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Research Article

Femur Fractures in Older Children and Adolescents Treated by the Sign Intramedullary Nail

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Abstract

Objectives: To evaluate the clinical results of intramedullary nailing of femoral shaft fractures using a rigid intramedullary SIGN nail in older children and adolescents. Is it safe to use it on this group of age?

Design: A retrospective study was carried out evaluating all skeletally immature patients with femoral shaft fractures treated with the SIGN nail system at the Vicente Corral Moscoso Hospital, Cuenca, Ecuador.

Patients/Participants: Thirty-four children and adolescents with displaced femoral fractures and one case of non-union of the femur and open growth plates.

Main Outcome Measurements: Patients were evaluated to determine hospital stay, time to union, final fracture alignment, complications, proximal femoral changes including avascular necrosis or proximal femoral valgus with femoral neck narrowing.

Results: The average age of the patients was 12 years old (range from 8 to 17 years). Fractures healed at a mean of 6 weeks (range 5-14 weeks) after a fracture. The average hospital stay for patients with isolated femur fractures was 2.8 days (range 1-5 days). At an average follow-up of 57 weeks, no patient had developed malunion, avascular necrosis, femoral neck valgus, or femoral neck narrowing. Patients were followed for a minimum of 6 weeks (range: 6 - 351 weeks). The SIGN intramedullary nail provided a quick, first quality solution in osteosynthesis of diaphyseal fractures of the femur, without affecting the budget of the institution.

Keywords: Femoral Shaft Fractures; Antegrade Intramedullary Nailing; Femur; Femur Fractures in Children and Adolescents

Abbrevations

SIGN: Surgical Implant Generation Network; CIM: Clavo Intra-Medular

Introduction

Fractures of the diaphysis of the femur in older children and adolescents are one of the most frequent causes of hospitalization [1,2]. Among the factors that determine its treatment are the patient's weight, bone age, social situation, type and mechanism of the fracture, and the presence of concomitant fractures, as well as adequate knowledge of the anatomy and biomechanics to achieve optimal results without negatively affecting the growing bone.

Treatment options range from skeletal traction, external fixation, blocked sub-muscular plates, flexible intramedullary nails (TENS), rigid Intra Medullary Nails (IMN), and even biodegradable nails.

Intramedullary interlocking is associated with a high rate of fracture consolidation and a low complication rate [3-7,10,11].

Intramedullary nailing with flexible nails in the treatment of fractures of the diaphysis of long bones in adolescents is very popular [4,5,8,9,11], the technique requires trans operative image intensifier and special skill of the surgeon. It should be supplemented

with a brace, a cast, or prolonged rest when the fracture is located very proximal or distal in the diaphysis and/or is unstable, comminuted, or oblique long. An alternative treatment in these cases is a rigid intramedullary nail [10]. The American Academy of Orthopedic Surgery -AAOS- recommends it in patients > 11 years and weighing > 49Kgrs by the site of lateral insertion in trochanter major [11,12].

We report the results of treating fractures of the diaphysis of the femur in older children and adolescents with the system of rigid blocked intramedullary nails of SIGN (Surgical Implant Generation Network), which is used in the Vicente Corral Moscoso Hospital since 2009 and thanks to CAMPTA: (Canadian Association of Medical Teams Abroad), the treatment has no cost for patients.

"SIGN", an organization whose mission is to promote "equality in the treatment of fractures throughout the world" by distributing orthopedic implants [13,14] thus allows patients without economic resources to walk in a short time and return to activities or return to study and play in the case of adolescents and children.

Why Intramedullary nails? A diaphyseal fracture involves the middle segment of the long bones, called the diaphysis, whose main feature is its cylinder shape. Severe diaphyseal fractures (Figure 1) require surgical treatment without which we can say that the ends of the bone will not be able to join properly, which can leave the patient disabled for life.

SING's IMN is a premium stainless surgical steel rod that passes through the bone canal to secure fragments and allow for proper bone healing.

The nail is fixed to the bone at the ends through cortical screws that pass through the bone and holes in the nail. The screws are seen on the x-ray as white lines perpendicular to the nail, their purpose is to give greater stability to the osteosynthesis medium (Figure 1).

