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Original Research Article

Radiation Free Insertion of Distal Interlocking Screw by Nail over Nail Technique in Femoral / Tibial Shaft Fractures : Our Experience in a Rural Teaching Institution

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Abstract: Though for insertion of the distal interlocking screw in intramedullary nailing of long-bones` fracture, the free hand technique remains the standard technique, yet it remains a challenging task for orthopedic surgeons. This technique is inundated with dependence on an image intensifier which sometimes is not available at all centers especially in developing countries like ours. Also, the radiation and operative time increase with this method. It is difficult particularly when the surgeon is not much experienced. Nail over nail technique is a radiation-free technique of distal interlocking screw insertion which can easily be performed. It was a prospective study, which was conducted during the period of Dec. 2014 to July 2016 in the institute`s hospital to evaluate the results of distal locking with the nail over nail technique. Fifty six patients with femoral or tibial diaphyseal fractures, treated by intramedullary nailing, were operated during this period where this technique was used. There were 22 femoral shaft fracture and 34 tibial shaft fracture. These included 20 open fracture and 36 closed fracture. In 20 of 22 femur fractures and in 31 of 34 tibial fractures, satisfactory radiographic bony union was achieved within 6 months of follow-up. There were five cases of nonunion and all these cases were open fractures.The nail over nail technique appears to be a reliable solution for decreasing radiation exposure during closed femoral intramedullary nailing. Moreover as this method is simple, so it can be used in third world countries or in hospitals where image intensifier facility is not available.
Keywords: Distal interlocking screw, femur fracture, intra-medullar nailing, radiation, tibia fracture

INTRODUCTION

Nailing techniques have been much evolved since they were first described in the form of the Kuntscher nail for femur and the 'V' nail for tibia. Closed locked nailing has now become a gold standard method of internal fixation for the management of tibial and femoral shaft fractures. Insertion of distal interlocking screws by targeting the distal holes of the intra-medullar (IM) nail has always been a challenge for the orthopedic surgeons. A lot of experience is needed on the part of both the surgeon and the radio-technician to achieve distal locking perfectly, in the least possible time, and with the least possible exposure to radiation. Numerous devices and techniques have been reported to help distal targeting in attempts to conquer some of the related problems. These various methods include free hand techniques and hand-held guides [1-3], image intensifier mounted targeting devices [4], and nail-mounted guides [5, 6]. Some under developmental computer-assisted methods offer an alternative approach [7, 8]. Each technique has its own advantages and disadvantages, moreover all these techniques are either not available in developing countries or are still in their developmental stages. So as a result the free hand technique remains the most popular method for insertion of distal interlocking screws [5, 9]. However, technically this process is demanding, time consuming, and afflicted to considerable radiation exposure of the patient and the surgical personnel [10-16]. Among orthopedic surgeons, radiation induced cancer is a growing problem, linked with a relative risk for cancer of 5.37 as compared to the general population [17]. Malignancies of exposed personnel range from cancers of solid organs (e.g. thyroid and pancreas), to skin and hematopoietic cancers[18]. According to Sanders *et al*. [11] who put dosimeter rings on the surgeon's hand for all orthopedic fluoroscopy cases, there is increased risk of positive reading with increased fluoroscopy time. During intra-medullary nailing procedures, the risk further increased. Gugala *et al*. reported a fluoroscopy time of 36 seconds for placement of two screws in the tibia, [19] whereas Suhm *et al*. stated intense use of fluoroscopy during freehand locking of 108 seconds per screw [20]. In the investigation of Kirousis *et al*., [21] a complete tibia nailing procedure required 72 seconds of radiation and resulted in an effective dose of 0.04 mSv for the operating surgeon and 0.11 mSv for the C-arm technician. So to avoid radiation induced complications, there should be minimum possible radiation exposure [22]. Hence, to replace/supplement freehand distal locking techniques, there is need to develop a radiation safe and a near perfect method in this green world to decrease carbon emissions. This nail over nail technique decreases our dependence on the image intensifier. This is certainly of great help when an image intensifier inadvertently and suddenly develops a technical snag or error. The aim of this prospective study was to evaluate the results of nail over nail technique used in cases of femoral and tibial shaft fractures treated by intra-medullar nailing over a period of 20 months in the institute (a rural teaching institution).

