Intramedullary Nailing with Blocking Screws in the Treatment of Fractures of Proximal and Distal Ends of Tibia - A Prospective Observational Study in a Tertiary Care Hospital of Kannur, Kerala

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ABSTRACT

BACKGROUND
Fractures of both proximal and distal metaphyses with small distal fragment of tibia are not uncommon. Internal fixation using intramedullary nails alone could lead to misalignment. Using blocking screws (Poller screws) in addition to intramedullary nails would help in narrowing the medullary cavity and decreases the degree of misalignment and chances of displacement. The present study was conducted to evaluate functional and radiological outcome of blocking screws with intramedullary nail in the treatment of proximal and distal metaphyses fractures of tibia with short distal fragment.

METHODS
A prospective observational study of 34 patients with proximal and distal tibial metaphyses fractures was treated with statically locked intramedullary nailing with supplementary blocking screws. The study was conducted from January 2018 to December 2020 with a maximum follow up of 18 months. Medullary canal diameter was measured at the levels of fracture and isthmus.

RESULTS
Among the 34 patients, 29 (85.29 %) were males and 05 (14.70 %) were females with a male to female ratio of 5.8 : 1. The mean age was 34.97 ± 3.10 years. The mean healing period was 20 ± 1.45 weeks. 25/34 (73.52 %) of the patients showed Karlstrom and Olerud functional grading score of excellent. The fracture varus/valgus alignment was 1.9 ± 0.3 degrees. The mean antecurvatum/recurvatum alignment was 0.3 degrees.

CONCLUSIONS
Blocking screws act as reduction tools, help in reducing the medullary lumen of distal metaphyses and prevent failures in initial reduction. They extend the indication of intramedullary nailing to the distal segment of tibia and minimize the misalignment in terms of varus /valgus and/or antecurvatum/recurvatum.

KEYWORDS
Tibia, Intramedullary, Blocking Screws, Internal Fixation and Misalignment

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BACKGROUND

Conventional treatment with intramedullary nail alone in the management of distal and proximal metaphyses fractures of tibia is a challenge.[1] The goal of the surgeon is not only reduction of fracture but also maintenance of both sagittal and coronal alignment; maintenance of length and rotation with early restoration of normal movements of knee and ankle.[2] Regular usage of interlocking medullary nailing is familiar to most surgeons which also allows load sharing, protects extra osseous blood supply, avoids extensive soft tissue dissection.[3] But intramedullary nailing in tibial fractures with short proximal and distal fragments in the metaphyses is associated with misalignment especially in coronal plane, non-union, requiring secondary procedures to achieve better union. The cause for misalignment is attributed both to displacing muscular forces and residual instability.[4] Misalignment is also explained as a result of mismatch between the medullary canal and the diameter of the nail used, resulting in lack of contact between the nail and cortex of the tibia. It caused lateral translation along the locking screws fixed in coronal plane. It could be due to increased stress placed on the locking holes to maintain fracture alignment after surgery.[4] The other methods used in preventing misalignment were temporary uni-cortical plating, percutaneous reduction clamps, and fibular plating.

Blocking Screws

Blocking screws (Poller screws) were placed adjacent to the nail and perpendicular to the screw holes usually in an anteroposterior direction. These screws were thought to improve the stability of short distal and proximal metaphyses fracture fragments acting as reduction tools to overcome the displacing forces at the time of introduction of intramedullary nail. The screws basically reduce the width of the metaphyses medulla and are particularly useful with nails of smaller diameter.[4] In 1994 Krettek et al. first used blocking screws (Poller screws) as a tool to avoid axial deformities of proximal and distal third fractures of tibia during intramedullary nailing.[5,6]

Objectives

- To evaluate functional and radiological outcome of blocking screws with intramedullary nail in the treatment of proximal and distal metaphyses fractures of Tibia with short distal fragment.
- To observe the degree of misalignment, time taken to achieve radiological healing and final joint mobility.

METHODS

A prospective observational study was conducted at the Department of Orthopaedics, Kannur Medical College, Anjarakandy, Kannur, Kerala, India and Department of orthopaedic, Rajiv Gandhi Medical College, Thane, Mumbai, Maharashtra, India from February 2018 to January 2020 with a maximum follow up of 18 months. Patients consulted in department of orthopaedics with features of upper end or lower end or both-metaphyseal fractures of the tibia were included.

