Distal Interlocking Screw Placement in the Femur: Free-Hand Versus Electromagnetic Assisted Technique (Sureshot)

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Objectives: To compare the free-hand (FH) technique of placing interlocking screws to a commercially available electromagnetic (EM) targeting system in terms of operating time, radiation dose, and accuracy of screw placement.

Methods: Between September 2011 and July 2012, we prospectively randomized 100 consecutive femur shaft fractures in 99 patients requiring intramedullary nails to either FH using fluoroscopy (n = 43) or EM targeting (n = 38; Sureshot).

Setting: Single Level 1 University Hospital Trauma Center.

Main Outcome Measurements: The 2 groups were assessed for distal locking with respect to time, radiation, and accuracy.

Results: Eight-one fractures had data accurately recorded (38 EM/43 FH). The average total operative time was 50 minutes (range, 25–88 minutes; SD, 13.9 minutes) for the FH group and 57 minutes (range, 40–103 minutes; SD, 16.12 minutes) for the EM group. The average time for distal locking was 10 minutes (range, 4–16 minutes; SD, 3.56 minutes) with FH and 11 minutes (range, 6–28 minutes; SD, 10.24 minutes) with EM. Average radiation dose for distal locking was significantly less ($P < 0.0001$) for EM at 230.54 μGy (range, 51–660 μGy; SD, 0.17 μGy) compared with 690.27 μGy (range, 200–2310 μGy; SD, 0.52 μGy) for FH. There were 2 misplaced drill bits in FH and 3 in EM. This was not statistically significant ($P = 0.888$).

Conclusions: The electromagnetic targeting device (Sureshot) significantly reduced radiation exposure during placement of distal interlocking screws, without sacrificing operative time, and was equivalent in accuracy when compared with the FH technique.

Key Words: intramedullary nails, distal locking, trauma

Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Intramedullary nailing of long bone fractures of the lower extremity has long been the standard of care, revolutionizing the management of the multiply injured patients and providing high union and low complication rates.[1–3] The addition of interlocking screws provides rotational stability and leg length and angulation control. Ever since the introduction of the first commercially available interlocking nail by Kempf et al in 1972,[2] the placement of the distal interlocking screws has remained technically challenging with a steep learning curve. The time for insertion of these screws can vary from 4 to 60 minutes.[4] The proximal screws are easily placed with the aid of targeting jigs attached to the nail proximally, but jigs for the distal screws are inaccurate because of the inevitable deformation the nail undergoes during insertion and excessive amounts of "play" in these longer jigs.

Numerous systems, techniques, and devices have been developed over time in an attempt to overcome this problem. These devices include jigs attached to the fluoroscope,[2] computer-assisted navigation system,[5] complicated proximally mounted targeting devices,[6] and also simpler techniques such as drilling over K-wires with cannulated drill bits[7] and the flag and grid technique described by Yiannakoupolos et al.[8] The perfect circles technique was first described in 1986 and is to this day the most popular method used.[4] It is a free-hand (FH) technique that relies solely on correct positioning of the C-arm and the surgeon's skill to accurately place the distal screws.[9] Popular as it may be, this technique exposes the patient, surgeon, and operating room staff to large amounts of additional radiation. There remains a need to minimize radiation exposure, improve accuracy of screw placement, and accelerate distal interlocking insertion. New technologies are still being developed to offer a solution to these problems.

One new technology uses nonionizing electromagnetic field tracking to locate the position of the drill bit relative to

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the locking holes in 3-dimensional space. A computer-generated image then provides real-time feedback to the surgeon as to the position and trajectory of drill bit, allowing for accurate placement of the locking screws without the use of fluoroscopy. One such device is the Sureshot (Smith-Nephew, Memphis, TN). We hypothesized that using this targeter would improve the accuracy of distal locking and reduce radiation exposure during screw insertion.

