

Retrospective Study Comparing Outcomes of Open Antegrade and Open Retrograde Femoral Nailing Using the SIGN Nail in Philippine General Hospital Patients

Wilfredo B. Pacheco, M.D. and Bernardino B. Alpuerto II, M.D.

Department of Orthopedics, Philippine General Hospital, University of the Philippines Manila

Objectives: To compare the outcomes of open antegrade and retrograde intramedullary nailing of the femur using the Surgical Implant Generation Network (SIGN) nail in adult PGH patients.

Methods: This is a retrospective review of adult patients with closed femoral shaft fractures who were treated using an interlocked intramedullary nail (SIGN nail). Forty-two patients were treated by open antegrade nailing and 16 patients were treated by open retrograde nailing. The two groups were compared using the following outcomes: duration of surgery, amount of blood loss, length of hospital stay, infection rate, weight bearing time, union rate, malunion, knee and hip pain, neurovascular deficits, peri-implant fracture incidence and length of post-op hospital stay.

Results: There was a statistically significant difference in the duration of surgery between the antegrade nailing group compared to the retrograde nailing group. All the other outcome parameters were not statistically different between the two groups.

Conclusion: Outcomes of femoral shaft fractures in adults treated by open antegrade nailing and open retrograde nailing using the SIGN nail are similar except for a slightly longer operative time for the retrograde nail group.

Key words: open intramedullary nailing femur; retrograde nailing femur; SIGN nail

Femoral shaft fractures are one of the common fractures encountered in Philippine orthopedic practice, accounting for twelve per cent (12%) of all orthopedic emergencies seen at the Emergency Room.¹ Femoral shaft fractures cause significant morbidity and would delay the patients return to function without surgical management.

The current recommended treatment for femoral shaft fractures in adults is intramedullary nailing. Nailing of the femur may be done in an antegrade or retrograde manner. Antegrade intramedullary nailing is the gold standard for treatment of diaphyseal femoral shaft

fractures; it has a high union rate (99%) and low infection and malunion rates (<1%).²

In patients where antegrade nailing would be difficult i.e. obese patients, patients with bilateral femur fractures, ipsilateral pelvic fracture, ipsilateral tibial fracture, and pregnancy, the retrograde nailing technique is favored.²

Both approaches have its own indications for use and advantages and disadvantages. Studies have shown that results of retrograde nailing are comparable to that of antegrade nailing.³

In developing countries like the Philippines, many patients cannot afford the commercially available locked intramedullary nails. The Surgical Implant Generation Network (SIGN) was created in 1999 as humanitarian, non-profit corporation with a goal to provide improved health care and appropriate orthopedic treatment of fractures at little or no cost to people in need throughout the developing world. SIGN developed an interlocked nail for fractures of the tibia. It was designed for use in conditions where intraoperative imaging is minimal or non-existent. After much success in its use for the tibia, the indication for its use has been extended to fixation of femoral shaft fractures as well.^{4,5,6}

The SIGN nail (Surgical Implant Generation Network, Richland, Washington) is inserted in an open manner while the nails used in Western literature are inserted in a closed manner with intraoperative use of the C arm. For the SIGN nail, the fracture site is opened and reduced under direct vision while for commercial interlocked nails, the fracture site is not opened and the fracture is reduced under the guidance of a C arm. The nail insertion points for the SIGN nail also require larger

incisions in order to visualize or palpate the proper position to ream, seat and lock the nail, compared to the closed nailing technique which uses the C arm to determine the correct position.⁵

The authors wanted to find if there is a difference in the outcomes of adult patients treated by open antegrade nailing compared to those patients treated by open retrograde nailing using the SIGN nail system.

The outcomes of interest were: duration of surgery, amount of blood loss, length of hospital stay, infection rates, weight bearing time, union rates, malunion, knee and hip pain, neurovascular deficits, peri-implant fracture incidence, and length of post-op hospital stay.

Methods

This is a retrospective study conducted at the Department of Orthopedics, Philippine General Hospital involving patients with femoral shaft fractures treated using the SIGN nail system from 2004-2012. The study protocol was evaluated and approved by the hospital's Institutional Review Board.