Sample Size

Based on the previous studies[7] and low incidence of the metaphyses fractures of upper and lower ends of tibia the sample size was taken as 34 subjects.

$$n = \frac{\mathrm{Z^2pq}}{e^2}$$

Where - margin of error- (16.81 %) = 0.1681
P - Is the estimated proportion population which has the attribute in question- (50 %)
Q - Is 1-p
Z - Calculated from Z table
Confidence interval- 95 %

$$n = \frac{1.96 \text{ x } 1.96 \text{ x } 0.25}{0.168 \text{ x } 0.1681}$$

N= 34
The calculated sample size was 34.

Inclusion Criteria

Patients aged above 18 years were included. Patients presenting with clinical and radiological features of fractures of upper or lower or both ends of tibia were included. Patients with acute fractures were included. Patients with delayed union were included. Patients with both open and closed fractures were included.

Exclusion Criteria

Patients with diaphyseal fractures of tibia were excluded. Patients undergoing intramedullary nailing with additional procedures like fibular grafts or fibular plating were excluded.

Among the 51 tibial fracture patients admitted in the hospital during the study period, 34 patients were found to have met the inclusion and exclusion criteria. Mechanism of injury was recorded and analysed. The following variables were noted in all the patients: The gender incidence of the subjects was noted. The age incidence of metaphyses fractures of tibia was noted. All the patients were clinically examined and the X-ray of lower limbs - both antero-posterior and lateral views were taken. The nature of fractures whether open or closed were observed and recorded. Open fractures were grouped as described by Gustilo Anderson:[7] Type I, II and III. Metaphyses fractures of tibia were classified according to Association of Orthopaedics guideline[8] into their categories: 41 A2- 1, 41 A2- 2, 41A2- 3, 43 A1- 1, 43 A2- 2 and 43 A3- 3. The distance between the fracture line and the articular surface were measured on X-rays. The time lapse between the injury and surgery was noted in all the patients. The indications for insertion of blocking screws were noted (Based on the degree of fracture correction needed; the screws used for blocking were 4 mm to 4.5 mm locking screws). The time required for completion of the surgery was noted. The mean diameter of the medullary canal was measured during the surgery. The number of patients showing bone healing on X-rays at the end of the follow up was noted. The alignment and functional aspects in the final outcomes were quantified using Karlstorm- Olerud score.[8]

Operative Procedure Adopted

Under spinal anaesthesia without tourniquet through a mid-line trans-patellar tendon approach, a guide wire was passed under C arm in all patients. Metaphyses fractures were stabilized with intramedullary nails with manual traction. Except in open comminuted fractures, delayed healing fractures and fractures with overriding fragments, all fractures were managed under closed reduction. Intramedullary nails of 8- or 9-mm diameter were used which were unreamed cannulated, with two proximal and three distal locking options. If the blocking screw is one, it was always used on the concave side of the deformity close to the fracture line between the cortex and the nail. If the blocking screws were 2, then the second screw was used on the convex side of deformity near the end of the nail in the short fragment. In patients with gross misalignment with unstable fracture, the screw holes were drilled with the nail in place while applying manual over correction. To avoid damage to the medullary nail, a 2.5 mm or 3 mm K wire was used to drill the pilot hole for blocking screws. In patients with stable fractures with gross misalignment, the nail was temporarily removed to place the blocking screws and the intramedullary nail was reinserted.

Post-Operative Follow Up

No weight bearing was allowed up to 2 weeks. Partial weight bearing was allowed and continued from 4 to 8 weeks depending on the radiological evidence of union.

Follow Up

All the patients were followed up to 18 months at an interval of 3 months. Check X-rays were taken to analyse bony healing, correction, maintenance of nail position, shortening and rotational misalignment. The alignment and functional aspects in the final outcomes were quantified using Karlstrom- Olerud score.[8]

Complete Heal

It was required of the patient to have no pain on full weight bearing on the injured limb and without support; also X-ray showing callus formation at least in three cortices.

Statistical Analysis

Repeated tests analysis of variance (ANOVA) were used to analyse the test results. Karl storm- Olerud[7] score was used to assess the functional outcome of the treatment protocol used.

