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Original Article

Outcome of Intramedullary Interlocked Nailing in Closed and Gustilo Anderson Grade I Tibial Fractures

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Abstract

Introduction: Most common long-bone fracture is tibial shaft fracture. Open fracture wounds must be continually evaluated by the operating surgeon. The first step is to assess the damage to the soft tissues, which often extends past the opening in the skin. Foreign bodies, dead muscle, dead bone, and soft tissue must be removed. Treatment of tibial diaphyseal fractures has always been tough because of its subcutaneous location, and there may be severe soft tissue injuries and many of these can be open fractures.

Methods: In this Study attempt has been made to critically evaluate the outcome of closed intramendullary interlocked nailing in tibial fractures regarding union, functional healing and the complications of the procedure. In this study we have selected patients of closed and open grade-I tibial shaft fractures in patients of age more than 16 years, treated by closed IMIL nailing at Rajendra Institute of Medical Sciences, Ranchi. Study was done from November 2020 to November 2022. Total 30 cases were included. All the cases were followed up till the union of fracture was achieved. They were examined clinically, radiologically and functionally.

Results: According to Karlstrom & Olerud functional scoring system 18patients had excellent overall functional results, 9 had good results, 2 had acceptable results only one patient had poor result on account of her old age and poor health condition.

Conclusion: Statically locked, reamed intramedullary nailing remains the standard treatment for displaced tibial shaft fractures. Closed intramedullary interlocked nailing for acute tibial fractures gives excellent results in closed and grade-I open fractures if done judiciously and with proper technique.

Key words: Interlocked nailing, Diaphyseal fracture, Gustilo Anderson classification, Tibial shaft fracture

INTRODUCTION

A tibial shaft fracture occurs commonly due to trauma, commonly in middle-aged and young people[1] less prevalent in children and older people.[2] The most common site of long bone fractures is tibial shaft because of its superficial location.[3] Most common long-bone fracture is tibial shaft fracture.[4]

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Open fracture wounds must be continually evaluated by the operating surgeon.[5] The first step is to assess the damage to the soft tissues, which often extends past the opening in the skin.[6] Foreign bodies, dead muscle, dead bone, and soft tissue must be removed. Copious irrigation continues as long as foreign material and dead tissue flow out of the wound. If the fracture is multifragmentary, small bony fragments without muscle attachment are removed. Avoid soft-tissue stripping of fracture fragments.[7] High-pressure irrigation systems may force bacteria back into the tissues and these bacteria will emerge later and cause infection.[8] The location where the injury occurred may also add bacteria as in the classic "barnyard injury." Appropriate antibiotics are given for these.[9]

Treatment of tibial diaphyseal fractures has always been tough because of its subcutaneous location, and there

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may be severe soft tissue injuries and many of these can be open fractures.[10]

In this study, attempt has been made to critically evaluate the outcome of closed intramedullary interlocked nailing in tibial fractures regarding union, functional healing, and the complications of the procedure.[11]

Intramedullary nail fixation remains the treatment of choice for unstable and displaced tibial shaft fractures in the adult.[12] The goals of surgical treatment are to achieve osseous union and to restore length, alignment, and rotation of the fractured tibia.[13] Intramedullary nailing carries the advantage of minimal surgical dissection with appropriate preservation of blood supply to the fracture.[14] Moreover, the surgical implant offers appropriate bio-mechanical fracture stabilization and acts as a load sharing device allowing for early post-operative mobilization.[15] Recent advances in nail design and reduction techniques have expanded the indications for intramedullary nail fixation to include proximal and distal third tibial fractures.[16]

This procedure has 2 benefits, one is it controls the rotational stability of fracture parts, better correction of angulation deformity, lesser damage to soft tissue covering of bone thereby preserving vascularity of the bone, decreased blood loss, may be used not only in the mid shaft fractures but also in proximal and distal fractures.[17] Therefore, it is popularly accepted as primary method of fixation in Grade I open fractures.[18] However, this method is associated with complications like general complications: Deep Vein Thrombosis, Pulmonary Embolism, Pneumonia, Infections, etc.