MATERIALS AND METHODS

We included all patients presenting to our trauma unit with fractures of the femoral shaft requiring antegrade intramedullary nailing from September 2011 to June 2012. Patients were excluded from the study if they had fractures necessitating a cephalomedullary locking configuration or a retrograde intramedullary nail. We also excluded patients whose fracture patterns necessitated only 1 locking screw distally (eg, skeletally immature patients), because it is our institution policy to use 2 screws in all skeletally mature patients. Randomization was performed by selecting sealed envelopes that were mixed in a box. Patients were randomized to either distal locking using the traditional FH method or to distal locking using the electromagnetic technique (EM). Parameters measured for the placement of the 2 distal screws were operative time, radiation dose (measured in micrograys), and fluoroscopy time. The same modality (FH vs. EM) was used for the placement of both screws in each patient. We also documented the incidence of misplaced drill bits and screws. All procedures were performed by orthopaedic registrars in our department, and fluoroscopy was performed using a Phillips BV Endura (Phillips, the Netherlands) standard C-arm. Once the nail was seated in the canal and the surgeon was ready to insert distal screws, the C-arm readings were recorded, and once distal locking was completed, the readings were recorded again. The former readings were subtracted from the latter to give a reading for distal locking. For the EM group, the timing started once the nail was inserted and the computer was switched on ready for nail details to be entered. For the FH group, the measured time included the time it took to position the C-arm to get the perfect circles. Locking operative time was recorded using a stopwatch. Fluoroscopic confirmation of screw position and length was performed in EM group, and this radiation was included in the radiation recording. The distal locking time and radiation for both groups included the set-up time for EM and attainment of perfect circles for FH. The data were analyzed with respect to the above parameters to determine the differences between the 2 groups.

All patients were operated in the supine position with both legs extended on a traction table within 24 hours of admission using 1 C-arm.

RESULTS

We collected data for 100 fractures in 99 patients. Nineteen patients were excluded because of incorrectly entered data or incompletely filled data sheets. This left a sample size of 81 fractures in 80 patients. In the patient with bilateral fractures, each limb was randomized individually. Fifty-two patients were male and 28 were female. Average age was 32 years (range, 14–90 years). There were 38 fractures in the EM group and 43 in the FH group. The fracture types in the 2 groups were similar in terms of OTA/AO classification of femur shaft fractures.[10] The average total operative time was significantly less (P = 0.032) at 50 minutes (range, 25–88 minutes; SD, 13.9 minutes) for FH and 57 minutes (range, 40–103 minutes; SD, 16.12 minutes) for EM. The average time for distal locking time for FH was 10 minutes (range, 4–16 minutes; SD, 3.56 minutes) and 11 minutes for EM (range, 6–28 minutes; SD, 10.24 minutes) (P = 0.153) (Table 1). The average radiation dose for distal locking was significantly reduced (P < 0.0001) for EM at 230.54 μGy (range, 51–660 μGy; SD, 0.17 μGy) compared with 690.27 μGy (range, 200–2310 μGy; SD, 0.52 μGy) for FH.

The reduction in radiation dose for placing of the distal screws was found to be statistically significant (2-tailed test, $P \leq 0.002$). The reduction in distal locking fluoroscopy time was also statistically significant ($P \leq 0.002$). There were 2 misplaced drill bits in the FH group and 3 in the Sureshot group. This was not statistically significant (P = 0.888). The results and statistical analyses of the 2 groups are summarized in Table 1.

DISCUSSION

There are few other clinical studies that have been performed comparing the use of an EM aiming device with the traditional FH locking in terms of radiation exposure. Chan and Burris[11] in 2012, in their study of 40 intramedullary nails, found that no radiation was required for placing screws using an EM device. The set-up time and operative time for distal interlocking were significantly reduced. Uruc et al[12] found that fluoroscopy time to achieve equivalent precision is significantly reduced with electromagnetism-based surgical navigation compared with FH fluoroscopic guidance. Also their operative time was significantly reduced with EM-based navigation.[12] Their superior results with EM guidance were also reproduced by Langfitt et al[13] and Stathopoulos et al[14] on both antegrade femur and tibia nails and Moreschini et al[15] on tibial nails.

We found that operative time was increased when using the EM aiming device. The average radiation exposure figures were obtained from the fluoroscope itself and represent emitted

TABLE 1. Statistical Analysis

	Total Operative Time (min:sec)	Distal Locking Time (min:sec)	Distal Locking Radiation (μGy)	Distal Locking Fluoroscopy Time (min:sec)
Free-hand	50:35	10:03	690.27	00:19
Range	25–88 mins	4–16 mins	200–2310	00:07–01:35
SD	13.9	3.56	0.52	0.20
Sureshot	57:57	11:00	230.54	00:07
Range	40–103 mins	6–28	51–660	0:02–0:4
SD	16.12	10.24	0.17	0.094
P	0.032	0.153	<0.0001	<0.0001
Significant?	Yes	No	Yes	Yes

radiation, not absorbed radiation, by the surgeon and other operating room personnel. However, in a recent publication by Singer,[16] estimated radiation exposure during surgery was as follows: exposure from scatter using a regular C-arm 5 mrem/min (0.05 mGy) at 50 cm from the C-arm and exposure to the surgeon's hands was 30 mrem/min (0.3 mGy) and to the torso 20 mrem/min (0.2 mGy). Using those figures, the reduction in fluoroscopy time when using the Sureshot EM device led to a decreased absorbed radiation of approximately 1 mrem from scatter, 6 mrem to the hands, and 4 mrem to the head and neck per procedure. In a high-volume institution like ours, where many fluoroscopically assisted surgeries are performed, even this seemingly small reduction in radiation may have a significant cumulative effect.