The inclusion criteria were:

1. The level of the femoral shaft fracture must be at least 5 cm distal to the lesser trochanter and at least 5 cm proximal to the articular surface of the distal femoral condyle
2. The fracture is closed.
3. The fracture configuration must be from Winquist 1 to Winquist 3 only.
4. Treated with the use of the SIGN nail in an antegrade or retrograde manner.
5. Must be at least 18 years old.
6. Follow up of at least 6 months or with radiologic signs of bone union.

Excluded were patients with:

1. ipsilateral fractures of the tibia.
2. fractures of the spine and pelvis
3. open or closed knee injuries
4. pathologic fractures

Union of the fracture was defined as presence of bridging callus in two orthogonal radiological views and patient had no pain on full weight bearing.

The charts were reviewed as to the following outcomes: duration of surgery, amount of blood loss, length of hospital stay, infection rates, weight bearing time, union rates, malunion, knee and hip pain, neurovascular deficits, peri-implant fracture incidence, and length of post-op hospital stay.

The independent t-test and Pearson Correlation test were used to analysis the data.

To detect a difference of 1 hour in the duration of surgery, assuming a standard deviation of 1.43, setting the level of significance at 5% 2-tailed, power of 80%, 32 patients per group are needed.

Results

Patient characteristics

There were a total of 202 patients with closed femoral shaft fractures treated with a SIGN nail found in the database. Of these, 168 patient were treated with open antegrade nailing while 34 patients were treated by open retrograde nailing. Of this number, 42 with open antegrade nailing and 16 patients with open retrograde nailing, met the inclusion criteria and had available in-patient and follow-up charts for review.

The mean age of patients in the antegrade group is 32.3 years old (19-60) compared to 41 years old (18-68) in the retrograde group. Of the antegrade group, 25% had associated injuries/fractures in the upper extremities. Only 1 patient in the retrograde group had an associated upper extremity fracture. For the antegrade group, 88% of the fractures were located in the middle 3rd of the femoral shaft while in the retrograde group, 56% were located in the distal 3rd of the femur. The average diameter of the SIGN nail used for the retrograde group was 10mm and 9.7mm for the antegrade group.

Figure 1 shows a radiograph of a patient who underwent retrograde nailing of the femur, Figure 2 shows a radiograph of a patient who underwent antegrade nailing of the femur. Figure 3 is a clinical picture showing the hip and knee motion of the same patient in Figure 1

and Figure 4 is a clinical picture showing the hip and knee motion of the patient in Figure 2.

Table 1 shows the summary of statistical comparison of outcome measures between the 2 groups.

Time Interval Between Injury and Surgery

Mean time from injury to surgery in the retrograde group is 19.56 days, which is higher compared to the antegrade group which had a mean of 13.98 days. This difference was not found to be statistically significant.



Figure 1. X ray of patient who underwent antegrade nailing.

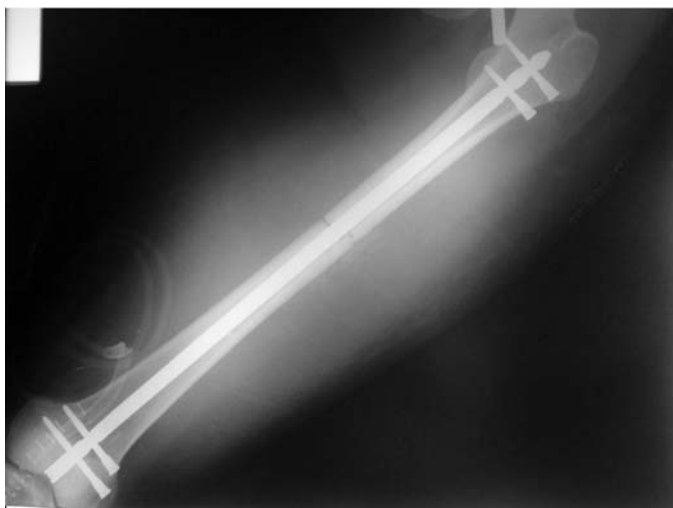


Figure 2. X ray of a patient who underwent retrograde nailing.



Figure 3. Retrograde nailing: Hip and knee flexion of the patient in Figure 1.