In distal third tibial shaft fractures undergoing intramedullary nail fixation, adjunct fibula fixation may allow for achieving and maintaining fracture reduction of the tibia.[19] However, there remains the concern of wound complications from the additional incision in the area of traumatized tissue.[20] We therefore suggest using adjunct fibula fixation cautiously.[21]

Good outcomes and reproducible results can be achieved with intramedullary nail fixation of tibial shaft fractures.[22] The reported union rates of intramedullary tibial nailing vary among different studies.[23] With contemporary implants and appropriate surgical techniques, union rates above 90% can be expected.[24] Tibial shaft fractures that fail to heal following intramedullary nail fixation typically respond well to exchange reamed nailing procedures.[25] Proximal locking helps to keep the nail from backing out into the knee if it loosens or the fracture telescopes.[26] Neil *et al.* used open technique of intramedullary nailing with distal locking first because this process help to control the nail and able to check drill in proper position through guide wire.[27] Compression is achieved through distal locking first and back slapping. It is commonly used method in tibial shaft fracture.[27]

Anterior knee pain is a commonly reported complication after intramedullary nailing of tibial shaft fractures.[28] Potentially contributing factors may include traumatic and iatrogenic damage to intraarticular structures, injuries to the infrapatellar branch of the saphenous nerve, thigh muscle weakness secondary to pain-related neuromuscular reflex inhibition, fat pad fibrosis leading to impingement, reactive patellar tendonitis, bending strain exerted by the nail on the proximal part of the tibial bone, and proximal protrusion of the nail.[29] In an attempt to address the etiology of anterior knee pain after intramedullary nailing, transtendinous approaches have been compared to paratendinous approaches. The previous studies suggested that transtendinous may be associated with a higher incidence of postoperative knee pain.[30] However, prospective randomized clinical data has not shown any significant difference between the transtendinous and paratendinous approach. Jones *et al.* reported no statistical differences with regards to anterior knee pain between patients undergoing suprapatellar versus infrapatellar nailing.[31] However, the authors reported that there was trend toward greater symptomatic knee pain in the infrapatellar group.[32] Due to hinge joints at the ankle and knee, no adjustment occurs for rotatory deformity after a tibial shaft fracture.[33] Non union, infection and delayed-union and are common complications after open tibial shaft fractures.[34] Rapid restoration of bone continuity and early callus formation is the main aim for diaphyseal fracture of tibia.[35]

MATERIALS AND METHODS

In this study, we have selected patients of closed and open Grade-I tibial shaft fractures in patients of age more than 16 years, treated by closed IMIL nailing at Rajendra Institute of Medical Sciences, Ranchi. Study was done from November 2020 to November 2022. Total 30 cases were included in the study. All the cases were followed up till the union of fracture was achieved. They were examined clinically, radiologically, and functionally.

Inclusion Criteria

The following criteria were included in the study:

1. Patients from either sex of above 16 years.
2. Isolated tibia fracture.
3. Closed or open Gustilo Anderson grade-I, fractures of both bones leg.
4. All those fractures of tibia which are 7 cm distal to knee and 4 cm proximal to the ankle joint.

5. Unilateral or bilateral tibial fractures.

Exclusion Criteria

The following criteria were excluded from the study:

1. Patient <16 years of age.
2. Any associated fracture in the same or opposite lower limb.
3. Fractures proximal to 7 cm of tibia or distal to 4 cm of tibia.

Open fractures were classified according to the classification of Gustilo and Anderson. Other investigations done included a complete blood count with ESR, prothrombin time, activated partial thromboplastin time, blood urea nitrogen, serum creatinine, random blood sugar, blood grouping and matching, and chest X-ray.

Management

After the patients came to emergency, appropriate dose of analgesic were given to patients to relieve pain and above knee plaster of paris (POP) back slab was given to the patient.

Injuries to the surrounding skin and soft tissues, such as fracture blisters, skin abrasions, or skin tenting, must be recorded. Open fractures must be identified and appropriate tetanus update and antibiotics should be initiated immediately on the initial presentation. A comprehensive neurovascular examination must be performed and documented.

The evaluating surgeon should maintain a high suspicion for an associated compartment syndrome and serial clinical examinations are required in these patients.

It was tried that the patients be operated as early as possible depending upon condition of the patients of fractured limb as well as systemic conditions. Preoperatively, the patients were given a broad-spectrum antibiotic, generally a third generation cephalosporin and dose repeated after 6–8 h postoperatively.

