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Study of Difficulties Encountered in the Closed Intramedullary Interlocking Nail Operation Along With its Complications Among Patients With Diaphyseal Fractures of Tibia

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ABSTRACT
The tibia, being a frequently fractured long bone, is particularly susceptible to direct blows and high-energy trauma due to its exposed anatomical location. Closed nailing without reaming, followed by early walking and weight-bearing, has proven to be one of the most effective treatment options. This approach demonstrates significantly lower complication rates and comparable outcomes when compared to other existing methods. This study's goal was to examine the difficulties and complications related to the closed intramedullary interlocking nail treatment among patients with tibia diaphyseal fractures in a tertiary hospital. The current investigation was a single-center, prospective, observational study involving patients aged above 18 years, of any gender, who had a closed fracture of the tibia's diaphysis and were scheduled for dynamic interlocking nailing. One hundred and twenty patients with leg bone fractures were examined in the current study, 88 of whom were men. Seventy percent of the cases (patients) were under the age of 45. When compared to other modes, road traffic accidents accounted for 73% of the cases and were the main cause of these injuries. Regarding the kind of fractures, the majority of them (51%) were either non-comminuted or had minor comminutions (31%). Most of the fractures that needed to be fixed were in the middle (52 percent) or distal third of the shaft (34%). Nail-setting was done within 1-7 days of the injury in 83% of the patients. The study also found delayed problems, such as delayed union (8 patients), discomfort (8 patients), reduced range of motion in the ankles (5 patients), malunion (2 patients), non-union (2 patients) and limb shortening of more than 1 cm (2 patients). Patients can begin to bear weight earlier thanks to the use of interlocked intramedullary nailing, which promotes quicker fracture healing with fewer problems. We think that closed interlocking nailing is the best course of action for treating tibial diaphyseal fractures because of how well it works at encouraging union and how little chance of infection there is.

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Key Words
Intramedullary, interlocking nail, diaphyseal fractures of tibia, union rate

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INTRODUCTION

Due to its exposed anatomical placement, which makes it vulnerable to direct strikes and high-energy trauma, the tibia is the long bone that fractures most commonly. Tibial diaphyseal fractures can now be treated using a variety of procedures, and the choice of approach may depend on the type of fracture, its location, its degree of comminution, the patient's age, and their social and economic circumstances[1,2].

The traditional method for treating patients with displaced tibial diaphyseal fractures requires closed reduction of the fractures, which is followed by the placement of a groin-to-toe cast for the course of clinical and radiological recovery. The disadvantage of this approach is that patients must spend several months bedridden and unable to lift anything heavy. Joint stiffness, muscle atrophy, osteoporosis, prolonged immobility, and potential side effects like Cast syndrome are just a few of the issues that might result from this[3,4].

In comparison to other procedures, the closed nailing approach without reaming, early ambulation, and weight-bearing offer definite advantages. It produces results that are equivalent but has a far lower rate of complications. It has the extra benefit of not requiring specialist equipment, which makes it more suitable for addressing high-energy fractures than the A.O. approach[5-7]. Examining the difficulties encountered during the closed intramedullary interlocking nail treatment and the related consequences in patients with tibia diaphyseal fractures at a tertiary hospital was the main goal of the current study.

MATERIAL AND METHODS

The current study was an observational, prospective inquiry carried out at the Orthopaedics Department of Rajarshi Chhatrapati Shahu Maharaj Government Medical College in Kolhapur, India. The study was approved by the institutional ethical committee and lasted for two years, from October 2014 to October 2016.

Inclusion criteria: The study included individuals aged above 18 years, of any gender, with closed fractures in the diaphysis of the tibia, who were scheduled for dynamic interlocking nailing. The patients selected were deemed suitable for general anesthesia, meaning they did not have any major head, chest, or abdomen injuries. The study focused on tibial fractures and the use of closed intramedullary interlocking nailing.

Exclusion criteria: Patients with compound tibial shaft fractures who underwent conservative treatment for their tibial shaft fractures.

Patients who were unwilling or unable to provide consent for participation in the study.

Patients who accepted to participate in the trial received written consent after the study procedure was given to them in their native tongue. A groin-to-toes slab was applied to properly align the bone after the emergency room's first care and resuscitation procedures. The extent and kind of tissue trauma, as well as the nature and severity of the injury, were all documented during the thorough history that was collected upon admission to the ward. The injured extremity was also thoroughly examined. In order to categorise and ascertain the level of the fracture, X-rays were carefully examined. Within seven days of the injury, surgery was performed in all cases. Without opening the fracture site, the closed intramedullary nailing operation was carried out either with or without reaming, according on the circumstances of each patient.

