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ORIGINAL STUDY

Blade expandable intramedullary nails for fixation of tibial shaft fractures

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This study is aimed to compare the clinical and radiological differences between classic locked intramedullary nailing (LIN) and blade expandable intramedullary nailing (BEIN) at tibia shaft fractures. Operation time, exposing of radiation time and fracture healing times were recorded. Pain visual anolog scale (VAS), shortening of tibia and angulation of fracture line were compared. All patients healed. In LIN group operation time, exposing of radiation time was longer (statistically significant). Because of shorter operation time and lower radiation exposure we recommend the BEIN technique as a preferable technique in tibia intramedullary nailing.

Keywords : Tibial fractures ; intramedullary nail ; blade expandable nail.

INTRODUCTION

Locked intramedullary nailing is a standard treat-ment procedure for tibial shaft fractures. Proximal and distal interlocking screws 1) improve rotational stability 2) allow the treatment of poly-fragmental fractures 3) protects the bone length. Disadvantages of interlocking screws are 1) risk of neurovascular injuries *(11) 2)* soft tissue damage-irritations 3) difficulties in insertion of distal inter-locking screws that increase radiation exposure. In blade expandable nail (Tianjin Walkman-China) that does not have screws. This nail and its blade will fit the isthmus of the bone and establish a direct contact with the endosteum which allows stability of the fracture. Interlocking is not necessary with this system. This study is aimed to compare the clinical and radiological differences between classic locked intramedullary nailing (LIN) and blade expandable intramedullary nailing (BEIN) at tibial shaft fractures .

MATERIAL AND METHODS

From May 2013 to May 2015 a total of 36 participants were included in our study. Tibial shaft fractures were identified as AO classification type A-B1-B2 and divided group 1 (LİN group, n :18) and group 2 (BEİN group, n :18) randomly. There were 17 women and 19 men participants who has been followed up for 2 year. The mean age was 44±15 (20-75) for group 1 and 42±20 (18-78) for group 2. AO C-type fractures were excluded from the study. There were 7 A1 (simple spiral), 13 A2 (simple oblique), 6 A3 (simple transverse), 3 B1 (spiral wedge), 2 B2 (bending wedge) and 5 B3 fractures (fragmented wedge). Thirty-six fractures were in the middle third (zone 2) of the

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Figure 1. — a and b tibia shaft fracture ; c and d early post-operative radiograms ; e and f post-operative first year radiograms ; g and h after nail removed radiograms.

tibial diaphysis. Operation time, radiation time and fracture healing times were recorded. After one year visual anolog scale (VAS) , shortening of tibia , angulation of fracture line was compared.

Surgical Techniques

The current most popular form of surgical treatment for tibial shaft fractures is intramedullary nailing. During this procedure especialy designed metal rod is inserted from the anterior of the knee down into the marrow canal of tibia. The rod passes across the fracture to keep it in position . The intramedullary nail is screwed to the bone at both ends . the screw passes through the rod. This keeps the nail and the bone in proper position while healing.

In all patients nailing was carried out with the patient lying supine with the knee on the affected side hanging at 90° flexion. No traction was used. We use medial approach of proximal tibia. A guide wire was passed across the fracture site and reaming was carried out in all cases. The canal was overreamed to one and a half millimetre more than the diameter of the nail to ensure smooth nail insertion.

In BEIN group we use screwless blade expandable nails ; after reaming, the guide wire was removed and the nail was inserted as it is not

Figure 2. — Screwless blade expandanble nail.

canulated. The blade expandable nail diameter was chosen 1-2 millimetres smaller than the diameter of the last reamer. The initial tibial nail diameter was 9 millimetres in 8 cases, 10 millimetres in 10 cases . Distal positioning of the nail is similar to the classic interlocking nails. After nail insertion, the nail slot turned to anteromedial of the tibia and nail blade put in nail slot under fluoroscopy guidance.

In LIN group surgical techniques has similar techniques as blade expandable nail. After reaming the guide wire doesn't removed and the nail was inserted over the guide wire as it is canulated . Distal locking was performed by using free hand technique and it is done before proximal locking by proximal locking guide.

Table 1. — Difference between BEIN and LIN at tibial shaft fractures

	BEIN Group	LIN Group	p value
Operation Time	23±48 min	62±9,5 min	**<0,01**
Exposing Radiation Time	21±3,4 sec	67±6,1 sec	**<0,0002**
Fracture Healing Time	16,2±2,4 weeks	19,4±6,5	>0,05
Shortening of tibia	0,22±0,1cm	0,24±0,14 cm	<0,75
Pain –VAS (one year)	2±0,7	1,7±0,8	>0,05

Postoperative care and follow-up : Knee and ankle motion was started in day one post-operatively when feasible. Weight bearing was allowed as tolerated in A2 and A3 fractures (fractures with no risk of shortening. Clinical records and radiographs were reviewed retrospectively by a orthopaedic surgeon. Postoperative informations, based on the medical records, were collected retrospectively. Complications and healing time were recorded.