Criterion	Excellent	Good	Acceptable	Poor
Symptoms from thigh or leg	None	Intermittent Slight symptoms	More severe symptoms	Considerable impaired function and pain at rest
Symptoms from knee and ankle joint	None	Same as above	Same as above	Same as above
Walking ability	Unimpaired	Same as above	Walking distance restricted	Uses cane, crutches or other support
Work and sports	Same as before	Given up sport; work same as before	Change to less strenuous work	Permanent disability
Angulation or rotational or both deformities	0	< 10 degrees	10 to 20	➢ 20 degrees
Shortening	0	< 1 centimetre	1 to 3	➢ 3 centi meters
Restricted joint mobility	0	< 10 degrees at ankle, < 20 degrees at hip, knee or both	10 to 20 degree at ankle, 20 to 40 degree at hip, knee or both	➢ 20 degrees at ankle, more than 40 degrees at hip, ankle or both

Table 1. Karlstrom Criteria for Functional Assessment after Management of Floating Knee Injuries

RESULTS

Out of 51 patients attending the Department of Orthopaedics, Kannur Medical College, Anjarakandy from February 2018 to January 2020, 34 patients meeting the inclusion criteria were included in this study for analysis. There were 29 (85.29 %) male patients and 05 (14.70 %) were female.

Variable	Number	Percentage
Male	29	85.29
Female	05	14.71
Age		
19 to 28 years	02	05.88
29 to 38 years	11	32.35
39 to 48 years	09	26.47
49 to 58 years	04	11.76
59 to 68 years	03	08.82
Nature of accident		
Road traffic accident	27	79.41
Fall from height	07	20.58

Table 2. Demographic Data in the Study (n - 34)

Among the 34 patients, 27 (79.41 %) patients had new fractures (attending the hospital within 10 hours to 24 hours) and 06 (17.64 %) patients were attending the orthopaedics outpatient department (OPD) for delayed union of their old fractures (Table 3). 21/34 (61.76 %) of the patients had open fractures and among them, 09 (26.47 %) were type I, 07 (20.58 %) were type II and 05 (14.70 %) were type III. According to metaphyses fracture classification by Association of Orthopaedics classification, there were 05 (14.70 %) 41A2-1, 10/34 (29.41 %) 41 A2-2 type, 07/34 (%) 41 A2-3 type, 06/34 (%) 43 A1-1 type, 04 /34 (11.76 %) 43 A2-2 type and 02/34 43 A3-3 type of fractures noted (Table 3). The distance between the articular surface and fracture line was measured in all patients and noted that in 05 (14.70 %) it was ranging from 2.5 centimetres to 3.5 centimetres. In 09 (26.47 %) patients, it was 3.5 to 4.5 cms, in 11 (32.35 %) patients, it was 4.5 to 5.5 cms and in 09 (26.47 %) patients, it was more than 5.5 cms (Table 3). The mean diameter of medullary canal was

10.78 mm at the isthmus, 20.15 mm at the fracture site and 48.25 mm at the distal metaphyses (Table 4).

Variable	Number	Percentage
Fractures		
New	27	79.41
Old	07	20.58
Open Fracture (Gustilo Anderson[8] types)		
Type 1	09	26.47
Type 2	07	20.58
Type 3	05	14.70
Closed	06	17.64
Tibial fracture AO Types		
41 A2 1	05	14.70
41 A2 2	10	29.41
41A2 3	07	20.58
43 A1 1	06	17.64
43 A2 2	04	11.76
43 A3 3	02	05.88
Distance between Fracture Line and Joint Line		
2.5 cms to 3.5 cms	05	14.70
3.5 cms to 4.5	09	26.47
4.5 to 5.5	11	32.35
>5.5 cms	09	26.47
Mean Diameter of Medullary Canal in mm		**Range**
At isthmus	10.78	09.35 to 12.50
At fracture site	20.15	17.85 to 23.25
Distal metaphyses	48.25	45.20 to 55.65

Table 3. Analysis of the Nature of Fractures and Their Parameters (n - 34)

Among the new fractures, the mean delay in surgery was noted to be ranging from 1.65 weeks to 7.40 weeks with a mean delay of 4.35 ± 0.55 weeks. Among the 07 delayed old fractures, the mean delay was 17.65 ± 2.80 weeks with a range of 16.30 to 20.25 weeks (Table 4). The mean time taken for surgery was 98.50 minutes (range from 86.45 ± 4.10 to 167.30 ± 21.10 minutes). The indications for using blocking screws differed in the fractures treated in the study; in 11 (32.45 %) patients, it was used to correct alignment after insertion of nail, in 15 (%) patients it was used to maintain alignment or to improve the stability of bone implant complex and in 08 (23.52 %) patients it was used to control the nail during insertion.