This technique is the state of the art in the treatment of diaphyseal fractures. It is the standard method of treatment in adults for severe diaphyseal fractures in developed countries. The goal of SIGN is to make this method the world standard for diaphyseal fracture treatment. It should be noted that no transoperative image intensifier is required for the insertion and blocking of the sign intramedullary nail. The blocking of the IMN is achieved thanks to external guides that are attached to the nail (Figure 3).

Material and Methods

Thirty-four fractures of the diaphysis of the femur and one case of pseudoarthrosis of the femoral diaphysis (Figure 2) were treated between January 2009 and December 2019 at the Vicente Corral Moscoso Hospital using the rigid intramedullary standard nail of SIGN in an anterograde form and taking as the site of entry of the nail the major trochanter at a point between 1/3 middle and posterior of its apex. In this case series, 8 patients were female and 26 were male. The average age of patients was 12 years at the time of injury (range: 8 to 17 years).

Each clinical case in which the SING intramedullary nail is used is reported online to the SIGN data center in Richland, Wa. In the USA, attaching the pre and post-operative radiological study and the relevant clinical data, an indispensable requirement for the nail used to be replaced by the SIGN organization. Likewise, it allows to maintain fast and efficient communication and exchange criteria on the treatment and to know the suggestions of Professor Dr. L. Zirkle, founder, and president of the organization.

Patients who in the same period used another means of osteosynthesis were not included in this series, fractures of the diaphysis of the femur treated with the pediatric NAIL of SIGN were not considered in this series. Also not included in this series are patients who presented open fractures GIIIb according to the Gustilo classification or fractures in which the use of intramedullary nails is not indicated.

The most frequent mechanism of fractures was falls: 79.4% of cases and 20.6% consecutive to traffic accidents.

Surgical Technique: After adequate pre-surgical assessment and a dose of antibiotic prophylaxis, the patient is taken to the operating room where the surgery is performed on an ordinary surgical table, under general anesthesia, and the patient is in lateral decubitus. A longitudinal incision is made on the major trochanter (more prominent in lateral decubitus) of 3cms and the entry point is located, the union of the middle and posterior 1/3 of the major trochanter recommended to avoid osteonecrosis in patients with

an immature skeleton. Intramedullary nailing should be initiated in trochanter major not in the piriform fossa [4,14-16]. If closed reduction is not possible, the reduction of the fracture is facilitated by performing a small longitudinal insertion at the level of the focus fracture through which the passage of rhymes, the nail, and the final reduction are checked by palpation with a finger (Figure 4). The IMN is blocked with the help of the external guide of the SIGN system (Figure 3).

Lock the nail using screws, prevents rotation and telescoping movements adding stability to the fracture, and allow mobilization and weight loading early. It allows to extend the indications of the intramedullary nail to fractures in the proximal and distal third of the diaphysis as well as comminuted and segmental fractures.

If an open reduction is necessary, it is recommended to do so before making the incision through which the IMN will be inserted. In the HVCM, open reduction was performed in 80% of cases through small incisions (Figure 4). Closed reduction of the fracture without the use of an image intensifier, requires experience of the surgeon in maneuvers that allow the reduction of the passage of rhymes, and finally of the intramedullary nail.

Ambulation with crutches has been instituted in the immediate postoperative period and partial support for six weeks or until bone consolidation is observed in radiological controls.

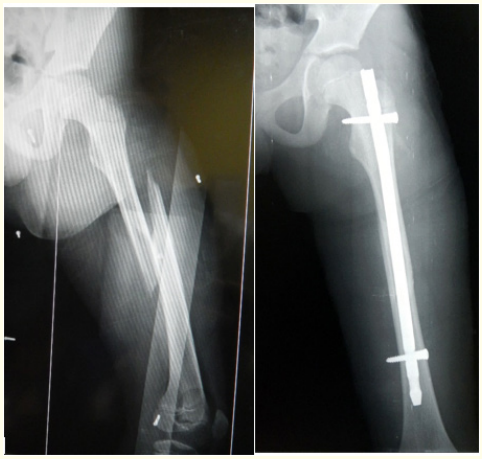

Figure 1: Fracture of the diaphysis of the femur and immediate post OP control.

Figure 2: Pseudoarthrosis diaphysis femoris. Girl 9 years old. Consolidation.

