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Comparison of casting versus elastic nail for the treatment of pediatric tibial diaphyseal fractures

Muneeb Ur Rehman Niazi[1], Syed Wasif Ali Shah[2], Riaz Qadeer[3], Abdul Qadir[4], Zaigham Habib[5], Sunit Dahal[6], Usman Amjad[7]

[1]PG Trainee MS Orthopaedics, Department of Orthopaedics, Shaikh Zayed Hospital, Lahore
[2] Associate Professor, Department of Orthopaedics, Shaikh Zayed Hospital, Lahore
[3,4] Senior Registrar, Department of Orthopaedics, Niazi Medical and Dental College, Sargodha
[5] Consultant Orthopaedic Surgeon, THQ Feroz wala Sheikhpura
[6]Consultant Orthopaedics, Department of Orthopaedics, Grand International Hospital Kathmandu, Nepal
[7]Consultant Orthopaedic Surgeon, Department of Orthopaedics, Shaikh Zayed Hospital, Lahore

Author`s Contribution

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Address of Correspondent
Dr. Muneeb Ur Rehman Niazi
PG Trainee MS Orthopaedics,
Department of Orthopaedics,
Shaikh Zayed Hospital, Lahore
Email:
muneebniazi87@gmail.com

ABSTRACT

Objective: To assess outcomes of Titanium elastic nail (regarding radiologic union, discrepancy of limb length, malalignment, pain and complications) in treating pediatric tibial fractures in comparison with the traditional Casting method.

Methodology: This randomized controlled trial study was conducted in Department of Orthopaedics, Shaikh Zayed Hospital, Lahore through emergency /Outdoor patient department from Jan 2018 to Dec 2018. The total number of patients were categorized into two groups, 14 each group. In Group A, patients underwent treatment by elastic nails and patients in group B, underwent treatment with cast method. Post op X-Rays (serial) were done and Leg length inequality, Malalignment, pain and radiological union were assessed radiologically. Follow up of the patients was done in the outpatient department of Orthopaedic department after 1,3 and 6 months. The comparison for this among both groups was done by using Chi-square test. P value ≤ 0.05 was considered significant.

Results: The mechanism of injury was statistically same in both groups, p-value > 0.05. In group-A, 7(50.0%) cases had Transverse, 4(28.6%) had Oblique and 3(21.4%) cases had comminuted fracture while in group-B there were 5(35.7%) cases who had Transverse, 2(14.3%) had Spiral, 4(28.6%) cases had Oblique and 3(21.4%) cases had Comminuted fracture, p-value > 0.05. In both groups, the leg length inequality, frequency of malalignment, pain severity and complications were statistically same, p-value was > 0.05.

Conclusion: Similar outcomes of Titanium elastic intramedullary nailing as compared to cast application in terms of bone union, alignment and infection rates.

Keywords: Tibial fractures, Leg length inequality, Malalignment.

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Introduction

Tibia is a long bone of human body that is superficially located, due to which it is more prone to fractures.[1] Pediatric fractures of tibia are the 3rd commonest fractures of long bones after forearm and femoral fractures[2] and in pediatric hospitals, these fractures are the 2nd commonest reason for orthopaedic inpatient

admissions. The annual incidence of tibial shaft fractures of children (infancy-18 years) among boys has been shown to be almost 190 per 10,000 and 110 per 10,000 among girls.[3]

Regarding the pediatric tibial fractures, less research has been published so far. There are specific unique features that are seen in tibial fractures of children such as discrepancy of leg length by tibial overgrowth and there is spontaneous improvement due to remodeling.[4] In children that are 12 years or above, this is not a consistent phenomenon and therefore a strict criteria should be followed for acceptable reduction in such cases.[5] There is an excellent healing potential of pediatric tibial shaft fractures due to the biological potential of their periosteum to heal and mostly without any complications.[6,7]

In most of the pediatric diaphyseal fractures of the tibia, close reduction and cast immobilization is a successful choice of treatment and is a gold standard of care. It is observed that low-energy tibial shaft fractures mostly can be treated non-operatively, whereas comminuted, open or displaced fractures mostly benefit from surgical treatment. In those cases in which fractures are not effectively managed by closed methods, other treatment choices are present such as intramedullary stabilization, pins in plaster, external fixation, open reduction with internal fixation.[8]

There are certain conditions in which there is failure of reduction method. Such conditions include angulation, malrotation at the site of fracture or excessive shortening and require operative intervention.[9] In certain cases, where there is polytrauma, open fracture, severe soft tissue compromise or compartment syndrome, surgical treatment is necessary.