Operative Technique

The patients were operated under the spinal anesthesia as considered appropriate by the anesthetist. A tourniquet was applied over the thigh and pressure raised to 250 mm Hg most of the time depending on systolic blood pressure.[36] However for nailing, tourniquet was avoided.[37]

Establishing an accurate starting point continues to play a crucial role in any intramedullary nailing procedure. In general, the more proximal the fracture, the more lateral the entry point should be. Ideal starting point lies at the anterior edge of the tibial plateau and just medial to the lateral tibial spine. Moreover, Tornetta *et al.* reported on a safe zone with a width of 22.9 mm ± 8.9 mm which allows for a safe nail insertion without the risk of damage to the adjacent articular structures.[38] Traditionally, the starting point for intramedullary nailing of tibial shaft fractures has been established through an infrapatellar approach either by splitting the patellar tendon (transtendinous approach) or alternatively by dissecting just adjacent to the patellar tendon (paratendinous approach). Nailing in the semiextended position has recently gained significant attention in the orthopaedic literature.[39] Nailing in the semiextended position using a medial parapatellar approach has been suggested by Tornetta and Collins as a method to avoid apex anterior deformities.[40] Recent reports have adopted this concept suggesting tibial nailing in the semiextended position using a suprapatellar portal and nail insertion through the patellofemoral joint.[41]

The procedure is performed with the knee flexed approximately 15–20°. An approximately 3 cm longitudinal incision is made about one to two fingerbreadths above the patella. The quadriceps tendon is split in a longitudinal fashion and the patellofemoral joint is entered through further blunt dissection. A cannula system with a blunt trochar is then inserted through the patellofemoral joint to establish the starting point at the junction of the anterior cortex of the proximal tibia and the articular surface. The starting point is established under fluoroscopic guidance using a 3.2-mm guide pin strictly adhering to the fluoroscopic landmarks described above. A multiholed guide pin sleeve is available and may allow for fine adjustments of the starting point. The remaining surgical procedure including reaming of the canal and tibial nail insertion is performed through the cannula system which allows for safe protection of the surrounding soft tissues and articular structures. The semiextended leg position potentially facilitates the fracture reduction in particular in proximal third tibial fractures with the typical apex anterior deformity.[42] Suprapatellar nailing in the semiextended position may also represent an alternative to the traditional infrapatellar approach when soft tissue injuries around the infrapatellar area make the placement of surgical incisions undesireable.[43]

Reduction

Placement of the tibial nail alone does not result in adequate fracture reduction and appropriate fracture alignment must be maintained throughout the reaming process and nail placement.[44] While application of longitudinal traction typically results in improved fracture alignment through ligamentotaxis, the simple application of manual traction by itself may not al- ways achieve an anatomic fracture alignment.[45] The universal distractor can be used as an additional reduction tool. The universal distractor may

assist in maintaining length and alignment.[46] Careful attention must be paid to the placement of the Schanz pins. These are placed from the medial side into the proximal and distal fragment away from the planned position of the tibial nail.[47] Similar to the universal distractor, two-pin external fixation can be used to obtain and maintain length and alignment during intramedullary nailing of tibial shaft fractures. Blocking screws (or "poller" screws) have been popularized by Krettek *et al.*[48] The purpose of blocking screws is to narrow the canal in the metaphyseal area and to substitute a deficient cortex.[49] The blocking screws are placed prior to the reaming process and nail placement. Blocking screws are typically placed in the short, articular fragment and on the concave side of the deformity.[50] For instance, the typical deformity of a proximal third tibia fracture is characterized by a valgus- and apex anterior deformity.[51] To overcome the valgus deformity, a blocking screw can be placed in an anterior to posterior direction into the lateral portion of the proximal fracture fragment (i.e., on the concave side of the deformity). This blocking screw is used to guide the nail medially and thus prevents a valgus angulation.[52] Similarly, the apex anterior deformity can be overcome by a blocking screw that is placed in a medial to lateral direction in the posterior portion of the proximal fragment (i.e., on the concave side of the deformity).[53]

However, in our study, para patellar approach or splitting of patellar tendon was used, reaming was done in most of the cases.[54] Length was measured by measuring tape on uninjured limb.

