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Rust score–An adequate rehabilitation guide for diaphyseal femur fractures managed by TENS

Ekansh Debuka, Narendra Singh Kushwaha*, Dharmendra Kumar, Ajai Singh, Vineet Sharma

Department of Orthopaedics, KGMU, Lucknow, 226018, U.P., India

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ABSTRACT

Introduction: The optimal mode of treatment among the wide variety of surgical and nonsurgical treatment options for children between 5 and 15 years of age continues to be controversial. Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications.
Methods and methodology: From Jan 2015 to August 2016, 35 patients including 37 limbs with diaphyseal fractures of the femur in the age group 5–15 years were managed by Titanium Elastic nailing and their clinico-radiological and functional outcome was assessed at 1 year post operatively as per the Flynn's criteria. RUST score was used as a guide for post-operative rehabilitation.
Results: 37 patients were managed by TENS nailing including 28 males and 9 females. The outcome in proximal, middle or distal fractures of the shaft were found to be similar and the difference was statistically insignificant. Similarly, the difference in the outcomes as per fracture patterns was also found to be statistically insignificant. Partial weight bearing was allowed after a score of 6 was achieved and full weight bearing after a score of 8.
Conclusion: As per the Flynn's criteria, 75% of the patients (28 out of 37) were found to have an excellent outcome while 7 had a satisfactory outcome and two had a poor outcome. RUST score can be used as an effective guide for post op rehabilitation.

1. Introduction

Lower limb fractures, typically caused by blunt trauma, are the most common major pediatric injuries and 70% of those involve the femoral shaft.[1] Closed reduction and pop hip spica application is the most widely accepted management for diaphyseal femur fractures in children under 5 years of age while antegrade solid intramedullary nails are the standard treatment in skeletally mature adolescents of more than 15 years of age. [2–4]

Although there exist various surgical and nonsurgical treatment options for children between 5 and 15 years of age, operative reduction and fixation with flexible intramedullary titanium nails (TENS) has become the standard.[5] These simple load-sharing flexible nails are simple, effective and function as an internal splint as the fracture unites. Many studies support their use citing advantages like closed insertion, preservation of the fracture hematoma, early mobilization, micromotion at fracture site that encourages union and a physis sparing entry point.[6,7]

However, there is no definitive post-operative rehabilitative protocol for patients managed by elastic IM nailing. Several key factors like splintage and weight bearing resumption are a matter of surgeon's training and preference. This study was undertaken to assess the use of RUST score to guide the post-operative rehabilitative protocol and the safety and efficacy of TENS for femur fracture treatment in children between 5 and 15 years.

2. Materials and methods

This prospective study includes 37 cases admitted at the Department of Orthopedics Surgery, of our institution between Jan 2015 and Dec 2016. Twenty-eight patients were male and nine females. Nine patients (24.3%) were above the age of 12 years. Only children between the age of 5 and 15 years with a closed or a Gustillo Anderson Grade I diaphyseal fractures of the femur were included in the study.[8] Those with metaphyseal fractures, Gustillo Anderson grade II or III compound fractures, pathological fractures and those with congenital or medical co morbidities were

* Corresponding author.
E-mail addresses: ekansh.debuka@gmail.com (E. Debuka), orthosurgeon.narednra2007@gmail.com (N.S. Kushwaha), dharmendra00715@gmail.com (D. Kumar), as29762@gmail.com (A. Singh), vineet902011@gmail.com (V. Sharma).

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excluded. A written consent was taken and an ethical committee clearance was obtained from the institution.

The patients were assigned into 3 different groups based on the fracture pattern as per the AO classification of diaphyseal fractures of the shaft of femur. Group A included spiral or oblique (AO 32 A1 and 32 A2), group B - transverse (AO 32 A3) and group C – wedge or comminuted fractures (AO 32 B and C).[9] Further sub-grouping was done based on whether the fracture was in the proximal, mid or distal 1/3rd of the diaphysis.

2.1. Pre-operative work up

Patients were evaluated for their fitness for surgery and anesthesia as per our institution norms and were operated by a retrograde nailing technique within five days of admission. The internal diameter at the isthmus of the femur was calculated and two nails of forty percent of this measurement were selected so that the opposing bending forces were equal.[10]

2.2. Operative technique and considerations

All patients were operated under regional anesthesia on a fracture table. The entry was made using a bone AWL 2 cms proximal to the distal physis of the femur and 2 adequately sized pre-bent nails were introduced into the canal. The amount of bending was three times the diameter at the isthmus of the shaft.