SURGICAL PROCEDURE

For femoral fractures, lateral decubitus with the fractured limb uppermost and for tibial fractures, supine position was used. Nailing was done as the standard procedure [23], except the distal interlocking, for which radiation-free nail over nail technique was used. This technique of the nail over nail technique requires 1.5 mm of over-reaming of the medullary canal to avoid deformation of nail during insertion. The instruments used for the technique are shown in Figure 1. Figure 2 shows the diagrammatic assembly of the instruments. Another nail of the same size is placed over the thigh/leg. Through the holes of the proximal guide, two trocars and cannulas are inserted into the proximal holes of the second nail (Fig. 3). By this the second nail placed along the longitudinal axis of the femur/tibia, is stabilized. At the site matching to the distal most screw of the second nail, a 2-cm long incision is made down to the bone. A 4.0 mm drill bit which is recommended for the interlocking screws, is passed through the distal most hole of the second nail and drilled into the lateral cortex (Fig. 4). Now the hole is slightly enlarged using a matching bone awl. With a Ryles tube (no. 12, 14) attached to a suction tube, intramedullary blood is now suctioned off from the hole. Following this, the distal hole of the intramedullary nail could be clearly seen. Once under view, by inserting the tip of the awl into the hole, it is rotated perpendicular to the nail; thus creating the entry point for the succeeding insertion of 4.0 mm Steinman pin through nail hole and medial cortex. A matching drill bit is now inserted through this hole and the opposite cortex drilled. The screw length is then determined. At this stage, a free drill bit is passed through the distal locking holes of both the nails. This helps stabilizing the second nail placed along the longitudinal axis of the femur/tibia by fixing the outer nail at three points [Fig. 5]. A 2-cm incision is made down to the bone at the matching site of the second distal screw of the second nail. Through the second distal hole of the second nail, a 4.0-mm drill bit is passed and drilled into the lateral cortex. To lock the second distal screw, the rest of the procedure is the same as for the distal screw. As the hole in the near cortex is slightly enlarged with awl, a washer is usually used to secure the locking screw heads [Fig. 6 a, b]. Direct visualization of the distal locking holes along with the use of matching bone awl and three point fixation of a juxtaposed outer nail are the key factors for the success of this technique.In addition to washers in these cases we sometimes resorted to placing bone grafts. The lateral position for femoral fracture and supine position for tibial fracture inter-locking, was used in all cases. All the patients were encouraged for active mobilization immediately after surgery allowing partial weight bearing. Patients were also encouraged to do isometric quadriceps exercises and knee flexion as tolerated. Patients were asked to come for follow up after 3 weeks, 6 weeks, 3 months, and 6 months of surgery.

MATERIALS AND METHODS

In a prospective study, 56 patients (40 males and 16 females) with femoral(22 fracture) and tibial (34 fracture) diaphyseal fractures were operated upon with closed interlocked nailing using the nail over nail technique for distal interlocking screw fixation from Dec 2014 to July 2016. These included 20 open fractures (Gustilo Anderson grade 1–3B) and 36 closed fracture. Average age of the patients was 33.2 years (range 18–66 years). All patients were operated upon by the same surgeons (first and second authors). Antero-posterior and lateral radiographs including full extent of femur/tibia-fibula from hip/knee joint to knee/ankle joint were obtained. Operations were performed on ordinary operation tables under image intensifier control. Both of the distal screws in all these cases were inserted without the use of image intensifier. The total time taken for inserting the distal screws was recorded.

The success or failure of the technique

The accuracy of passing the drill bit through the interlocking holes in the nail was assessed as follows. Accuracy was considered successful if only one lateral cortical hole was made for single interlocking and successful with difficulty if up to two lateral cortical holes were made for single interlocking. When more than two holes were drilled in the lateral cortex during single distal interlocking, a failure of the technique was recorded. In all failure cases of the nail over nail technique, the free hand technique was used for the insertion of distal interlocking screw. In these cases, the time taken for distal locking was not included with the nail over nail technique.