Rotational malalignment was avoided by aligning the iliac crest, patella, and the second ray of foot.[55] Distal locking was done using free hand technique and proximal locking was done through the jig. All wounds were closed and antiseptic dressing was done.

Post-operative Management

Limb elevation was done and above knee POP posterior slab was applied. Surgical wound dressings and drain removal (if any) was done 48 h after surgery. A post-operative radiograph was taken for evaluation of surgery. Partial weight bearing was started when there was clinical evidence of fracture healing, usually about 3 weeks. Full weight bearing was started when there was radiological evidence of fracture union, usually about 3–4 months. Karlstorm and Olerud 36-point clinical grading system and radiological evaluation of leg was used during follow-up of patients.[56] This system evaluated the patients both subjectively and objectively and thus gave a comprehensive picture of the patient's condition. An overall result of excellent, good, acceptable, or poor was determined according to the following criteria:

- Excellent - Score of 3 in all the factors listed above.
- Good - Score of 2 or more in all the factors listed above.
- Acceptable - Score of 1 in one factor and scores of 2 or 3 in all other factors.
- Poor - Score of 1 in more than one factor.

RESULTS

30 cases of closed and open Grade-I tibial shaft fractures were included in the study. This study is based on observations from 30 cases. The mean age of patients was 40.5 years. Transverse fracture was the most common occurring in 19 (63.3%) patients followed by Oblique fractures in 7 (23.3%) patients. 25 patients (83.3%) had closed tibial shaft fractures while 5 (16.6%) patients had an open grade I fracture. Reaming was done in 20 (66.6%) patients while unreamed tibial nail was put in 10 patients. 10 mm size nail was used in most (15) patients. Dynamic locking was done in 20 (66.6%) patients and static locking was done in 10 patients. No patients had valgus or varus deformity radiologically of more than 15°. Most (85%) patients needed no immobilization. 4 patients had an above knee POP slab while 2 patient had a below knee POP slab. Most patients (21) started partial weight bearing within 9 weeks post-surgery followed by 5 patients between 9 and 12 weeks and another 4 patients after 12 weeks post-surgery. The average interval between surgery and partial weight bearing was 10 weeks (3–32 weeks). Most patients (25) started full weight bearing within 24 weeks after surgery. Four patients started full weight bearing between 24 and 36 weeks and only one patient on account of old age started full weight bearing after 36 weeks. Dynamization was done in 5 patients. 27 patients had complete union while only 3 had delayed union.

According to Karlstrom and Olerud functional scoring system all patients had excellent results of pain evaluation. 27 patients had a score of 3 and only 3 patients had a score of 2 with regards to the previous sports activity. 19 patients had a score of 3, 7 patients had a score of 2 and only 4 patients had a score of 1 with regards to walking capacity. 18 patients had a score of 3, 9 patients had a score of 2 and only 3 patients had a score of 1 with regards to work limitation. No patient had any obvious deformity at follow-up. No patient had any limb length discrepancy at follow up. 90% patients had less than 10 degrees loss of knee motion while only 3 had between 10 and 20° loss of motion. All patients had almost full range of ankle movement. All patients had almost full range of subtalar motion. 26 (86.6%) patients had at least 140 degree range of movement, 4 (13.4%) patients at least 100 degree range of movement and no patient had less than 100 degree range of motion at the knee joint.