Figure 4. Antegrade nailing: Hip and knee flexion of the patient in Figure 2.

Table 1. Summary of statistical comparison of outcome parameters between retrograde and antegrade approach.

Group		Mean	P-value	Verbal Interpretation
Duration of Surgery (hrs)	Retrograde Group	4.96	.006	Significant
	Antegrade Group	3.16		
Blood Loss (L)	Retrograde Group	0.93	.438	Not Significant
	Antegrade Group	0.76		
pRBC (units)	Retrograde Group	1.22	.533	Not Significant
	Antegrade Group	0.92		
Length of Hospital Stay (days)	Retrograde Group	28.17	.939	Not Significant
	Antegrade Group	27.71		
Weight bearing time (weeks)	Retrograde Group	8.83	.390	Not Significant
	Antegrade Group	7.10		
Time to union (weeks)	Retrograde Group	35.33	.163	Not Significant
	Antegrade Group	27.21		
Time interval from injury to surgery (days)	Retrograde Group	19.56	.291	Not Significant
	Antegrade Group	13.98		
Length of post-operative stay (days)	Retrograde Group	11.25	.814	Not Significant
	Antegrade Group	12.30		
Pain on knee (incidence)	Retrograde Group	0.43	.150	Not Significant
	Antegrade Group	0.19		

Duration of Surgery

The retrograde group had an average duration of surgery of 4.96 hours (range: 3.25-6.32 hours) while the antegrade group had an average of 3.16 hours (range: 21- 5.3 hours). This difference in surgical time was found to be statistically significant. This result was further correlated with the time interval between injury to surgery but the result was not significant (Table 2).

Blood Loss and Transfusion

The average blood loss in the retrograde group per operation was 0.93 L while for the antegrade group it was 0.76 L. The retrograde group needed an average of 1.2 units pRBC transfusion per operation while the antegrade group needed only 0.92 units pRBC per operation. Both of these differences, however, were found to be not statistically significant.

Table 2. Correlation between duration of surgery and time interval from injury to surgery.

	Correlation Coefficient	P-value	Verbal Interpretation
Retrograde	.470	.202	Not significant
Antegrade	.028	.944	Not significant

Time to Union

Only patients who had a follow-up of at least 6 months or were documented to have radiologic and clinical signs of union were included for this statistical analysis. All patients went on to union except for 1 patient in the antegrade group. This patient had an associated humeral shaft fracture and underwent open reduction internal fixation with plates and screws. He still had pain and with visible fracture line with minimal

callus even after 52 weeks post-surgery but was full weight bearing. The overall union rate was 97%. The average time of union for the retrograde group was 35.3 weeks (range: 7-120 weeks); and for the antegrade group it was 27.2 weeks (range: 5-127 weeks). This difference was not statistically significant.

Time to Weight Bearing

In the retrograde group, the patients were either partial or full weight bearing by an average of 8.83 weeks post-operatively and for the antegrade group the average time was 7.1 weeks post-operatively. This was not found to be statistically significant.

Hip and Knee Pain

In the retrograde group, the incidence of knee pain post-operatively was 0.43 while in the antegrade group it was 0.15. This difference was not found to be significant. However there were two patients over 60 years old who had persistent knee pain at 6 months follow up. In terms of presence of hip pain post-operatively, no patient had hip pain in the retrograde group while 2 patients (incidence of 0.06) were documented in the antegrade group.

Length of Postoperative Stay/Length of Hospital Stay

The average time interval between operation and discharge in the retrograde group was 11.25 days while in the antegrade group it was 12.3 days. For the length of hospital stay, the average for the retrograde group was 28.17 days and for the antegrade group it was 27.71 days. Both of these differences were not statistically significant.

Complications

The rate of surgical site infection for the antegrade group was 0.07% and for the retrograde group it was 0.125%. The patients underwent multiple debridements and IV antibiotics until the infection resolved. No nails required removal. There was one patient who had an associated humeral shaft fracture that underwent open

reduction and internal fixation and had a surgical site infection in the arm. Debridement was done and the humeral plate was removed after which an external fixator was applied. This was also the same patient who had the non-union of the femur after antegrade SIGN nailing. There were two patients who underwent revision of the nail, both belonging to the antegrade group; one was due to malrotation of the distal fracture fragment and the other for revision of the distal screw. No peri-implant fracture and no neurological deficits were documented in the patients.