The strength of this study lies in the fact that it is based on our day-to-day clinical practice and not cadaveric limbs or sawbone models. The low number of enrolled cases represents a limitation of our study. Also, as alluded previously, we measured emitted radiation, not absorbed radiation.

CONCLUSIONS

In a high-volume institution like ours where we perform in excess of 200 femoral nails per annum and our surgeons are well versed in the FH technique, the Sureshot was equivalent in accuracy and speed of distal screw placement. Its main benefit, however, lies in the significant reduction in radiation exposure. In low-volume centers or inexperienced hands, the Sureshot will potentially assist in improving accuracy and reducing surgical times. Further studies are required to quantify the benefits of the observed reduction in radiation.

REFERENCES

1. Brumback RJ, Reilly JP, Poka A, et al. Intramedullary nailing of femoral shaft fractures. Part I: decision-making errors with interlocking fixation. *J Bone Joint Surg Am.* 1988;70:1441–1452.
2. Kempf I, Grosse A, Beck G. Closed locked intramedullary nailing. Its application to comminuted fractures of the femur. *J Bone Joint Surg Am.* 1985;67:709–720.
3. Brumback RJ, Uwagie-Ero S, Lakatos A, et al. Intramedullary nailing of femoral shaft fractures. Part II: fracture-healing with static interlocking fixation. *J Bone Joint Surg Am.* 1988;70:1453–1462.
4. Whatling GM, Nokes LDM. Literature review of current techniques for the insertion of distal screws into intramedullary locking nails. *Injury*. 2006;37:109–119.
5. Suhm N, Messmer P, Zuna I, et al. Fluoroscopic guidance versus surgical navigation for distal locking of intramedullary implants. A prospective, controlled clinical study. *Injury*. 2004;35:567–574.
6. Krettek C, Könemann B, Miclau T, et al. A new mechanical aiming device for the placement of distal interlocking screws in femoral nails. *Arch Orthop Trauma Surg.* 1998;117:147–152.
7. Knudsen CJM, Grobler GP, Close RE. Inserting the distal screws in a locked femoral nail. *J Bone Joint Surg Br.* 1991;73:660–661.
8. Yiannakoupolos CK, Kanellopoulos AD, Apostolou C, et al. Distal intramedullary nail interlocking: the flag and grid technique. *J Orthop Trauma.* 2005;19:410–414.
9. Medoff RJ. Insertion of the distal screws in interlocking nail fixation of femoral shaft fractures. Technical note. *J Bone Joint Surg Am.* 1986;68:1275–1277.
10. Marsh JL, Slongo TF, Agel J, et al. Fracture and dislocation classification compendium—2007: Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma.* 2007;21(suppl 10):S1–S133.
11. Chan D, Burris R. Electromagnetic device enables accurate placement of IM nail locking screws. Healio Orthopedics website. Orthopaedics today. 2012. Available at: www.healio.com. Accessed April 21, 2012.
12. Uruc V, Ozden R, Dogramacı Y, et al. The comparison of freehand fluoroscopic guidance and electromagnetic navigation for distal locking of intramedullary implants. *Injury*. 2013 [epub ahead of print].
13. Langfitt MK, Halvorson JJ, Scott AT, et al. Distal locking using an electromagnetic field guided computer based real time system for orthopaedic trauma patients. *J Orthop Trauma.* 2013 [epub ahead of print].
14. Stathopoulos I, Karampinas P, Evangelopoulos DS, et al. Radiation-free distal locking of intramedullary nails: evaluation of a new electromagnetic computer-assisted guidance system. *Injury*. 2013;44:872–875.
15. Moreschini O, Petrucci V, Cannata R. Insertion of distal locking screws of tibial intramedullary nails: a comparison between the free-hand technique and the SURESHOT™ Distal Targeting System. *Injury*. 2013;20:432–434 [epub ahead of print].
16. Singer G. Occupational radiation exposure to the surgeon. *J Am Acad Orthop Surg.* 2005;13:69–76.