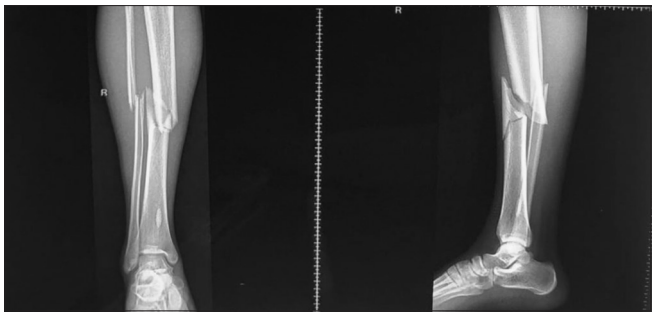

Figure 1: Case 1- fracture mid shaft tibia along with fibula at same level

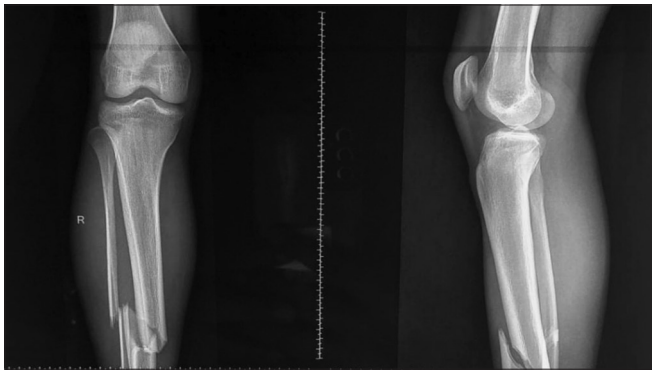

Figure 2: Case 1 (another radiograph)

