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A prospective study for TENS nailing as an alternative to external fixation in compound fractures of Tibia

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Abstract

Background: The treatment of compound fractures remains a major problem especially with regards to wound coverage, high risk of infection and therefore poor outcomes. Moreover, the use of External Fixators can limit the activities of the patient due to the unwelcoming appearance and bulkiness of the apparatus.

Materials and Methods: Gustilo Anderson II, IIIA, IIIB fractures of the diaphysis were included. A minimum of 2 and maximum 3 TENS (Titanium Elastic Nailing System) nails were used for fixation. The patients were followed up at 6, 12 and 24 weeks. The results were measured using Karlstrom & Olerud Criteria and Hammer *et al.* criteria.

Results: A total of 27 patients with 28 compound fractures were treated with TENS nailing. Mean operating time was 39.34 ± 9.15 minutes, mean time to wound healing was 5.2 ± 1.4 weeks. Functional results were Excellent to Good in 82.1% and Satisfactory in 17.9% fractures. There were no poor results. Radiological union was achieved in 24.6%, Delayed Union in 53.6%, and Non-Union in 17.9% fractures. The mean time to union was 19.5 ± 3.8 weeks.

Conclusion: We conclude that the use of TENS nail for the fixation of Compound Fracture of Long Bones of Lower Limbs is a feasible option with certain advantages pertaining to the better wound care, very good patient compliance, easy to perform, short operating time, excellent to good functional outcomes and lesser iatrogenic damage, infection and joint stiffness.

Keywords: Compound fracture, open fracture, Tibia, TENS nailing, external fixator, Gustilo anderson

Introduction

A fracture is called compound when the fractured bone and/or fracture hematoma are exposed to the external environment [1]. They usually occur due to trauma and therefore being high-energy injuries are associated with varying degree of insult to the soft tissues. Some authors even consider them a soft-tissue injury that involves a fracture [2]. They mostly occur singularly, and the most common long bone fracture is the tibia and fibula [1, 3].

They were classified in order of increasing severity into three types by Veliskakis in 1959 [4]. This concept was fully developed by Gustilo and Anderson in 1976 [5]. It was subsequently modified by Gustilo *et al.* in 1984 and is the most commonly used classification today for classifying compound fractures [6]. Compound fractures have very high risk of development of infections, impairment of wound and fracture healing due to various factors such as foreign contaminants, damage to periosteum, evacuation of fracture hematoma and damage to the protective envelope of soft tissues around the bone and therefore pose a great challenge to the treating Orthopaedician.

Various measures are to be taken to reduce these complications such as early administration of wide-spectrum antibiotics as soon after the injury as possible, and ideally within 3 hours of injury. Early use of antibiotics in the management of compound fractures significantly reduces the rate of infection [5, 6]. Immediately at presentation the wound should ideally be thoroughly washed with approximately [9]. Litres of gravity-flow irrigation in most cases. Additional fluid may be needed in highly contaminated fractures, whereas lesser amounts (5 to 6 L) are usually sufficient in minimally contaminated injuries [7]. The exposed bone should be placed inside and the wound should be covered primarily wherever possible.

It was earlier reported in literature that the wound should be debrided within 6 hours of injury to minimise the risk of infection but this 6 hour rule is now questioned by various authors due to the advancements with respect to antibiotics and their early use in management of compound fractures [8, 9]. Alongside treating the wound, the fracture also has to be fixed and various methods have been tried for this, such as POP (Plaster of Paris) casting, Pin and plaster technique which were used historically. Unreamed nailing, Reamed nailing, and external fixator application, each with its own advantages and disadvantages. The most frequently used method of fixation of compound fractures is external fixation as it achieves fracture fixation without disturbing the wound site thereby allowing for wound care to be done, but it carries various disadvantages such as risk of iatrogenic fractures, neurovascular injury, pin tract infection, pin loosening and pin breakage with subsequent loss of reduction. An external fixator in situ may also interfere with the activities of a patient due to its unwelcoming appearance and itself being a bulky apparatus hinders movements of patients leading to joint stiffness.

In our study we fixed compound fractures of long bones of lower limb using TENS nail (Titanium Elastic Nailing System) and results were noted. The aim of our study was To evaluate the clinical and radiological outcome in patients treated with TENS nailing in compound fractures of long bones of lower limbs.