RESULTS

In this present study average time taken for inserting the distal screws was 12 minutes (range 7–20 minutes). The average diameter of the nails used in this study, was 10.7 mm. A total of 108 distal interlocking screws (4.9 mm) were inserted using this nail over nail technique. Ninety-seven screws were inserted "*successfully"* and eleven screws were inserted "*successfully with difficulty"*. The technique *failed* in four screws in which more than two holes were drilled (all four in the distal hole). All second distal (more proximal) holes were inserted successfully. These four distal screws were inserted using free hand technique under image intensifier. Satisfactory radiographic union was achieved in 20 of 22 femur fractures and in 31 of 34 tibial fractures at the end of 6 months. The nonunion was seen in five patients (two femoral and three tibial fractures). All these fractures had open fractures. At the distal screw sites, there was no any complaint of pain. Clinically also there was no any local tenderness in any patient. In none of the patient clinical or radiological evidence of nail or screw breakage/fracture was reported at the site of distal screw. After implant removal no patient had fracture at the distal screw sites.

Fig-1: Instruments used in the nail over nail technique. (1) 4-mm drill bit. (2) 4-mm Steinmann pin. (3) Trocar. (4) Cannula. (5) Trocar. (6) Cannula

Fig-2: Assembly of the instruments

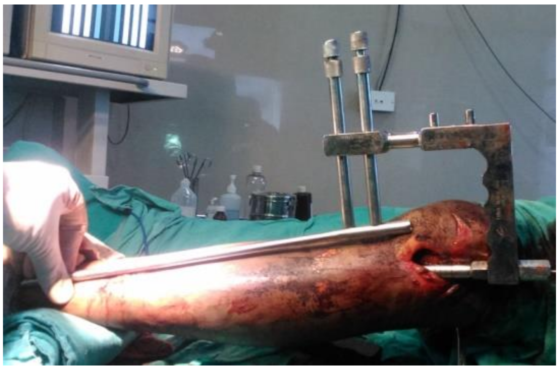

Fig-3: An externally placed nail is used as a guide for distal locking. The two trocars and two cannulas passing through the proximal interlocking guide stabilize the nail

Fig. 4 A 2-cm incision is made at the site corresponding to the distal most screw of the second nail and a 4-mm drill bit is used to drill the lateral cortex

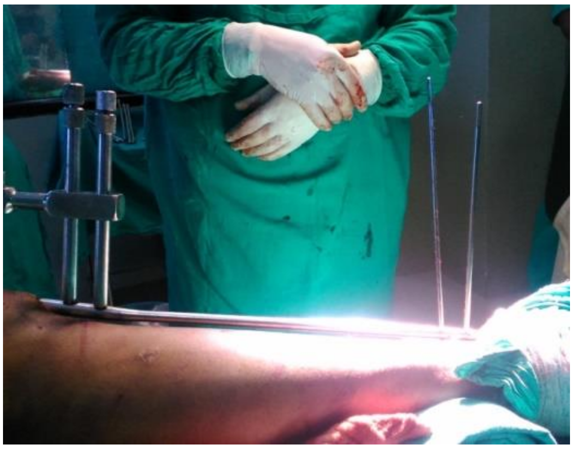

Fig. 5 Technique for placement of the second distal interlocking Screw

(a) (b)

Fig-6: (a) The distal hole in the intramedullary nail seen through bone; (b) Insertion of distal interlocking screw with washer