Variable	Time period	Range
Mean delay in surgery in weeks	4.35 ± 0.55	1.65 to 7.40
Mean time taken for surgery in minutes	98.50 ± 8.70	86.45 ± 4.10 to 167.30 ± 21.10
Indications for Blocking Screws	**Number**	**Percentage**
To correct alignment after insertion of nail.	11	32.45
To maintain alignment or to improve the stability of bone implant complex.	15	44.11
To control the nail during insertion.	08	23.52

Table 4. Data Related to the Surgery of Using Blocking Screws (n - 34)

The mean time taken for all the fractures to heal based on the X-ray findings was 13.20 ± 1.45 weeks (range 10.65 ± 1.10 to 16.25 ± 1.50). Karlstrom and Olerud functional grading score was excellent in 25/34 (73.52 %) of the patients, good in 06 (17.64 %) patients and poor in 03 (08.82 %). Repeated measure ANOVA test gave the f-ratio value were 354.45147. The P value was 0.00001. The result was significant (P significant at < 0.05). Similarly, the mean post-operative varus/valgus alignment was 1.9 ± 0.3 degrees (range was 0.75 to 2.90 degrees) were compared with its pre-operative values which being 10.75 ± 1.10 degrees (range 08.65 ± 1, 50 to 13.10 ± 1.25 degrees). Repeated measure ANOVA test gave the test value of f-ratio value was 368.975. The P value was < 0.00001, (Table 5). The mean post-operative antecurvatum/recurvatum alignment was degrees 0.3 degrees (range - 0.2 degrees to 0.6 degrees), which was compared to the pre-operative antecurvatum/recurvatum alignment 09.10 degrees (range 05.25 degrees to 12.15 degrees). Repeated measure ANOVA test gave the test value of f-ratio value was 61.798. The P value was < 0.00025, (Table 5).

Variable	Values	Range
Mean time taken for bony healing on X-ray	13.20 ± 1.45 weeks	10.65 ± 1.10 to 16.25 ± 1.50
Karlstrom and Olerud Functional Grading Score		
Excellent	25	73.52
Good/Fair	06	17.64
Poor	03	08.82
Mean post-operative varus/valgus alignment	1.9 ± 0.3 degrees	0.75 to 2.95 degrees
Mean pre-operative varus/valgus alignment	10.75 ± 1.10 degrees	08.65 ± 1,50 to 13.10 ± 1.25 degrees
Mean post-operative antecurvatum/recurvatum alignment	0.3 degrees	-0.2 to 0.6 degrees
Mean post-operative antecurvatum/recurvatum alignment	09.10 degrees	-05.25 degrees to 12.15 degrees

Table 5. Post-Operative Results in the Study (n - 34)