Discussion

The aim of this study was to determine if there are outcome differences between open antegrade and open retrograde intramedullary nailing of femoral shaft fractures using the SIGN nail. The authors found the open antegrade and retrograde insertion techniques using the SIGN nail to be similar blood loss in terms of pRBC transfusion, length of hospital stay, weight bearing time, time to union, presence of hip/knee pain, and length of postoperative hospital stay. Although they did not reach the number for an ideal sample size, the parameter with a statistically significant difference was the duration of surgery. Operative time using the retrograde approach was longer compared to the antegrade approach. This might be attributed to a greater familiarity of the surgeons with the antegrade approach. Historically, the antegrade approach is the standard and the retrograde approach was started much later, surgeons may be more adept using the antegrade approach. Furthermore, there were more comminuted and segmental fractures in the retrograde group which can make fracture reduction more difficult. This could explain the prolonged operative time in the retrograde group.

The location of the fractures may also be the reason for the longer operative time for the retrograde group. Antegrade nailing is usually chosen for midshaft fractures while retrograde nailing is chosen for more distal fractures. Another explanation for the longer operating time may be that in the retrograde technique used for more distal fractures, the fracture must first be reduced before reaming is begun while for the midshaft fractures where the antegrade technique is done, reduction need

not be done before reaming because the narrow canal will assure reduction when the nail is inserted. Thus there is one additional step for the retrograde technique compared to the antegrade technique.

The duration of surgery was also correlated with the time interval from injury to surgery with the premise that the longer the delay, the more difficult and lengthier the operation would be. There was a trend towards a longer operative time for patients whose surgery was delayed but no statistical difference was found between the antegrade and retrograde group.

There was also a trend towards greater amount of blood loss and greater number of transfusions for the retrograde group which may be the result of the longer operating time. However, this was not found to be statistically significant.

In a similar study regarding outcomes of SIGN nailing, the union rates were 93% and the mean duration of union was 18.5 weeks.⁷ However, in this present study the overall documented union rate was 97% and mean duration of union for the retrograde group was 35.3 weeks and for the antegrade group it was 27.2 weeks. This was not statistically significant. In another study comparing the mean durations of union in closed retrograde and antegrade nailing using a different nail, the union rates were 13.1 and 14 weeks respectively.³ This is much shorter compared to this study's mean union rates probably because the authors used the open technique which required greater periosteal stripping resulting in delayed fracture healing.

There are several reports that the retrograde approach has more incidence of knee pain post-operatively compared to the antegrade group^{3,8,9}, and in a recent systematic review of literature, it was concluded that retrograde approach is associated with higher rates of knee pain.¹⁰ In this present study, there was a trend towards greater knee pain in the retrograde group although the difference was not statistically significant. In the retrograde group, there were 3 patients who were 62 years old and above and of these, 2 patients had persistent knee pain on follow-up. In the other patient, pain resolved after 19 weeks. Since these are older patients, the persistent pain might be attributed to a pre-existing osteoarthritis of the knee prior to the injury which was unrecognized or not documented.

Length of post-operative hospital stay may serve as an indirect measure of recovery time from surgical trauma. The authors found no statistically significant difference between the post operative stay of patients treated with the two groups which indicates that their recovery time are similar. This could also mean that the retrograde approach causes no more surgical trauma compared to an antegrade approach.

The limitations of this study are: it is retrospective, it is not randomized, the sample size did not reach the desired number, different surgeons performed the surgeries, and there is poor long term follow-up.

Conclusions

The outcomes of adult patients treated with open antegrade and open retrograde nailing using the SIGN nail are similar if the following parameters are used: the amount of blood loss, pRBC transfusion, length of hospital stay/length of post-operative hospital stay, weight bearing time, time to union, and incidence of knee pain. However, the duration of surgery using the retrograde approach was longer compared to the antegrade approach. Caution should be exercised in doing an open retrograde nailing in patients over 60 years old because anterior knee pain may be persistent in this age group.

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