DISCUSSION

In freehand technique repeated fluoroscopy to insert the distal interlocking screws is needed as on insertion of a nail into a long bone, it is likely to bend according to the curvature of the intramedullary canal [24]. So the exact position of the distal interlocking holes is difficult to predict. Hence surgeons have adopted different indigenous techniques for the insertion of distal screws in many hospitals of developing and poor countries where image intensifier facility is not available. This technique differs from the "nail on nail" technique which was described by Rohilla *et al*., [24] as there is no involvement of "sounding technique," rather here direct visualization of the locking hole is aimed, doing drilling under direct vision. The major benefit of this technique is that as everything is performed under direct vision, there is less chance of screw misplacement and the procedure time is less. Further the chance of slipping of the drill bit on the bone is less under direct vision.Similar technique was also described by Tanna *et al*. [25] using K-wires which is image intensifier independent. However, it still depends on single radiographic imaging for estimating the location of the distal hole. Image intensifier or X-rays are very seldom used intra operatively in our technique. While their technique`s success depend on on interpretation of X-rays, our technique relies on correct alignment of the outer nail and sufficient widening of the near cortex to enable the visibility of distal holes.However there are few likely downsides of this technique. One is that the length of incision for interlocking distal screws is much larger than that which is given during the free hand technique (about 5–6 cm compared to 1–2 cm). For the evaluation of the effect of widening of the near cortex on fracture healing, further studies are needed. So far, we have not come across any fracture through distal screws with this technique. Other studies have also not reported such complication. A big hole around distal screw may act as stress riser. The probable complications of iatrogenic fracture, delayed union or nonunion cannot be avoided with this technique. Further this technique certainly cannot be used in cases where bone quality is poor or in osteoporotic individuals. A securely fit screw offers better biomechanical strength. Use of washer underneath the screw head in larger hole may increase the strength. In the present series, five cases had nonunion. All these patients with nonunion had open fracture which is a significant cause for nonunion. Whether the nonunion is because of open nature of injury or it is because of biomechanical disadvantage of distal screw interlocking in a wide hole, is difficult to explain.Distal screw insertion by standard freehand technique is definitely ideal, though there is risk of radiation exposure, but it should be done where the facility is available. This technique is especially useful in conditions where image intensifier or trained radiographers are not available. Hence it is more suitable for rural hospitals and third world countries or in situations where image intensifier have stopped functioning technically. Further there is no need of any special equipment or any particular learning. This technique uses freely available instruments and is not technically difficult. The second nail can be reused after autoclaving.To avoid nail deformation, no forcible insertion or hammering is done. To prevent deformation of the nail, the canal has to be reamed 1.5 mm more than the diameter of the nail. Thus the key to success of this technique lies in over-reaming. Endosteal and cortical blood flow though can have an early damaging effect because of reaming, but in the end canal reaming seems to have several encouraging effects on the fracture site, such as increasing extra osseous circulation, which helps in fracture healing [26]. Union of the fracture was not affected in the present series, as also noted in another series of closed antegrade interlocked nailing of femoral shaft fractures in 200 patients where the canal was reamed 2 mm more than the diameter of the nail to prevent deformation of the nail [27]. Over-reaming helps in the insertion of a smaller diameter nail, which has been implicated as a biomechanical cause of nail failure [28]. As compared with the percutaneous method of screw insertion in the free hand technique, a larger distal skin incision is made with this technique. Another disadvantage of this method is multiple cortical holes which are sometimes made in case of accuracy failure. The placement of two holes in close proximity produces an area of stress concentration and the repeated drilling may lead to screw loosening [9]. The presence of multiple cortical holes is another known complication of the free hand technique [9]. Kanellopoulos et al. reported a technique of distal locking under direct vision through a small window in the anterior femoral cortex [29]. No postoperative fractures occurred through the cortical defect [29]. In our study also we did not detected any fracture at the screw sites. Hajek et al. stated that only one distal screw could provide adequate distal fixation [30]. Similar to the nail over nail procedure of distal locking, various procedures are described in literature. Rao et al. used the nail as a guide for locking more proximal of the distal holes [2]. Following the placement of a Kirschner wire into the distal hole, a second nail is positioned external to the limb with the wire passing through the corresponding hole. Using the nail as a guide, a wire is passed through the more proximal of the distal holes [2]. Tanna described an image intensifier independent technique of distal locking for tibial nailing [25]. A Kirschner wire is drilled through the hole in the distal jig, which corresponds to the site of the distal locking holes in the interlocking nail. Plain radiographs are taken to confirm that the location of the wire is at the level of the interlocking hole. A 4.5-mm drill hole is made at the judged entry site after wire removal. A fine suction tip and good light allow the nail and locking hole to be seen through the drill hole. The far cortex can now be drilled and the screw inserted [25]. Steriopoulos et al. described an H-shaped device, which aided distal locking in femoral nailing by holding two similar intramedullary nails parallel to one another [6]. All these techniques [2, 6, 25] still need radiographic images for distal locking whereas the nail over nail technique of distal locking is almost radiation independent as radiographic images were taken only to confirm screw placement or when some intra-operative difficulty occurred.

CONCLUSION

This prospective study on distal locking of femoral intramedullary nails shows that radiation exposures to achieve equivalent precision are reduced with the nail over nail technique compared with the free hand technique. The nail over nail technique can also be used when an image intensifier is unavailable or goes out of order per operatively. Success of the nail over nail technique lies in prevention of nail deformation during insertion. Over-reaming of the medullary canal by 1.5 mm serves this purpose.

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