Materials and Methods

Inclusion criteria

Patients presenting with compound fractures of long bones with:

1. Gustilo Anderson Grade II, IIIa, IIIb
2. Diaphyseal in location

Exclusion criteria

1. Pathological fracture.
2. Compound fracture with Gustilo Anderson grade IIIc.
3. Patients presenting with gross contamination of wound requiring amputation.
4. Periarticular fractures.
5. Bone loss more than 2cm or 2/3rd of the circumference.

Pre-operatively

After thorough cleaning and washing of the wound, primary wound closure was done wherever possible and fracture was stabilised by splinting. Parenteral antibiotics were administered as soon as possible and patients were taken up for surgery after anaesthesia clearance.

Intra OP

Debridement of the wound was done and fracture was fixed using a minimum of 2 TENS nail and a maximum of 3 TENS nail and all the nails were inserted from different points in the bone. In our study in tibia, the nails were inserted from the medial and lateral proximal part of the bone near the metaphysis and the tip of the medial malleolus served as the site for a third nail.

Post-operatively

Parenteral antibiotics were continued and the limb was kept elevated. The limb was supported with a POP splint in the immediate postop period. Regular Aseptic Dressings were done and patients were discharged when the wound condition was satisfactory.

Follow-UP

Patients were followed up at 6 weeks, 12 weeks, 24 weeks post op and Non weight bearing mobilization and weight bearing was encouraged as per patient condition. Radiological union of fractures was graded according to the Hammer *et al.* criteria and Functional outcomes were graded according to the Karlström & Olerud criteria [10, 11]. Any complications that occurred in the patients were also noted. (Table 1 and Table 2)

Table 1: Karlstrom and Olerud Criteria for functional outcomes [11]

Measures	3 Points	2 Points	1point
Knee pain	NO	Little	Severe
Ankle pain	NO	little	severe
Difficulty in Walking	NO	Moderate	Severe
Difficulty in Stairs	NO	Supported	Unable
Difficulty in Previous Sports Activity	NO	Some Sports	Unable
Limitations at work	NO	Moderate	Unable
Status of Skin	Normal	Various Colours	Ulcer/Sinus
Deformity	NO	Little	Remarkable
Muscle Atrophy	<1	1-2	>2
Shortening	<1cm	1-2cm	>2cm
Loss of Motion at Knee	<10 degree	10-20 degree	>20 degree
Loss of Motion at Ankle	<10 degree	10-20 degree	>20 degree

Table Legend: 36points- Excellent; 35-33points- Good; 32-30points- Satisfactory; 29-27points- Moderate; 26-24points- Poor

Table 2: Hammer *et al.* Criteria [10]

Grade	Callus Formation	Fracture Line	Stage of Union
1	Homogeneous Bone Structure	Obliterated	Achieved
2	Massive Bone trabeculae	Barely Discernible	Achieved
3	Apparent bridging of fracture line	Discernible	Uncertain
4	Trace no. of bridging fracture lines	Distinct	Not Achieved
5	No callus formation	Distinct	Not Achieved

Results

The results of a total of 27 patients with 28 compound fractures of tibia with Gustilo Anderson Grade II, IIIA and IIIB were treated with TENS nailing. Case photographs of one patient are as shown. (Figure 1, Figure 2, Figure 3, Figure 4).



Fig 1: Pre-operative Xray picture



Fig 2: Post-operative Xray pictures



Fig 3: Wound condition (At Presentation and after primary closure)



Fig 4: Wound Condition

Age distribution, Sex distribution, Mode of injury and laterality of affliction are as shown in the tables. (Table 3 and Table 4)

Table 3: Age and Sex Distribution

AGE		
Age group	No. of Patients	Percentage
21-40 years	11	40.7%
41-60 years	13	48.1%
>60 years	3	11.1%
Mean age	42.62±12.02 years	
SEX		
Male	24	88.9%
Female	3	11.1%

Table 4: Mode of injury and Laterality of Fracture

Mode of injury		
Mode of injury	No. of Patients	Percentage
RSA	26	96.3%
Gunshot Injury	1	3.7%
Laterality		
Side	No. of Patients	Percentage
Right	15	55.6%
Left	11	40.7%
Bilateral	1	3.7%

In our study the majority of fractures were Gustilo Anderson Type II (46.4%) (n=13), followed by Type IIIA (32.1%) (n=9), followed by Type IIIB (21.4%) (n=6). All fractures had associated ipsilateral fibula fracture. 2 patients had Ipsilateral femur fracture (1 Femur shaft, and 1 Distal Femur Fracture) and 1 had Ipsilateral Lisfranc Injury, all of which were fixed surgically, either in the same sitting or at a different time.