DISCUSSION

To improve the alignment and provide stability to the fractured bone and surrounding soft tissue, surgery remains the choice especially for the fractures of tibia. Surgery also restores maximum function to the knee and ankle joints.[8,9] Intramedullary nailing to stabilize the diaphyseal fractures of tibia is an universally accepted surgical method,[10] but its role in the proximal or distal metaphyseal fractures is known to produce higher rate of complications including misalignment and failure in reduction.[11] Among the most common deformities with intramedullary nailing for tibial fractures were valgus misalignment, apical anterior angulation and anterior displacement of the proximal fragment.[12] The former is due to the attachment of the pes-anserinus on the fracture fragment and the latter is due to the patellar tendon dynamic forces pulling the proximal fragment into an apex anterior angulation.[13] Valgus misalignment may also be caused due to a medial nail entry point and a laterally directed nail insertion angle in the proximal fragment. Few of a posterior cortex, the 'wedge effect' of the 'Herzog' bent of the nail and a distal starting point for nail insertion.[14] The incidence of misalignment was observed in 58 % of fractures of the proximal third when compared to 7 % of fractures of the middle and 8 % of fractures of the distal segments of tibia.[15] Hence, blocking screws (Poller screws) were introduced which were placed perpendicular and adjacent to the intramedullary usually in an anteroposterior direction. They were found to have improved the stability of metaphyses fractures and also help as a tool to reduce the chances of misalignment by overcoming the displacing forces.[16] Blocking screws not only narrow the medullary canal but also correct the out of balance soft tissues that cause axial displacement by neutralizing its tension by means of a three-point arrangement similar to a tension-band construct. Two screws can be used if there was biplanar displacement, one in each plane. The blocking screws around the nail help in relieving the axial strain in the fixation construct, whereas the interlocking screws through the nail help in controlling the length and rotation of the fracture site. In fractures of distal metaphyses of tibia, though the intramedullary nailing was found crucial, the distinctive anatomical features like medullary canal which is hourglass in shape does not allow the intramedullary nail to fit in tightly.[17] To overcome this difficulty, many modifications were made in the design of the nail such as shortened standard tibial nail to diminish the distance between the most distal interlocking hole and the nail tip.[18,19] Tarr et al. and Puno et al. from their study have observed that misalignment following distal metaphyseal tibial fractures are poorly tolerated than proximal misalignment.[20] The acceptable misalignment as per Trafton's recommendations are less than 5 degrees of varus-valgus angulation, 10 degrees of anteroposterior angulation, 10 degrees of rotation, and 15 mm of shortening.[21] Distal tibial fractures with deformity of more than 5° were demonstrable on X-rays of the ankle.[22,23] In another study, after 15 years follow up of 88 patients with lower tibial fractures by Van der Schoot reported: misalignment in 49 % with at least 5 degrees, arthritis in the knee and ankle adjacent to fracture than in comparable joints of the uninjured leg. In the present study, all the fractures healed at a mean time of 20 ± 1.45 weeks (range 10.65 ± 1.10 to 16.25 ± 1.50). 25/34 (73.52 %) of the patients showed Karlstrom and Olerud functional grading score of excellent, good in 06 (17.64 %) patients and poor in 03 (08.82 %). Applying repeated measures ANOVA test to the values gave the f-ratio value was 354.45147. The P value was 0.00001. The result was significant (P significant at < 0.05). Similarly, the fracture alignment measured during the post-operative follow up in terms of varus/valgus was 1.9 ± 0.3 degrees with a range of 0.75 to 2.90 degrees. This was compared with preoperative readings being 10.75 ± 1.10 degrees with a range of 08.65 ± 1.50 to 13.10 ± 1.25 degrees. Applying repeated measures ANOVA test to the values gave the value of f-ratio value was 368.975. The P value was < 0.00001. (P value significant at < 0.05), (Table 5). Similarly, the mean post-operative antecurvatum/recurvatum alignment was degrees 0.3 degrees with a range of -0.2 degrees to 0.6 degrees. The pre-operative values were 09.10 degrees with a range of 05.25 degrees to 12.15 degrees. Applying repeated measures ANOVA test to the values gave the test value of f-ratio value was 61.798. The P value was < 0.00025. (P value significant at < 0.05), (Table 5). Studying the possibility of breakage of intramedullary nails by blocking screws, it was reported by Ai et al. that blocking screws improved the stability of fracture area distinctively and prevents the breakage.[24] Hence, the role of blocking screw as reduction tool was proved in this study. The results were comparable to the study by Krettek et al.[5] Use of blocking screws not only helped in improving the stability of fractures but also promoted early union. Second time surgery was necessary in only one patient (02.94 %). None of the patients required bone grafting, bone marrow injection, or exchange of nailing. Functionally, reduction of width of metaphyses medulla by the blocking screws as these are applied in an anteroposterior direction as the coronal plane misalignment is more prone to occur than the sagittal plane. In metaphyses fractures of tibia, the deformities in the sagittal plane are better tolerated and are less common if the fracture is reduced at the time of initial locking. In case the fracture analysis suggests the possibility in sagittal plane, the blocking screws are to be used in the mediolateral direction.

CONCLUSIONS

Blocking screws act as reduction tools. It helps in reducing the medullary lumen of distal metaphyses, prevents failures in initial reduction. They extend the indication of intramedullary nailing to the distal segment of tibia and minimize the misalignment in terms of varus/valgum and/or ante-curvatum/recurvatum.

Limitations of the Study

Limitations in this study includes that it was a study with small number of subjects and no control group was used.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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