Previously the treatment options for unstable tibial shaft fractures requiring operative fixation included internal fixation and open reduction with plates or close reduction and external fixation using fixators but there are certain complications associated with these techniques such as overgrowth, loss of reduction and infection.[10]

"Elastic stable intramedullary nail (ESIN) implants" have been used by French surgeons for more than 2 decades showing good results.[11] Based on its French city of origin, this technique has also been called "Nancy nailing". These implants limit stress shielding and promote oscillation which promotes the formation of callus at the fracture site and healing.[12] These nails are neither load bearing nor load sharing devices.

In this method the two bent nails cross each other and provide 3 point fixation within the medullary canal, by which the traction forces transform into compression forces. The 3 point fixation stability occurs at i) Site of entry ii) Fracture site iii) Distal end and therefore resist the bending forces. This also acts as internal splints for most fractures and it maintains length, alignment and also provides rotation for most fractures. This technique, also called flexible intramedullary nailing has many proposed advantages.

It leads to early mobilization, immediate fracture stabilization, there is less soft tissue disruption and lower infection rates. There is rapid return to daily functioning than the conservative treatment.[13] This technique provides fixation that is elastic and stable and allows controlled repetitive motion at the fracture site. This leads to cyclic loading and also provides resistance to rotational and angular deforming forces. Controlled motion at the site of fracture leads to improved healing of long bones.[14]

Titanium elastic nailing has previously been a successful technique for treating fractures involving the femur, tibia, humerus and forearm in children.[15] It has been used to stabilize fractures in children of school going age but the relevant controlled studies are very few and there is a relatively short term follow up for such cases in order to assess the benefits, risks and complications of this technique compared to those observed in traditional traction and cast application.

Operative treatment has social, psychological, economical and educational advantages as compared to conservative treatment due to early mobilization and shorter hospitalization. In children above five years of age presenting with this type of fracture, when treated with plaster can lead to malunion, loss of reduction, complications associated with plaster and intolerance.[16] But since the last two decades, operative approach has become more popular for treating children that are above 6 years of age.[17]

The development of TENS has proved to be a simple technique with biocompatible and load bearing internal splint that allows early mobilization. In this procedure epiphyseal growth plate is not breeched and therefore prevents from growth disturbance and has less risk of complications. Due to its advantages and less complications, it has emerged as the most popular

surgical modality being used for managing lower extremity long bone fractures in children.[11]

Objective of this current study was to assess outcomes of Titanium elastic nail (regarding radiologic union, discrepancy of limb length, malalignment, pain and complications) in treating pediatric tibial fractures in comparison with the traditional Casting method.

Methodology

This Randomized Controlled Trial study was conducted in Department of Orthopaedics, Shaikh Zayed Hospital, Lahore through emergency /Outdoor patient department from Jan, 2019 to Dec, 2019. Randomized Sampling technique was applied. The sample size was calculated by the 99% confidence level and was estimated to be 28 patients (14 in each group), 80% power of test with an expected mean of bone union time with elastic nails 4±2 months and with cast 9±5 months.[18]

The participants of this study were counseled and those who gave consent were included and were placed in either of two categories. The technique applied on each category was randomly decided by lottery method of sampling. The total number of patients were categorized into two groups. In Group A patients underwent treatment by elastic nails and patients in group B underwent treatment with cast method. The group names were written separately on slips and were put in a big jar and then the patient was told to pick out a slip. The patient was allocated to the group written on the chosen slip.

Patients included in this study were of Both genders, age ranging from 7-14 years and all those who presented during two weeks of injury and had displaced tibial diaphyseal fracture (cortical contact less than 50%). All those who had Fractures of open type, presented with Compartment syndrome, those who presented with severe soft tissue compromise, Intra articular proximal or distal tibial fracture, associated ipsilateral lower limb fracture, Osteogenesis imperfecta, congenital pseudoarthritis, skeletal dysplasia and Closed tibial physis were excluded in this study.

After approval from Hospital ethical approval committee this study was conducted. Informed written consent was taken from all participating patients for research. After doing the pre-operative workup, according to the allotted group the patients were operated (elective list) by the principal researcher under the supervisor's supervision. The patients were kept in the ward post operatively and after satisfactory post op recovery the patients were discharged and on OPD basis follow up of all the patients was done. Radiographs (Antero posterior and lateral views) of the involved tibia including the knee joint and ankle joint were taken.

X-Rays (serial) were done and Leg length inequality, Malalignment, pain and radiological union were assessed radiologically. Follow up of the patients was done in the outpatient department of Orthopaedic department after 1,3 and 6 months. After the clinical and radiological assessment and confirmation of bone union, plaster and gliding nails were removed accordingly. Weight bearing was started gradually after callus formation (6-8 weeks) depending on the radiological findings. Outcome was evaluated by TEN outcome scoring and was graded excellent, satisfactory and poor accordingly. Radiological union was evaluated by bridging callus across fracture site:[9]

All the data was entered and processed by using SPSS v 23.0. Radiological parameter like bone union and functional outcomes using TEN's scoring system at 1,3 and 6 months was presented as mean ± SD for both groups. For the comparison among both groups, t-Test was used. The rates of functional outcome and complications in both groups were presented in frequencies and percentages. The comparison for this among both groups was done by using Chi-square test. P value ≤ 0.05 was considered significant.