The mean operating time in was 39.34±9.15 minutes, with operating time for fixation of 92.9%(n=26) fractures being <45 minutes and 7.1%(n=2) fractures between 46-90 minutes. There was an operating time of 80 minutes in the patient with gunshot injury due to time taken for retrieval of bullet fragment.

The mean time for wound healing was 5.2±1.4 weeks without the requirement of additional surgery for wound closure in any patient.

According to Karlstrom & Olerud Criteria, Excellent to Good results were seen in 82.1% fractures (n=23) and Satisfactory in 17.9% fractures (n=5). There was no fracture with moderate or poor results in our study.

According to Hammer *et al.* Criteria, Radiological union was achieved in 24.6% fractures (n=8), Radiological union was Uncertain in 53.6% fractures (n=15), and Radiological union was Not Achieved in 17.9% (n=5). And the time to union in our cases varied from 16-24 weeks with a mean time of 19.5±3.8 weeks.

Outcome According to Gustilo Anderson Classification of Fractures is shown in the table. (Table 5) Complications found in our study were; Delayed union (in 15 out of 28 fractures, 53.57%), superficial infection due to hardware prominence (in 9 out of 28 fractures, 32.14%), Non-union (in 5 out of 28 fractures,17.85%). Due to a superficial infection due to hardware prominence, TENS nails were removed in one patient after union was achieved. No patients in our study developed deep infection, neurovascular complications, implant failure, loss of reduction, iatrogenic fractures, joint stiffness or wound healing related complications.

Table 5: Outcome According to Gustilo Anderson Classification of Fractures

Gustilo Anderson Classification of Fractures	Union Achieved	Union Uncertain	Union Not Achieved
Grade II	38.46% of all Grade II (5 out of total 13 Grade-II)	46.15% of all Grade II (6 out of total 13 Grade-II)	15.38% of all Grade II (2 out of total 13 Grade-II)
Grade IIIA	22.22% of all Grade IIIA (2 out of total 9 Grade-III A)	66.67% of all Grade IIIA (6 out of total 9 Grade-III A)	11.1% of all Grade IIIA (1 out of total 9 Grade-III A)
Grade IIIB	16.67% of all Grade IIIB (1 out of total 6 Grade-IIIB)	50% of all Grade IIIB (3 out of total 6 Grade-IIIB)	33.33% of all Grade IIIB (2 out of total 6 Grade-IIIB;)
Total	8	15	5

Discussion

The management of compound fractures remains a challenge for the surgeon. They carry significant morbidity and subsequent disability, if not managed appropriately. The initial management of Open fractures usually affects the ultimate outcome [12]. With the advent of modern therapy, the expected outcome has improved dramatically with regards to the management of compound fractures. Whereas, one hundred and fifty years ago, mortality was common following compound fractures [13, 14]. Methods to decrease morbidity include early stabilization of fracture and debridement of the wound. Early soft tissue coverage plays an important role and use of prophylactic parenteral antibiotics has helped decrease the incidence of acute and chronic infection, including osteomyelitis [15].

In our study, the mean age of patients was 42.62±12.02 years, with majority patients (48.1%, n=13) having age between 41-60 years. In a study by Jaiswal R *et al.* [16] with TENS nailing for compound fracture fixation, the mean age of the patients was 39.6±14.49 years and the majority of patients belonged to the age group of 31-40 years. Baydar M *et al.* [17] and Soni JK *et al.* [18] report in their studies with external fixators, a mean age of 35.8±14.6 years and 38.3 years respectively. This suggests that compound fractures occur more commonly in middle aged people.

Majority of patients in our study were males (88.9%, n=24) and only 11.1% (n=3) were females. In a study by Jaiswal R *et al.* [16] 76.7% were males while 23.3% were females. In a study done by Anoop Kumar [19] 90% were males and 10% were females. This indicates that compound fractures are more common among males.

In our study, majority of fractures affected the right side (55.6%, n=15), in 40.7% patients (n=11) the left side was affected and 3.7% patients (n=1) had bilateral fracture. Roy S *et al.* [20] report that the right side was more commonly involved (70%) and left side was involved in 30% cases.

