul cas. Nous pouvons conclure qu'il est possible, grâce à la méthode que nous décrivons de verrouiller un clou sans imagerie.

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## Introduction

Fractures involving the shaft of long bones are common worldwide. The methods used to achieve skeletal stabilisation could vary considerably, depending on the configuration of the fracture line and the geographical location of the surgeons' practices. These long-bone fractures occur in the femur, tibia, and the humerus and may be treated with external splints: Plaster of Paris, Scotch cast, external fixation (fixator), and skin traction, or internal splints: Rush nails, Kuntschner nails, plates, and screws, in addition to interlocking nails.

Interlocking nailing has been increasingly used to treat both acute and chronic injuries to long bones [5]. These are commonly performed in the developed countries and involve the use of an image intensifier [6, 25, 26]. These image intensifiers are very expensive and are not readily available in most resource-poor countries of the world, such as in the West African subregions, including Nigeria. With SIGN (Surgical Implant Generation Network) interlocking nails, it is now feasible to achieve interlocking nail insertion without the aid of an intraoperative image intensifier, simply by the use of an external jig and slot finder. Successful interlocking nailing using this method should not only improve the quality of fracture care, but should also lead to a reduction of exposure to intra-operative ionizing radiation [3, 12, 21, 22, 24]. This work, which describes the authors' experiences in using this method, is expected to contribute to knowledge in our subregion, since there is a paucity of literature on this subject matter. This work will also help to introduce this mode of treating fractures in resource-poor regions of the world, thereby, offering high-quality fracture care.

## Patients and methods

A prospective descriptive analysis of 40 consecutive cases studied with shaft fractures of the humerus, femur, and tibia was done. This is a hospital-based study that recruited patients from whom informed consent was obtained over a period of 18 months. Patients with closed and open fractures were included. However, open fractures considered to be severely contaminated were excluded. Fracture fixation was performed using SIGN interlocking nails and instrumentation. The protocols for the treatment of these patients was established prospectively and followed with only minor alterations.

The guidelines were as follows. All open fractures were treated as surgical emergencies. Open fractures were graded according to Gustilo-Anderson classification [11]. The importance of thorough wound debridement and copious fluid irrigation was emphasised in order to make the wound

clean enough for surgery; otherwise, it was excluded. All patients were given 1.5 g of prophylactic cefuroxime at the induction of anaesthesia and a further 750 mg of cefuroxime 6 h and 12 h later. Plain radiography was taken preoperatively in the radiology department to determine the fracture configuration and its suitability for interlocking nail insertion. Also, radiographs were taken postoperatively to determine the position of the SIGNs nail and locking screws. There was no facility for intraoperative plain radiography or the use of an image intensifier. The SIGN nails were inserted according to the manufacturer's instructions. All nails were statically locked, but not all possible screw holes were used.

All patients had a similar postoperative regime. Early physiotherapy of all involved joints, as well as early weight bearing, was encouraged. No cast or brace was applied and the patients were discharged as soon as their condition allowed. Analysis of the outcome of treatment with respect to the time of fracture union and the presence of complications was performed. Fracture union was assessed clinically and radiologically at 6 weeks and 3 months, and then subsequently at monthly intervals. The fracture was considered to have united when there was no pain or tenderness, when there was no abnormal movement at the fracture site and when bridging callus was visible on a plain radiograph. Delayed union was recorded when the fracture united between 4 and 6 months, while non-union was noted when union had not occurred after 8 months of treatment. All of our patients were followed-up for at least 12 months.

The results were analysed on a computer using the SPSS (Statistical Package for Social Scientists) software, release 11.01.

## Results

Forty limbs in 34 patients were studied. Three bones were involved in two patients and two bones were involved in two patients. The others had single-bone involvement. There were 12 females (F) and 22 males (M), giving a ratio of 1:2. The mean age (years) of the patients was  $35.75 \pm 13.15$  and the range was 17–70 years. The characteristics of the fractures are shown in Table 1. The distribution of the involved bones include: humerus 10%, femur 65%, and tibia 25%. The configuration of the fracture lines included: transverse 40%, oblique 15%, and comminuted 45%. Closed fractures constituted 90% of the cases, whereas open fractures totalled 10%. The Gustilo-Anderson grade of the open fractures were as follows: grade I, 5%, grade II, 2.5%, and grade IIIA, 2.5%. The surgical approaches were: antegrade 62.5% and retrograde 37.5%; all of the retrograde procedures were performed on the femur. The indications for fixations were: recent fracture 92.5%,

