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Outcome of the Treatment of Gunshot Open Fractures of the Lower Extremities with 'SIGN' Interlocking Nails.

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Background: Gunshot injuries are gradually on the increase in civilian populations in developing countries due to increasing violence in our society. The treatment of fractures from these injuries is changing with the use of locked intramedullary nailing becoming an acceptable and effective method of fixation. Surgical Implant Generation Network interlocking nails are gaining universal acceptability in these countries due to ease of use without the need for image intensifier. The purpose of this study was to evaluate the outcome of the use 'SIGN' interlocking nailing in gunshot open fractures of the lower limbs.
Methods: This is a prospective study of all patients in three tertiary centres in developing countries who had gunshot fractures of lower limbs fixed with SIGN nails from 1st January to 31st December 2009 and followed up for a period of 2 years.
Results: Twenty eight patients with 31 fractures with average age of 32.5years±12.6SD. All the patients were males except one female. Fractures occurred in femur in 20(71.4%) and tibia in 11(29.6%) SIGN nail was used to fix all fractures and union was achieved in all the patients. The most common complication was wound in infection in 5 (15.2%).
Conclusion: SIGN intramedullary locked nail provided an effective method of fixation for gunshot fractures of the lower extremity with minimal complication.

Introduction

Gunshot injury is increasing worldwide due to the increasing violence in civilian society[1]. The management of these injuries could be challenging and sometimes the prognosis may be difficult to predict in those that survive the initial assault. The nature and the severity of the bullet wound depend on the characteristics of the bullet and tissue through which it travels[2]. The damage to the tissue is a function of the kinetic energy dissipated which is the product of half the mass of the bullet and velocity ($1/2MV^2$) in addition to shock wave, temporary and permanent cavitation and secondary missiles. The bullets could also cause injuries by wadding, yaw or tumbling.

Extremities gunshot injuries when it involves the bone often results in comminuted fractures with associated complex musculotendinous soft tissues injuries; the management of which is gradually becoming a continuous burden on community and hospital resources around the world[3]. The civilian Orthopaedic Surgeons will be required to manage gunshot injuries of the extremities with frequencies that demand a thorough understanding of the principles of ballistic injury and familiarization with the nature of low and high energy transfer wounds to soft tissue and bone[1]. There is wide range of methods that has been advocated for the treatment of these gunshot bone fractures from non-operative 'low tech' splintage through external fixation to internal fixation with locked intramedulary nail. There appears to be a consensus to treat Gustilo and Anderson Stages 1, II and IIIA with locked nail while external fixation is reserved for IIIB and C[3]. Others have also combined both external fixations (Damage Control Orthopaedics-DCO) then followed by intramedullary locked nailing.

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There was no statistically significant difference in clinical outcome between those treated with immediate and delayed reamed intramedullary locked nailing. However those treated by immediate interlocking nails had a shorter hospital stay with significant decrease in hospital expenses[4]. The study was done to evaluate outcome of treatment of gunshots open fractures of the lower extremities in three centres located in developing countries using 'SIGN' interlocking nail. The 'SIGN' is acronym for Surgical Implant Generation Network; now called SIGN fracture care which is nonprofit oriented organization devoted to the creation of equality of Orthopaedic care for surgeons in developing countries.[5] The SIGN interlocking nail is a solid nail with target arm. The target arm has a distal jig through which the slot finder is used to locate the hole in the nail for distal locking. It is designed for use with or without image intensifier or C arm[6,7].

Patients and Methods

This is a prospective descriptive study of gunshot open fractures of lower extremities treated with SIGN interlocking nails at three centres located in developing countries. The study was done over a period of one year from 1st June 2007 to 31st May 2009. The inclusion criteria are gunshot to the lower extremities with long bone fractures and who were followed up for a minimum of 2years. All the patients were adequately resuscitated and stabilized in Emergency room (ER). Wound debridement was done to excised necrotic tissue and copious irrigation done with saline. Intravenous second generation cephalosporin-cefuroxime was administered at presentation to all the patients and continued for 5 days. Bio data and information on when the patient was shot and the assailant were obtained. Neurovascular status of the limb injured limbs was examined to document neural and vascular injuries.

Radiographs of the affected limb were taken in two orthogonal plane- anteroposterior (AP) and lateral views (LAT) to determine the pattern of injuries and the presence of bullets or pellets. The fracture was classified using the Gustilo and Andersen method of classification of open fracture. All fractures were fixed with SIGN interlocking nails. The interval between injury and surgery and associated injuries were recorded. Intra-operatively the shells (wad) were removed but the bullets and pellets were removed only if encountered during the course of wound debridement or lying along course of an artery or nerve. There was no deliberate attempt to "chase" them. Clinico-radiological follow up of the patients were done at the outpatients clinic to monitor for union. Complications like infection were looked for in the outpatient and where they are suspected complete blood count (CBC) and Erythrocyte sedimentation rate (ESR) were done at every outpatient visit. Other complications looked out for were limb length discrepancy, delayed union, and implant failure. The data obtained were analyzed using the Statistical Package for Social Sciences (SPSS) 13 and test of significant association was done using Chi square and level of significance was $P<0.05$.

Results

Twenty-eight patients with 31 fractures with age range of 15-70 years with average age of 32.5+ 12.6years. All patients were male except one; half of them were shot by unknown/armed bandits assailants while the other half were shot by security agents. 20(71.4%) of the injuries were low velocity missile and 8 (38.6%) high velocity missile. The low velocity gunshot injuries were caused by local Dane gun and pistol while high velocity injuries were from armed bandit attack**.** The fractures were 26(83.9%) femoral shaft and 15 (16.1%) tibia fractures. Sixteen (61.5%) of the femoral shaft fractures were operated using the retrograde approach and 10 (38.5%) had antegrade approach. The time interval between injury and SIGN nailing ranged from 1-26 days with average of 7.8±6.1days.