Radiographs in AP and lateral view of the tibia were performed the day after surgery and during follow-up at 6 to 8 weeks intervals thereafter until clinical and radiological union of the fracture had occurred. Evaluation : Union was defined as complete bridging of at least 3 cortices in AP and lateral views. Based on the anaesthetic charts the time of incision and closure were used to calculate the duration of surgery. The use of fluoroscopy was calculated. Duration of hospital stay and complications were recorded. Postoperative shortening was evaluated on digital radiographs by measuring the outcome over time of the gap or the overlapping between the proximal and distal fragments. The measures were performed based on first postoperative radio graphs and after weight bearing. Non-union was defined as absence of consolidationat 9 months *(8)*. Malunion defined as an angular deformity > 5° was evaluated in both sagittal and frontal planes. Influence of fracture characteristics on union and operation time and fluoroscopy time were tested by the log rank test in Kaplan-Meier analysis for the time to union. Values for $p < 0.05$ were regarded as significant.

RESULTS

Fracture union occured all of the patients without additional surgery. Average follow up time was 30 months (24-48m). LIN and BEIN groups respectively average operative time 62±9,5 and 23±4,8 minute p<0,01 ; exposing of radiation time 67±6,1 and 21±3,4 seconds p<0,0002 ; average fracture healing time 19,4±6,5 and 16,2±2,4 weeks. After one year no statistically significant difference was found in pain VAS respectively 1,7±0,8 and 2±0,7 p>0,05. After one year shortening of tibia was respectively 0,24±0,14 cm and 0,22±0,1cm p<0,75. In LIN group skin sensivity was detected at 6 patients because of nail head irritation and nails were removed at 4 patients after fracture healing. In LIN group at 2 patients delay of fracture healing was detected and dynamization done to them. Deep vein thrombosis and nonunion was not detected in both groups. In cases the nail was removed after fracture healing, upon patient's request, without any difficulties.

DISCUSSION

We found that the BEIN group mean time to union was shoter than LIN group. Our results show that the implant can be used efficiently in various indications. Our results have shown full union which is comparable expandable nail and classic interlocking nails *(6)*. The mean time to healing was shorter than the classic interlocking nails *(2)*. Early dynamisation of the fracture site, as the expandable nail avoids the need for interlocking screw insertion cloud encourge early bone union.

In our studies the average surgical time was in LIN group 62 minutes and in BEIN group 23 minutes. Ghafil et al determined that average surgical time was 60 minutes with expandable nail *(5)*. Ben-Galim et al compared in a prospective, randomized clinical trial the expandable nail with an interlocking nail in tibial shaft fractures. The operation time was

significantly shorter in expandable group (52,9 minutes) compared with the interlocking group (104 minutes) *(1)*.

Several minutes of fluoroscopy are required during stabilisation of long bone fractures with interlocking intramedullary nailing in order to determine the appropriate location of the starting hole and alignment for the distal locking screws *(7)*. There is no need for interlocking screws with the blade expandable nail, which reduces radiation exposure. Another disadvantage of interlocking screw insertion is the associated risk of neuro-vascular injuries *(4)*. Such complications are avoided with the blade expandable nail. Onur Hapa et al study reported for non-complex, closed or grade 1 open tibial shaft fractures, locking of an intramedullary nail with a single distal screw is safe, and may help to decrease operation time and radiation exposure *(9)*.

Digital radiographic measurement demonstrated no secondary impaction of the fracture site. The amount of shortening, in LIN group 2,4mm and in BEIN group 2,2 mm, was not significant and without clinical consequences. Shortening during the healing process is a potential complication with the blade expandable nail. Smith et al *(10)* reported in a prospective study of 49 long bone fractures treated by expandable nailing a rate of 14.3% of post-operative shortening and mentioned that a potential cause for this complication could be an occult crack during nail expansion. Ghafil et al *(5)* did not demonstrate any fracture progression during inflating, and secondary shortening was not significant. They think that the choice of the correct diameter of nail, which was selected on the basis of the diameter of the last reamer used, is an important factor to have a good fit within the intramedullary canal.

The overall rate of union 100% in BEIN group and 2 patients need dynamisation in LIN group (11,1%). A review of the literature demonstrates rates of re-operation required to achieve union ranging from 14 to 57% for tibial shaft fractures. The most commonly performed procedures were dynamisation of a statically locked nail and removal of broken locking screws, procedures not required with the blade expandable nail *(2,3,4,6)*.

Another potential complication is unacceptable malrotation after nail expansion, in which case the nail should be removed. Proper examination of the intact contralateral leg is mandatory preoperatively in order to evaluate rotation. For tibial fractures, we check the position of the foot with respect to the patella on the intact side and we replicate the same position on the fractured side after nail insertionand before blade nailing. This simple check can avoid significant malrotation exceeding 10 degrees *(5)*. In our study both group malrotation less than 5 degrees.

CONCLUSION

As a results all the patients healed successfully. In LIN group operation time, exposing of radiation time was longer (statistically significant). In LIN group delay of fracture healing, irritation of skin and anterior knee pain was detected. In BEIN group partial loading allow the dynamization and early healing of the fracture. In BEIN group intramedullary canal squeeze was occured with nail blade . Because of shorter operation time and lower radiation exposure we recommend the BEIN technique as a preferable technique in tibia intramedullary nailing. The surgical technique is easy and reproducible as several surgeon with different levels of experience . AO A and B type fractures are in our study good indications for the expandable nail. But further investigation in a large number of patients for long term follow up was needed.

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