After the operation, the limb was consistently elevated, and patients were encouraged to perform active toe movements. A close eye was kept out for any indications of exaggerated discomfort, edoema, or distal circulation. Five days following the procedure, the initial dressing was changed. If the suture line was clean, the sutures were removed totally aseptically 10-12 days later. Following the dressing change, vigorous knee and ankle mobilisation was started right away. Patients were permitted to bear some of their own weight with the assistance of two axillary crutches. Gait training on parallel bars was also done if practicable, with a follow-up appointment set for one month later. Based on pain levels and the stability of the fracture fixation, full weight-bearing was decided.

X-rays were taken and clinical evaluations were completed at various follow-up intervals (4, 8, 16, 20 weeks, and 6 months) to gauge the patients' development with regard to fracture union and functional recovery. Statistical analysis was performed using SPSS version 23.0, while data were collected and arranged using Microsoft Excel. The statistical analysis used descriptive statistics.

RESULTS

The current study included a total of 120 patients with fractures in their leg bones, with 88 of them being male. Patients under the age of 45 were involved in the majority of instances (70%). Compared to other modalities of injury, road traffic accidents were shown to be the primary source of these injuries, accounting for 73% of the cases (Table 1).

The majority of fractures in the study either had mild or no comminutions (51%) (31%). Seventy nine percent of the cases included in the study had close fractures. Grade I Gustilo's categorization was more

Table 1: General characteristics

Characteristics	No. of patients	Percentage
Age groups (Years)		
17-24	18	15
25-34	39	32
35-44	27	23
45-54	20	17
55 and above	16	13
Gender		
Male	88	72
Female	32	28
Mode of injury		
R.T.A.	88	73
Fall from height	11	9
Fall on floor/stairs	18	15
Assault	3	3

Table 2: Fracture characteristics

Characteristics	No. of patients	Percentage
Fracture comminution		
Non-comminuted	61	51
Mild comminution	37	31
Moderate comminution	14	11
Severe comminution with loose fragments	8	7
Grade of fracture		
Close fracture	95	79
Compound fracture	25	21
Grade I	20	17
Grade II	4	3
Grade III A	1	1
Level of fracture		
Proximal third	17	14
Middle third	62	52
Distal third	41	34
Associated injuries		
Fracture of metacarpal or phalanx	4	3
Fracture of upper limb long bones	3	3
Ipsilateral femur fracture	2	2
Contralateral fracture both bones leg	2	2
Fracture of skull bones	2	2
Fracture superior rami of pubis	1	1
Fracture of cervical spine	1	1

Table 3: Injury surgery interval

Fixation time after trauma	No. of patients	Percentage
Within 48 hrs	54	45
2-7 days	46	38
8-1 5 days	10	8
16-23 days	5	4
24-31 days	2	2
>1 month	3	3

common (17%) than Grade II Gustilo's among compound fractures (3%). Four patients had concomitant fractures of the femoral shaft (2) or supracondylar region (2), one patient had an associated fracture of the medial malleolus, and two patients had accompanying head injuries that delayed the surgery. The distal third (33%) or middle third (52%) of the shaft were where the majority of the fractures that needed fixing were found (34%) (Table 2).

The majority of patients (83%) had their nails put in between 1 and 7 days after the accident. The linked head injury (2 cases), associated femoral shaft fracture (2 cases), associated cervical injury (1 case), associated fat embolism (1 case) and other medical conditions were all blamed for the delay of up to 7 days in some cases. Three individuals also came in for care about a month after the first injury (Table 3).

Table 4: Post-operative complications

Complications	No. of patient
Early complications	
Infection	
• Superficial	09
• Deep	01
Stiff knee joint	02
Implant failure	02
Compartment syndrome	01
Neuro vascular injury/ Neuropraxia	01
Thromboembolism/ Fat Embolism	01
Delayed complications	
Delayed union	08
Pain	08
Ankle Range of motion	
• <25% restriction	04
• 25-50% restriction	01
Mal union	02
Non-union	02
Shorting Limb >1cm	02
Hardware failure - Nail breakage/Bent nail	02
Knee Range of motion - <20 % restriction of full flexion	02
Locking bolt breakage	01
Deformities	
• Angular	01
• Rotational	01

No additional internal fixation was utilized in the present study. In one patient, the interlocking nail had to be removed, and Phemister bone grafting was performed to address delayed union. Another patient required Phemister bone grafting after undergoing first fibula osteotomy, weight-bearing attempts, and delayed union.

Early complications observed included superficial wound infection at the proximal incision site in nine patients, deep infection in one patient, stiff knee joint in two patients, implant failure in two patients, compartment syndrome in one patient, neurovascular injury/neuropraxia in one patient and thromboembolism/fat embolism in one patient. All patients recovered successfully with conservative treatment.