In our study, majority of patients (96.3%, n=26) had injury due to RSA and one patient (3.7%) had gunshot injury. In the study by Anoop Kumar [19] 95% cases had injury due to two-wheeler accidents. Road traffic accidents accounted for 100% of the cases in the study by Soni JK *et al.* [18]. Therefore it can be said that road traffic accidents lead to an impact strong enough to lead to compound fractures.

In our study, the majority (46.4%, n=13) were Gustilo Anderson Type II fractures. In a study by Jaiswal R *et al.* [16] majority fractures (40%) were Gustilo Type II. Parupalli S *et al.* [21] also report that majority fractures (48.38%) in their study were Type II. This indicates that the low grade injuries are more common than high grade injuries.

The mean operating time in our study was 39.34±9.15 minutes. In two studies, one by Baydar M *et al.* [17] and another by Borah PJ *et al.* [22] where compound fractures were fixed with an external fixator the mean operation time was

132±68.87 minutes and 67.6 minutes respectively. This indicates that time needed for fixation of compound fractures with TENS nails is less than the time taken for fixation of compound fractures using External fixator.

In our study, 21.42% (6 out of 28 compound fractures) developed no complication, and in the remaining 78.58% fractures the complications seen were; Delayed union (in 15 out of 28 fractures, 53.57%), superficial infection due to hardware prominence (in 9 out of 28 fractures, 32.14%), Non-union (in 5 out of 28 fractures, 17.85%). No patients in our study developed deep infection, neurovascular complications, iatrogenic fractures, implant failure, loss of reduction, or wound healing related complications. In a study by Jaiswal R *et al.* [16] which treated the compound fracture with TENS nail fixation, no patient required realignment of fixation for wound closure procedure and no patients had infection after definitive surgery. In various other studies evaluating the use of external fixators the main complications observed were pin tract infection (incidence varying from 21-50%), pin loosening (15-40%), pin breakage (upto 10%), joint stiffness (16-50%), malunion (%), neurovascular complications (upto 10%), osteomyelitis (6.1-17.5%) [19, 18, 17, 23-26]. This suggests that fixations with TENS nails have lesser chance for implant failure, development of deep infection and neurovascular complications as compared to external fixators. Moreover the apparatus of external fixators is bulky which can hinder the movements of patients as is evident by the rates of joint stiffness.

Functional results in our study were excellent to good in 82.1% fractures (n=23) and satisfactory in 17.9% (n=5) according to the Karlstrom & Olerud Criteria at 24 weeks. No patients in our study had poor results. Baydar M *et al.* [17] report excellent to good results in 45.8 % fractures, satisfactory in 16.7% fractures, moderate in 20.8%, and poor in 16.7% with the use of external fixators. In a study by Ocguder D *et al.* [23] with the use of ring external fixators, the functional outcome was good in 42.4%, satisfactory in 33.3%, and moderate in 24.2% patients. This indicates that better functional results can be obtained with the use of TENS nails, as compared with external fixators for the fixation of compound fractures. Furthermore, no patient in our study had poor results which were seen in some patients where external fixator was used.

According to Hammer *et al.* criteria 28.6% fractures (n=8) achieved radiological union, 53.6% fractures (n=15) showed signs of fracture healing but did not progress to complete radiological union and 17.9% fractures (n=5) did not achieve union by 24 weeks. Jaiswal R *et al.* [16] with the use of TENS nails report that 13.3% patients achieved union on TENS nails alone while majority of the patients (86.7%) required a definitive surgery. On comparing with the study by Jaiswal R *et al.* [16] our study has slightly better union rates. This however needs to be evaluated further as a large number

of patients in our study had delayed union and their progress could be recorded in studies with a longer follow up period.

Conclusion

We conclude that the use of TENs nail for the fixation of Compound Fracture of Long Bones of Lower Limbs is a feasible option with certain advantages pertaining to the Better local wound care, very good patient compliance, and ease of performing the surgery, short operating time, excellent to good functional outcomes, lesser iatrogenic damage to soft tissues and bone with subsequent lower risk of iatrogenic fracture since the cortex is not breached by multiple pins, lower incidence of deep infection and lower incidence of joint stiffness. However, the rates of delayed union were more in our study, but this could be attributed to the fact that the patients in our study were only followed up till 24 weeks and further progression of union could be recorded and evaluated in future studies with a longer follow up period and a larger sample size.

Ethical approval: The study was approved by the ethical committee of our Institute.

Conflict of Interest

Not available

Financial Support

Not available

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