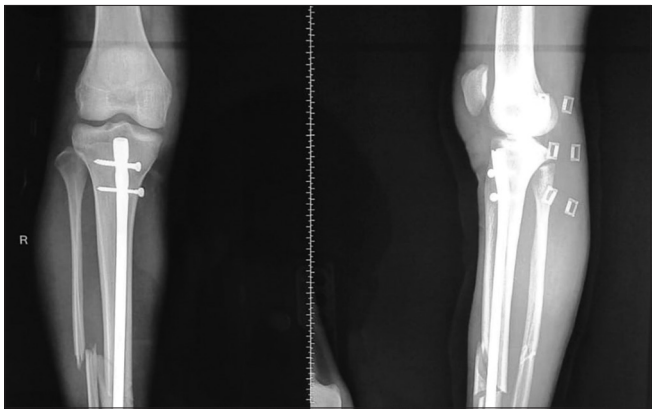

Figure 3: Post op X-ray of case 1

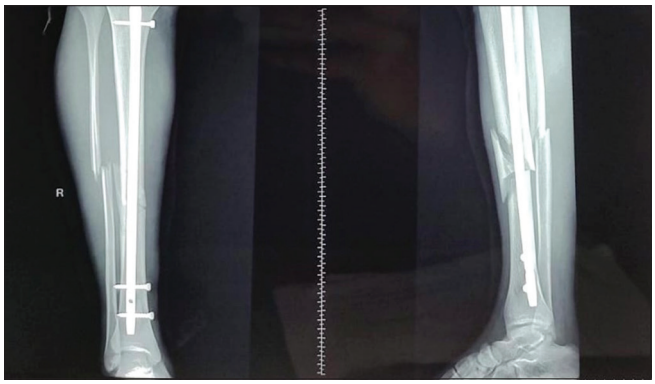

Figure 4: Another post op X-ray of case 1

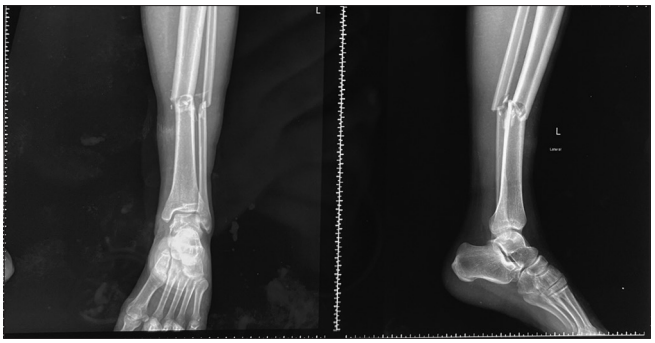

Figure 5: Case 2 fracture shaft of tibia and fibula

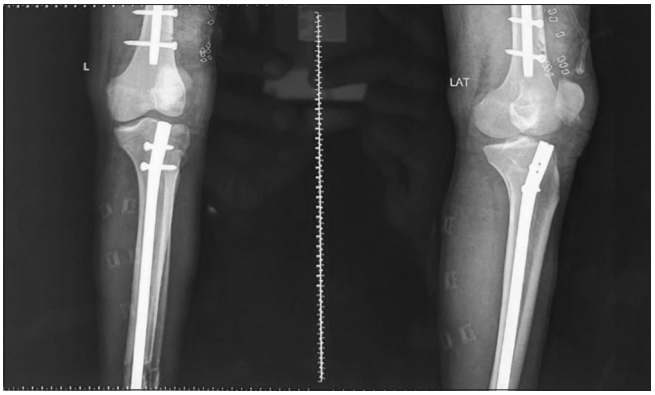

Figure 6: Post op X-ray of case 2

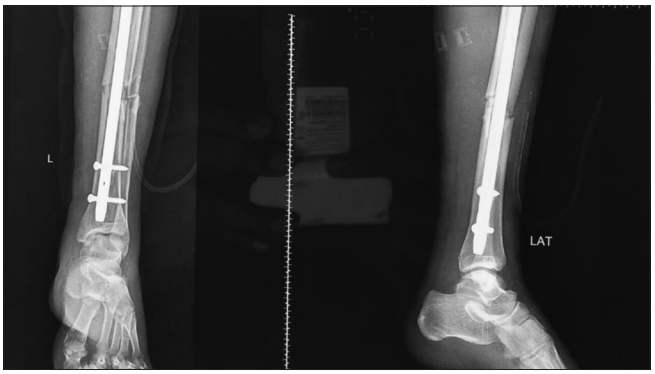

Figure 7: Post op X-ray of case 2

Most patients had bony union radiologically by 24 weeks and 4 between 24 and 36 weeks. Only three patients had infection at proximal insertion site at follow-up. 1 patient had a broken implant at 24 weeks when full weight bearing was done. Later on he was treated with an above knee POP cast with implant left in situ. The bone united at 6 months later. The proximal half of the broken nail was removed thereafter. No patient required secondary surgeries for surgical complications. According to Karlstrom and Olerud, functional scoring system 18 patients had excellent overall functional results, 9 had good results, 2 had acceptable results. and only one patient had poor result on account of her old age and poor health condition.

Figure 8: Case 3

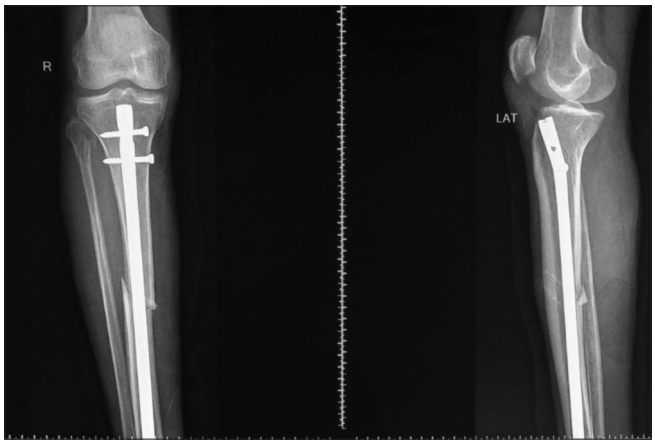

Figure 9: Post op X-ray of case 3

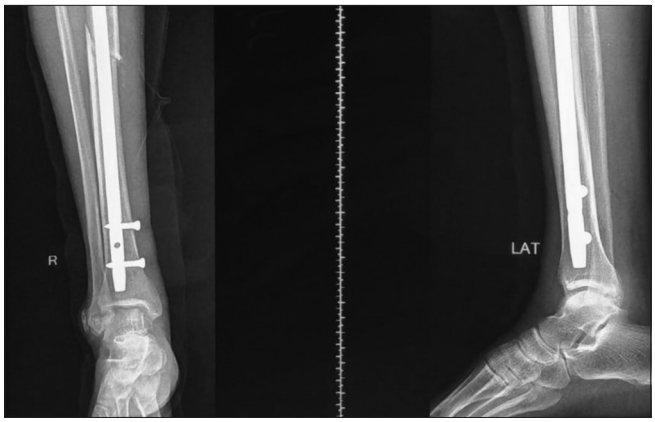

Figure 10: Post of x ray of case 3

DISCUSSION

Shaft of tibia fractures are the most common long bone fractures in adults and happen due to high-energy trauma. Its site and also that the anteromedial border is subcutaneous puts the bone susceptible to injury.[57] In particular, the younger patient population seems to be at high risk for the development of a compartment syndrome.[58] The diagnosis of a compartment syndrome should be based on clinical findings including pain, neurovascular changes, swelling of the muscle compartments, and pain increase with passive toe stretch. Thus, compartment syndrome remains a clinical diagnosis.*[59]* Measuring of intracompartmental pressure through a pressure needle has been suggested as a useful tool and may play a role, in the obtunded patient when the availability of clinical data points is limited.*[60]* To obtain reliable data, the intracompartmental pressures should be measured in all four muscle compartments and in different locations within the respective muscle compartments. A differential pressure (diastolic blood pressure minus compartment pressure) of <30 mmHg has been suggested to be indicative of a compartment syndrome.*[55]*