Delayed complications noted in the study were delayed union in eight patients, pain in eight patients, limited ankle range of motion in 5 patients, malunion in two patients, non-union in 2 patients, limb shortening greater than 1 cm in 2 patients, hardware failure such as nail breakage or bent nail in two patients, knee range of motion with less than 20% restriction of full flexion in two patients, locking bolt breakage in two patients, angular deformities in one patient and rotational deformities in one patient. During the course of treatment, some patients complained of anterior knee pain, pain at the site of the fracture, or discomfort caused by the locking bolt, but the majority of them recovered after attaining sound union, going through physiotherapy and using analgesics (Table 4).

According to the Alho *et al*.[4] criteria, the final follow-up parameters were evaluated as follows (Table 5):

Table 5: Final follow-up

Sr. No.	Criteria	Grade 1 excellent	Grade 2 good	Grade 3 fair	Grade 4 poor
A	**Tibial malalignment and shortening**				
	Varus Valgus(degree)	0	1	0	0
	Shortening(cm)	2	1	0	0
B	**Range of knee motion**				
	Flexion	117	2	1	0
	Extension deficit	2	0	0	0
C	**Range of ankle motion**				
	Dorsiflexion	115	4	1	0
	Planter flexion	116	3	1	0
D	**Foot motion (as compared to normal)**	119	1	0	0
E	**Pain in the limb**				
	Ant. Knee Pain	104	11	4	1
	Pain at fracture site	116	4	0	0
F	**Swelling**	108	9	3	0
	Percentage of Cases	85%	12%	2%	1%

- One of the patients who received interlocking nail treatment for tibial malalignment and shortening had a valgus angulation of less than 10 degrees. One patient showed a slight external rotation, but none of the patients had a major rotational deformity that exceeded 10 degrees. Shortening of 1 cm occurred in two individuals, one with an ipsilateral femoral shaft fracture and the other with a severely comminuted fracture
- **Range of knee motion:** None of the patients experienced leg extension, and 98 percent of them showed knee flexion more than 120 degrees. Only two patients' knee motion was slightly restricted
- **Ankle range of motion:** Nighty six percent of the patients showed plantar flexion exceeding 30 degrees and ankle dorsiflexion more than 20 degrees, indicating full range of motion
- **Range of foot motion:** When compared to normal, there was no discernible difference in foot motion.
- **Pain:** Around 10% of the patients experienced leg pain in the area of the anterior knee and ankle, which was bearable but occasionally necessitated the use of oral analgesics
- **Edema:** About 30% of patients had minimal swelling around the ankle and foot, which eventually went away with movement and wasn't serious enough to worry the patients

DISCUSSION

The closed dynamic interlocking nailing treatment approach for both closed and compound tibial diaphyseal fractures aims to achieve a low complication rate while minimizing interventions, reducing hospitalization and recovery time. The ultimate goal is to achieve results comparable to more complex treatment methods[8].

There are numerous ways to treat tibia shaft fractures. Applying a cast from the groyne to the toe following closed reduction until clinical union is achieved is one typical method. But doing so can result in unwanted side effects such joint stiffness, muscular atrophy, osteoporosis, extended bed rest and decreased productivity. Another common technique is the Sarmiento Tibial Plaster with early weight-bearing patellar tendon bearing cast, but it may not always be successful in controlling alignment[4]. Furthermore, there is a chance that the fracture will shift following weight-bearing. Additionally, adopting closed techniques may not always result in an acceptable fracture position.

Although it takes skill to perform, AO compression osteosynthesis has the advantage of establishing exact anatomical alignment and early mobility of the afflicted limb. Complications from using AO compression methods for therapy are frequently due to insufficient experience with the procedure[4]. Additionally, open reduction and internal fixation might not be the best treatment option for high-energy fractures, which are common in the tibia[5]. Open reduction and internal fixation also converts a closed fracture into an open one, resulting in a longer hospital stay despite their tempting potential. Delay in union also increases because weight-bearing while wearing a plate that is attached to the bone can lead to issues such plate fracture and bone refracture after the plate is removed[8].

In comparison to the AO technique, the current closed tibial nailing method has a number of benefits, including shorter operating times and a lower incidence of complications. It performs better than Sarmiento's patellar tendon bearing cast in terms of preventing misalignment and being appropriate for unstable fractures. Additionally, this approach lessens the risk of malalignment, joint stiffness, muscle atrophy, osteoporosis, and osteoporosis as compared to traditional conservative treatment utilising a groin-to-toe cast[8].