Results

Among total number of 28 patients, the mean age was 10.79 ± 1.19 years with minimum and maximum ages as 9 and 13 years. In group-A the mean age of cases was 10.50 ± 10.019 years while in group-B the mean age of cases was 11.07 ± 1.328. In total there were 16(57.14%) male and 12(42.86%) female cases, with male to female ratio as 1.33:1. According to the comparison of Gender in both study groups, In group-A there were 9 (64.3%) male and 5 (35.7%) female cases while in group-B there were 7 (50%) male and 7 (50%) female cases. Chi-square = 0.583, P-value = 0.445.

In total, there were 10 (35.71%) patients who presented with fall, 1 (3.57%) had abuse, 15 (53.57%) cases had road traffic accident (RTA) and 2 (7.14%) cases had other mechanism of injury.

In group-A, 5(35.7%) patients presented with fall, 1(7.1%) had abuse, 7(50.0%) had RTA and 1(7.1%) had

other cause of injury while in group-B, 5(35.7%) had fall, 8(57.1%) had RTA and 1(7.1%) cases had other cause of mechanisms of injury. The mechanism of injury was statistically same in both groups, p-value > 0.05. Chi-square = 1.067, p-value = 0.785

Comparison of Fracture Geometry of injury in both study groups showed that in group-A, 7(50.0%) cases had Transverse, 4(28.6%) had Oblique and 3(21.4%) cases had comminuted fracture while in group-B there were 5(35.7%) cases who had Transverse, 2(14.3%) had Spiral, 4(28.6%) cases had Oblique and 3(21.4%) cases had Comminuted fracture, p-value > 0.05. Chi-square = 2.33, p-value = 0.506.

Comparison of Leg Length Inequality (1 Month, 3 Months and 6 Months) in both study groups showed that at 1st month in group-A, 1(7.1%) case had leg length inequality, while at 3rd month and 6th month, in group-A and group-B, 1(7.1%) case each had leg length inequality. In both groups, the leg length inequality was statistically the same at each visit, p-value was > 0.05.

The comparison of Malalignment (1 Month, 3 Months and 6 Months) in both study groups is shown in Table I. The frequency of malalignment was statistically same in both groups at each visit, p-value > 0.05. The Comparison of Complications (1 Month, 3 Months and 6 Months) in both study groups is shown in table II. The complications in both study groups were statistically same at each visit, p-value > 0.05. Comparison of Pain (1 Month, 3 Months and 6 Months) in both study groups is shown in Table III. The pain severity in both groups was also statistically same, p-value was > 0.05.

Table III: Comparison of Pain (1 Month, 3 Months and 6 Months) in both study groups

		Groups		Chi-square	p-value
		Group-A	Group-B		
Pain (1 Month)	No	9(64.3%)	9(64.3%)	0.476	0.788
	Mild	3(21.4%)	4(28.6%)		
	Moderate	2(14.3%)	1(7.1%)		
Pain (3 Months)	No	13(92.9%)	9(64.3%)	3.394	0.065
	Mild	1(7.1%)	5(35.7%)		
Pain (6 Months)	No	13(92.9%)	11(78.6%)	1.167	0.280
	Mild	1(7.1%)	3(21.4%)		

Table I: Comparison of Malalignment (1 Month, 3 Months and 6 Months) in both study groups

		Groups		Chi-square	p-value
		Group-A	Group-B		
Malalignment (1 Month)	No	14(100.0%)	13(92.9%)	1.037	0.309
	Yes	0(0.0%)	1(7.1%)		
Malalignment (3 Month)	No	13(92.9%)	13(92.9%)	0.000	1.000
	Yes	1(7.1%)	1(7.1%)		
Malalignment (6 Month)	No	12(52.2%)	11(47.8%)	0.243	0.622
	Yes	2(14.3%)	3(21.4%)		

Group-A: Intramedullary Titanium Elastic nailing, Group-B: Cast application

Table II: Comparison of Complications (1 Month, 3 Months and 6 Months) in both study groups