Surgical treatment of tibial shaft fractures is debatable because good results are also there by closed reduction and casting as shown by Sarmiento *et al.*[55] However, with conservative treatment, loss of reduction which causes malunion and nonunion is also common.[57] The main objections to surgical treatment are mainly contributed to plate osteosynthesis because plating of the tibial shaft fracture causes high risk of infection.[59] After the invention of the interlocked nail there was a milestone achieved in the nailing technique as it provided the rotational stability. Furthermore, the dynamization of the nail was not problem because of slot for dynamic nail are given proximally.*[61]* Recently, these kinds of fractures are treated with anatomical restoration of alignment, stable, and rigid internal fixation with rotational stability and early weight bearing.[62] The aim of operative treatment is to obtain a proper anatomical alignment, early knee mobilization exercises, and early weight bearing even before the bony union is achieved.[63]

At many trauma centers reamed tibial nailing is preferred over unreamed tibial nailing.*[64]* However, the issue of reamed versus unreamed tibial nailing has been discussed controversially. It has been suggested that reamed nailing allows for placement of larger size nails allowing for increased biomechanical stability and potentially improved fracture healing.[65] In contrast, it has been reported that intramedullary reaming results in significant compromise of the endosteal blood supply which may potentially limit the biologic healing response at the fracture site.[66] Moreover, the concern remains that the reaming process may increase the risk of fat embolization and pulmonary failure.*[67]*

Most surgeons prefer reamed intramedullary tibial nailing over unreamed nailing. However, both reamed and unreamed intramedullary nailing can be suggested as

acceptable standard techniques and good outcomes can be achieved with both of these methods.[67]

CONCLUSIONS

Statically locked, reamed intramedullary nailing remains the standard treatment for displaced tibial shaft fractures. A correct starting point remains a crucial part of the surgical procedure. Suprapatellar nailing in the semi-extended position has been suggested as a safe and effective procedure. Open reduction techniques should be considered if anatomic fracture alignment cannot be achieved by closed means. Favorable union rates above 90% can be achieved by both reamed and unreamed intramedullary nailing.

This study consisted of mainly middle aged patients, mostly males. Age and sex did not changed the results significantly. High velocity road traffic accidents were the main cause of injury. Distal 1/3rd tibial shaft fractures were most common followed by middle 1/3rd, upper 1/3rd being the least common. Transverse fractures topped the study followed by oblique and spiral fractures. No obvious correlation of days between injury and operation with outcome of results was seen. However, delay in operation causes greater soft tissue swelling making the management more difficult. In comminuted fractures, rigid fixation like closed intramedullary interlocked nailing gave better functional results as it is a minimally invasive procedure which does not require opening of the fracture site thus hematoma is not drained. Moreover, the length and rotation of the limb are maintained and at the same time there is angular correction. The purpose of interlocking screws in tibial shaft fractures is to prevent shortening and malrotation. The introduction of interlocking screws has expanded the indication for intramedullary tibial nailing to more proximal and distal third tibial shaft fractures with metaphyseal involvement. In fractures involving the metaphyseal area, interlocking screws become more important in maintaining axial alignment due to the absence of a strong nail-cortex interface.

However, we also had our share of unsatisfactory results with regards to angulation deformity, delayed union, malunion, and non-union. Knee pain was the most common complication seen. This was due to slightly protruding proximal end of the nail, which was found to be jetting out just beneath the patellar tendon, which can be attributed to poor nailing technique. In the distal and proximal third there was some degree of angulation. Hence, the surgeon should be careful about the alignment while locking proximally and distally.

Finally, we conclude that closed intramedullary interlocked nailing for acute tibial fractures gives excellent results in closed and Grade-I open fractures if done judiciously and with proper technique. Moreover, it offers significant benefits to the patient in the form of short hospital stay, early range of motion exercises, also partial weight bearing can be started early, so both function and healing of fracture goes side by side and thereby, consequent good functional results were achieved in a majority of these fractures.

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