Both closed and open fractures underwent closed primary medullary nailing without exposing the fracture site, followed by early weight-bearing without a cast after 2-4 weeks. It was discovered that the study's findings agreed with those provided by Bone and Johnson[9]. The Grosse-Kempt nail was used in this series to treat Gustilo's grade one and two fractures. With the exception of two instances where open

reduction and nailing were required because the fractures were more than a month old and exhibiting signs of malunion, the majority of cases involved closed interlocking nailing.

Reaming, in contrast to employing a medullary nail without reaming, completely destroyed all of the vessels in the medullary canal, according to Court-Brown *et al*.[8]. Following the reaming process, their findings showed necrosis in the inner 50-70% of the cortex.

In the present study, 9 patients (7.5%) developed a superficial wound infection at the location of the proximal incision. These cases responded favourably to daily dressings and common oral antibiotics. One patient (1.8%) experienced a deep infection, which was treated with oral antibiotics, a regular dressing, and guarded weight-bearing until the fracture joined (18 weeks). A patellar tendon-bearing cast was then fitted after the nail was removed. Comparable to the infection rates described in the investigations by Court-Brown *et al*.[8], Bone and Johnson[9] and Klemm *et al*.[10], the infection rate seen in our series was discovered.

Nine cases had superficial infections, of which three were Gustilo's grade I cases and two were grade II instances. Two of patients received surgery within a week, but the other three required a delay of 15 to 30 days because of a concomitant brain injury. In two of these cases, the delayed operation was probably to blame for the surface infection. In one patient with a severe infection, the infection's origin was still unknown. This emphasises the significance of early surgery coupled with adequate antimicrobial treatment when nailing for a compound tibial fracture is being considered[11].

We came across 8 cases of delayed union, where despite waiting for roughly 16 weeks, we still didn't see a lot of callus in the skiagram, and the patients were still in pain where the fracture was located. Four of these patients required phemister bone grafting, whereas the non-union in the other two cases was of the hypertrophic variety. The use of a small diameter nail in these circumstances is most likely to blame for the non-union (8 mm). In these situations, Phemister bone grafting and a groin-to-toe cast did not produce the intended outcomes. This underlines how crucial it is to always use a nail that fits properly and has the right diameter. Puno et al. observed similar findings as well[12].

Oleurd and Karlstrom[13] used compression plating in their study and found that the nonunion/delayed union rate was 3.73%. Melher[14] reported one case of nonunion while using the AO unreamed tibial nail (5%). While none were recorded with the reamed Grosse-Kempf nail, Court-Brown *et al*.[8] reported a 20% incidence of nonunion with the unreamed AO-UTN nail.

The average union time for closed nailing and conservative therapy was determined to be 10.8 weeks and 16.68 weeks, respectively, in a research by Puno *et al*.[12]. In contrast to unreamed nails, Court-Brown *et al*.[8] showed that reamed nails union time was shorter (15.4 weeks) (22.8 weeks). The 17-week union time in our current series is comparable to the results of the research cited above.

The most frequent side effect seen following intramedullary tibial nailing is anterior knee discomfort. Eight instances in our series had this problem. For nail insertion, we created a midline longitudinal incision over the patellar tendon and used a paratendinous technique. Although the precise reason of anterior knee pain following intramedullary tibial nailing is unknown, it is most likely due to a number of different causes.

According to Toivanen *et al*.[15], intramedullary nailing of tibial shaft fractures did not significantly lower the prevalence of persistent anterior knee discomfort or functional impairment. The paratendinous method, as demonstrated by Oarfley *et al*.[16], is linked to decreased knee pain, and the position of the nail in regard to the anterior cortex and tibial plateau has no bearing on knee pain. However, only 45% of the individuals in their series reported improved symptoms after having their nails removed.

Although recent experiences with intramedullary treatment for tibial and femur fractures have been successful, additional development of the procedure is anticipated from ongoing research. Future research is likely to concentrate on two key areas: investigating various biomaterials and biologically active substances to promote bone repair. Shape memory alloys and biodegradable polymers are two examples of the biomaterials that have the potential to develop this industry. Bone healing has also been successfully promoted by biologically active substances such bone morphogenic protein -2 and -7 in both animal models and people. To achieve the best results, it is difficult to find a cost-effective approach to mix these bioactive chemicals with implants.

CONCLUSION

The use of an image intensifier for interlocked intramedullary nailing has proven to be a very successful technique, with union occurring in almost all cases. Early weight-bearing is made possible by this approach, hastening fracture union and lowering complications. The best treatment option for diaphyseal tibial fractures is closed interlocking nailing because of its high incidence of successful union and low infection rate.

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