		Groups		Chi-square	p-value
		Group-A	Group-B		
Complications (1 Month)	None	12(85.7%)	11(78.6%)	5.043	0.080
	Knee stiffness	0(0.0%)	3(21.4%)		
	Pin tract infection	2(14.3%)	0(0.0%)		
Complications (3 Months)	None	13(92.9%)	11(71.4%)	4.16	0.125
	Knee stiffness	0(0.0%)	3(21.04%)		
	Pin tract infection	1(7.1%)	0(7.1%)		
Complications (6 Months)	None	13(92.9%)	12(85.7%)	3.040	0.219
	Knee stiffness	0(0.0%)	2(14.3%)		
	Pin tract infection	1(7.1%)	0(0.0%)		

Discussion

In pediatric age group, surgical management of fractures involving lower extremity long bones has been controversial. Over the past two to three decades various treatment options have been applied and they were all associated with some complications. The treatment options for the age group of 5-14 years include traction, external fixation, compression plates and flexible/elastic stable intramedullary nailing, Plate osteosynthesis are used widely but have complications such as infection, delayed union and is associated with large dissection for implant removal, large exposure and have a relative longer duration of immobilization.[19] External fixation has good stability and early mobilization but on the other hand has complications such as loss of reduction, re-fractures through tracts and can also cause pin tract infections.[20]

Although the standard treatment of tibial fractures is still cast immobilization but the pediatric orthopaedic surgeons have been making efforts to minimize the prolonged immobilization required after the treatment. Fixation is of benefit in cases where the children have head injuries, open fractures, multiple injuries due to high energy trauma, compartment syndrome and in cases of children with older age.[21]

Many previous studies have demonstrated the effectiveness of surgical treatment in tibial fractures seen in children. In pediatric tibial fractures, the best internal fixation device should be a simple load sharing device that is able to maintain the alignment, does not cross the physis, is easy to insert and remove and causes mobilization which helps in formation of bridging callus. The treatment choice which fulfils most of these criteria is elastic intramedullary nailing and has led increasing number of surgeons to use this technique in treating long bone fractures such as tibial shaft fractures in children.[22]

Elastic stable intramedullary nailing done in cases of long bone fractures of the skeletally immature has gained a lot of popularity due to lesser chances of complications and effective treatment response. In many previous studies this technique has been used in femur and various advantages have been noted such as preservation of fracture hematoma, closed insertion and physeal-sparing entry point.[11]

Patients should be informed about these choices. In literature it has been suggested that when intramedullary nailing is done for displaced tibial fractures, its outcome may be better than that of nonoperative treatment done for such fractures. If the treatment chosen is of cast, then the surgeon should have skills of proper cast immobilization techniques and patient should have frequent follow-ups and proper adjustments while treatment is being done.[23] The technique of Titanium elastic nails has biomechanical stability due to the divergent ‘‘C’’ configuration. This leads to six points of fixation and acts as an internal splint.[24] Titanium elastic nailing technique provides elastic and stable fixation and this leads to controlled motion along the site of fracture. This results in healing by external callus.

Titanium elastic nailing has successfully been used in Europe for many decades and TENs also gained acceptance in North America in mid1990s. Since that time, several studies of North American on pediatric tibial shaft fractures, have shown efficacy and safety of this technique.[11] But only limited studies on tibial shaft fractures have discussed the role and use of titanium elastic nailing.[25]There are a few studies that have shown the usefulness of elastic stable intramedullary nailing done in tibial fractures [9] and a few studies are on the management of tibial diaphyseal fractures seen in children treated by intramedullary fixation.[6,7] O’Brien et al. in his study, reported 16 tibial fractures which were treated by intramedullary nailing fixation and the results showed very good functional outcome. In one case superficial infection was noted, in six cases there was coronal angulation and in seven cases there was sagittal angulation but functional compromise was not seen. [6]

Leg length discrepancy of about 1.5cm was seen in one child.[6] Vrsansky et al. reported 308 children having long bone fractures, which were treated with flexible intramedullary nailing and along these 36 cases were of tibial fractures. The functional outcome was excellent because all the patients were independently mobilized after three to five months.[26] Two other studies on the use of titanium elastic nails in children having tibial diaphyseal fractures, showed less malalignment, high union rate and less complications.[6,15]

In another patient after bone union (having grade II open fracture), Osteomyelitis was diagnosed at the site of fracture. In two cases, nail migration developed through the skin which required nail removal or modification. So in pediatric diaphyseal tibial fractures, fixation with titanium elastic nails is very effective but can have various complications as well.[8]

In most of the studies there is male predominance. In a study by Debnath S et al. there were 22(73.3%)males and 8(26.7%) female patients who underwent TENS nailing for the tibial diaphyseal fractures and in this study fractures due to road traffic accident (RTA) were 50% (15 fractures) , due to fall were 30%(9) and due to sports injury were 20%(6).[27]

Conclusion

According to the findings of our study, we found similar outcomes of Titanium elastic intramedullary nailing as compared to cast application in terms of bone union, alignment and infection rates. In future any of them can be applied to gain better outcome.

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