The fractures involved the right side in 13(38.7%) and left side in 18(61.3%). Complications observed were wound infections in 5(15.2%) cases, limb length discrepancy in 2(6.5%) and delayed union in

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1(3.2%) case. Among those with wound infection half had superficial infection and the other half had deep infection. Table 1 show the interval between injury and surgery and number of those with wound infection. There was no statistically significant association between interval between injury and SIGN intramedullary nailing. Table 2 shows the Gustilo-Anderson classification of fractures, bullet/bullets fragments at the fracture site and wound infection. Table 3 shows Bullet/bullets fragments or pellets at the fracture site and wound infection. The presence or absence of bullet/bullets fragments/ pellets at fracture site did not statistically affect the occurrence of wound infection (P= .449, CI 0.72, 1.94 OR.24, 11.63).

All the fracture progressed to union at between 12-16 weeks.

Table 1. Interval between Injury and SIGN Nailing, Number Fractures Fixed and Wound Infection

Interval between injury and SIGN nailing in days	Number of fractures fixed	Number of those with wound infection
0-5	15	3
6-10	10	-
11-25	6	2

X^2 =0.147,

P<0.05.

Table 2. Gustillo–Anderson Classification of Fractures, Bullet/Bullet Fragments at the Fracture Site and Infection.

Gustillo-Anderson Classification	Frequency (n)	Bullet/pellet fragments at the fracture site	Infection (n)	
			Superficial(n)	Deep(n)
I	12	12	0	0
II	13	9	3	1
IIIA	3	2	1	0
IIIB	1	1	0	0
IIIC	2	2	0	0

Table 3. The Presence of Bullet/Pellet Fragments/Pellet at the Fracture Site and Infection

Wound and bullet	Number (n)	Infections (n), Percentage (%)		
		Superficial	Deep	Total
Bullet/bullet fragments at the fracture site	24	4	0	4 (16.7%)
Fracture site with no bullet/bullet fragments	7	1	0	1 (14.3%)

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Discussion

Gunshot open fracture is usually high energy injuries by definition. Studies had shown that heat generated during firing does not make the bullet sterile. [8]. In this study 71.8% of the injury was caused by low velocity missile which was similar with previous study in developed countries where civilian gunshot injuries are most commonly low velocity, low energy missiles (300m/sec and lower)[3]. The assailants in most of these cases were security agents and sometimes accident discharge hunting expedition mishaps. Some of the patients sustained their injuries during 'stop and search' operation of the security agents. However those with high velocity missile injuries were from armed bandits.

Males were the most commonly injured in this study being the one who are often involved in travels in order to fend for their family. This was similar to reports in previously published paper[9,10,11]. This shows the vulnerability of the young productive males to sustaining long bones fractures in gunshot injuries with its attendant morbidity and man hour loss. All the fractures were in the lower limbs of which 83.9% occurred in the femur and 45.2% of the lower limbs fractures were around knees. This is in tandem with other reports where majority of the gunshot injuries were in the lower limbs.[3] This may be due to the fact that the assailant's aim was to immobilized the victim either for arrest in those shot by security agent or to enable them dispossess them of their personal belongings in those shot by armed bandit.

Standardized care for gunshot open fractures has been established in some centres in developed countries. These include operative debridement of all devitalized soft tissue and bone fragment followed by copious irrigation and early fixation. The method of bone fixation is predicated on the pattern of fracture communition, generalized status of the patient and local soft tissue problems encountered.[3] However there is general consensus to treat type I and II Gustilo Andersen staging of gunshot fracture injuries with locked intramedullary nailing with an increasing trend among surgeons to treat type IIIA and B with locked intramedullary nailing with good to excellent results.[4] In this series SIGN interlocking nails was to use to fix all fractures irrespective of Gustilo Andersen staging except one who had external fixator for a period of 26 days before intramedullary nailing was done. All the fractured progressed to union at average of 12-14 weeks. This was unlike the report by Ali et al who had nonunion in 4(5.88%) of the 68 fractures caused by high velocity gunshot injuries of the femur which in their series needed secondary procedure of bone grafting for union to occur. [9]

The most common complication was wound infection in 15.2% of the cases; of this half was superficial and the other half was deep. In the paper by Weil et al [12] and Mody et al [13] deep wound infection of 33% and 40% respectively was reported. However the report by Mody et al was in a war trauma setting where a higher than degree of wound contamination may be present. This is higher than the finding in this study. There was no case of nonunion but we had one case of delayed union due to early implant failure from breakages of the two distal locking screw and early mobilization without crutches. One of the patients with deep wound infection had gunshot injury with entry point on the medial aspect of the tibia. The fractures were fixed statically between 1-26 days after the injury with 7.8days±6.1SD. Table 1 shows that the interval between injury and SIGN interlocking nailing did not significantly the infection rates in the groups. This was in agreement with finding by Molinari et al that operative outcome with regard to immediate, intermediate or delayed fixation has no significant difference.[14]

The presence of bullet/bullet fragments did not contribute significantly to wound infection rate neither do the presence of entry and exit wound. Further studies with large sample may be needed to corroborate this. Among the 15 of the patient who had retrograde femoral nailing and five with tibia fracture with

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entry through or around the knee; 19 of them had restoration of normal range of motion of the knee at 6 month post-surgery with physiotherapy.

The main findings in this study are gunshots open fractures in predominantly young males affecting the lower limbs, infections were superficial with SIGN intramedullary nailing and union was achieved in all the patients. SIGN intramedullary nailing provided an effective intramedullary nailing device in patients with gunshot fractures of the lower limbs with union of all the fractures and reduced complications.

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