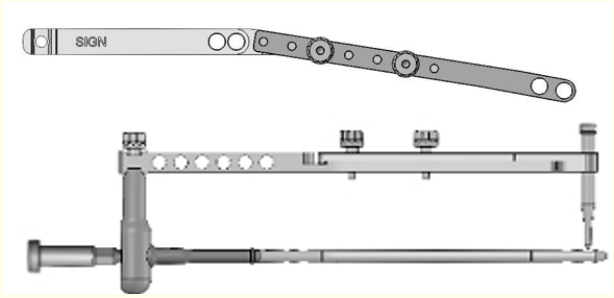

Figure 3: 3a.Blocking Guide SIGN. 3b: Guide assembled to the Nail.

Figure 4: Incision at the fracture focus level to control reduction and passage of the IMN.

Figure 5: Squat and Smile. Rx. Consolidated femoral fracture.

Results and Discussion

Patients were clinically and radiologically controlled between 6 and 351 weeks, five patients did not attend postoperative control (14%). If a SIGN radiological control is not possible, it considers a sign of bone consolidation when the patient can "Squat and Smile" (Figure 5).

Fractures consolidated at an average of 6 weeks (range 5-14 weeks) after a fracture.

The hospital stay of patients with isolated femur fractures was 2.8 days on average (range 1-5 days).

With an average follow-up of 57 weeks, none of the patients had developed vicious consolidation, avascular necrosis, femoral neck valgus, or narrowing of the femoral neck. No neurological injury or heterotopic ossification is reported. No additional immobilization method was necessary for the immediate postoperative period.

The removal of the nails was performed in 10 patients once the fracture was consolidated until the time of preparation of this report.

Conclusion

Gerhard Kuntscher revolutionized the osteosynthesis of fractures by experiencing his intramedullary nail between 1930-and 1940 but only since 1978 thanks to the contribution of Grosse., *et al*. [17-19] intramedullary nails are blocked to improve the fixation and stability of fractures.

Intramedullary nailing in children has changed substantially with the better knowledge of the vascularization of the proximal femur. The selection of the implant is based on several factors in addition to age and weight, the characteristics of the fracture, the preference of the surgeon, and having the implant. In the HVCM the rigid SIGN IMN is available, at all times, it does not require an image intensifier or traction table, the lateral decubitus during surgery was convenient allowing maneuvers of reduction of the fracture.

The technique of intramedullary nailing with the standard SIGN nail in children over 8 years of age and adolescents through the greater trochanter of the femur, is safe, effective, and well-tolerated by patients. It provides stable fixation, rotational control, preservation of limb length, and early rehabilitation.

It is important to have a meticulous surgical technique and particular attention to the site of entry of the nail as well as the reduction and control of rotation.

The hospital stay was short, as was the time for ambulation of the patient. There was no rupture or loosening of the implant.

Without exception, the use of the SIGN intramedullary nail provided a quick, first quality solution in osteosynthesis of diaphyseal fractures of the femur, without affecting the budget of the institution and was an important alternative in a case in which the attempt to consolidate a fracture of the diaphysis of the femur using a plate and screws failed. The use of the SIGN system also helped to reinforce the important custom of documenting surgical cases and monitoring the good and bad results of treatment.

The intramedullary nail of SIGN is not a new method of osteosynthesis, its main contribution is the humanitarian philosophy of its creator Dr. Lewis Zirkle Jr. who together with Randy Huebner, a founding engineer of "Acumed"[20] developed in the nineties the nail and instrumentation to be used in patients from the third world.

There are currently 388 SIGN programs in 54 countries around the world and more than 373,375 patients have benefited from an implant that allows them to recover quickly from severe fractures [13]. The SIGN Project in Cuenca is the second in Latin America and the first in Ecuador to remain active.

Amid endless commercial offers and material ambitions, the SIGN Organization not only contributes free of charge to the solution of traumatic injuries but offers those of us who contribute as surgeons to participate in spreading the humanitarian philosophy. As stated by Dr. David C Templeman [21] We cannot all be Zirkles but his example motivates each of us to do a little more for those who do not have the economic resources.

Conflict of Interest

The authors report no conflicts of interest.

Contribution of the Authors

TT, JCT: Study design, collection, data analysis, manuscript writing. The authors read and approved the final version of the article.

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