**Table 1** Characteristics of the fractures in the study

Data on the characteristics of the fractures	
Involved bones	Humerus 10% Femur 65% Tibia 25%
Fracture line	Transverse 40% Oblique 15% Communitated 45%
Intact skin	Closed fracture 90% Open fracture 10%
Grade of open fracture	Grade I 5% Grade II 2.5% Grade III 2.5%
Surgical approaches	Antegrade 62.5% Retrograde 37.5%
Indication for fixation	Recent fracture 92.5% Non-union 5% Malunion 3%
Method of reduction	Open 85% Closed 15%
Union time (months)	2.93±0.67
Complications	Delayed union 5% Superficial wound infection 5% Screw loosening 2.5%

non-union 5%, and malunion 3%. The methods of reductions employed were: open 85% and closed 15%, performed mainly on very slender patients, where the bones can be palpated and the fracture line is transverse. Postoperative plain radiographs confirmed that all of the cases had satisfactory positioning of the inserted SIGN nails and interlocking screws. The mean follow-up period (years) was 1.84±0.35. Union time (months) averaged 3 months, mean 2.93±0.67.

Complications seen were mainly screw loosening due to severe osteoporoses in one case, two cases of delayed union, and two cases of superficial wound infection. Other complications were wasting of the quadriceps, oedema, and ankle stiffness, and these were controlled with limb elevation, the use of tubigrip, and active exercises. There was a significant correlation between the union time and the complications rate ( $p=0.001$ ), as well as between the involved bone and complications rate ( $p=0.005$ ).

## Discussion

The most common cause of morbidity and mortality in the most productive period of life worldwide are road traffic accidents causing fractures [8, 13, 19]. It is not surprising, therefore, that these fractures occurred the most in people aged between 20 and 50 years. The sex ratio distribution is also in keeping with other reports [19] and further emphasises the greater vulnerability of males to trauma.

The availability of the appropriate treatment modality could be of utmost concern to any practicing orthopaedic surgeon in most resource-poor countries of the world, including the West African subregions [13, 20]. In this study, femoral shaft fractures accounted for 65% of the cases. Traditionally, in the absence of an image intensifier, stable fractures around the isthmus of the femur, internal fixation was performed with Kuntschner nails, whereas femoral shaft fractures with inherent instability located in the diaphysis or towards the metaphysis were offered skeletal traction because of the lack of a reliable intra-operative image intensifier. Open fractures were offered external fixation [13].

The use of interlocking nails for fractures of long bones has increased, and, indeed, has become the gold standard for the care of unstable long-bone fractures. However, its main drawbacks are cost and the need for a reliable intraoperative image intensifier support [5, 6, 22, 25]. There are now nails that can be locked with the aid of external jigs [1, 3, 12, 16, 22, 24, 25]. In this study, 100% of the fractures were fixed without the use of an image intensifier with the satisfactory placement of nails and screws in all cases. This is in agreement with other works [22, 25]. Closed fractures were reamed to accommodate larger sized nails, whereas open fractures were unreamed to limit the damage to the endosteal blood supply. Unreamed locked nailing with tight-fitting nails can produce satisfactory clinical results for acute fractures. It has the advantages of technical simplicity and an acceptable risk of implant failure [4, 7, 9, 14, 18, 23, 26].

Complications were few and mild. We recorded two cases of superficial wound infection that were treated successfully with extended antibiotic administration. There were two cases of delayed union that occurred in the distal third fracture of a tibia with severely comminuted fracture line. The blood supply to this region is very precarious and could be associated with an increase in the incidence of non-union [2]. A case of screw loosening due to severe osteoporosis was recorded [17]. There was no case of nail or screw breakage in this study [15].

It is important to emphasise that, in centres with an image intensifier, it can be used to insert SIGN interlocking nails intraoperatively. However, the exclusion of an image intensifier automatically eliminates the harmful effect of an increased dose of radiation to both the orthopaedic surgeon and the patient [10, 16, 24]. It has the added advantage of reduced cost to the patient whilst, at the same time, ensuring high-quality fracture care comparable to any in the developed countries. Proficiency in the use of these SIGN interlocking nail instrumentation will come with practice. We therefore conclude that, with the aid of external jigs and slot finders, interlocking can be achieved without an image intensifier.

**Acknowledgment** SIGN (Surgical Implant Generation Network), founded by Dr. Lewis G. Zirkle, was created in 1999 as a humanitarian, non-profit corporation in Washington, USA, with a goal to provide improved health care and proper orthopedic treatment of fracture at little or no cost to people in need throughout the world. All implants and instrumentations (FDA-approved) were provided free of cost by SIGN, USA, to our institutions in Nigeria.

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