In two cases, where closed reduction could not be attained, the fracture site was opened from the lateral aspect of the thigh, the soft tissue interposition released and the nails advanced. It was made sure that the patella was facing upwards and the foot was in neutral position at the time fixation to prevent rotational mal-alignment. The distal portions of the nails were left slightly protruding from the bone to prevent migration and ease their removal when required.

A Liston's long splint was given and removed after stitch removal on the 10th post-operative day. Those patients with comminuted fractures were given a POP hip spica for upto six weeks post operatively. Static in bed quadriceps and hamstrings exercises were done till splint or spica removal. Once removed, dynamic quadriceps and hamstrings drill were started and the patients kept non-weight bearing till adequate union was achieved

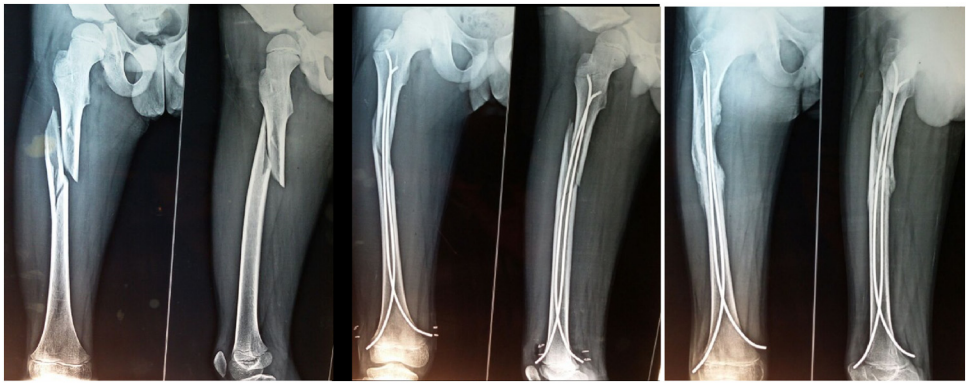
2.3. Post-operative follow up

Patients were followed up at 3 weeks, 3 months, 6 months and 1 year and assessed for clinical and radiological signs of union. The range of motion (flexion and extension) at the knee and the hip joints were noted with the help of a goniometer and complications like limb length inequality, angulations at the fracture site, infection or entry site ulcers were noted and duly addressed.

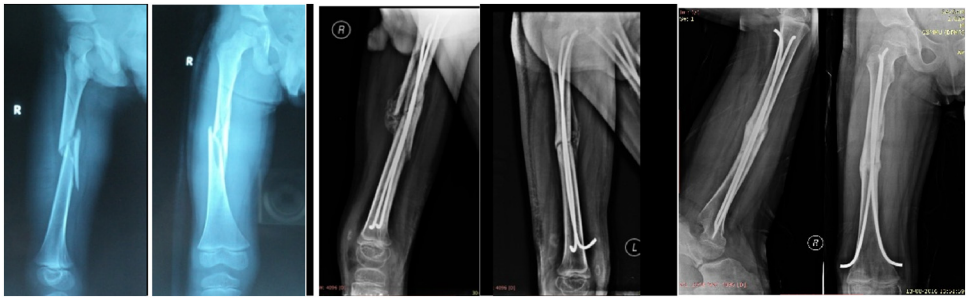
2.4. Outcome assessment

The Radiographic Union Scale for Tibia fractures (RUST) score [11] was used to assess the callus formation and radiological union. Each femur cortex (anterior, posterior, medial and lateral) was assigned a score from one to 3. A cortex with a visible fracture line and no callus was given a score of one, a visible fracture line but with callus present was given a score of 2 and callus without a fracture was scored as 3. The minimum total score was 4 and the maximum was 12 (healed).

This scoring was used to guide the post-operative rehabilitation in our patients at follow ups. Once a total score of 6 was achieved, the patients were allowed partial weight bearing with a walker.



Pic 1–3. Patient 1 X-rays.



Pic 4–6. Patient 2 X rays.

Full weight bearing was commenced when a minimum RUST score of 8 was achieved.

2.5. Statistical analysis

The outcome at the final follow up was assessed using the Flynn's criteria.[5] The complications were classified as major or minor and the final outcome classified as excellent, satisfactory or poor. Descriptive statistics like numbers, percentages, average and mean were used to represent the results and P value was used assess the significance of the results.

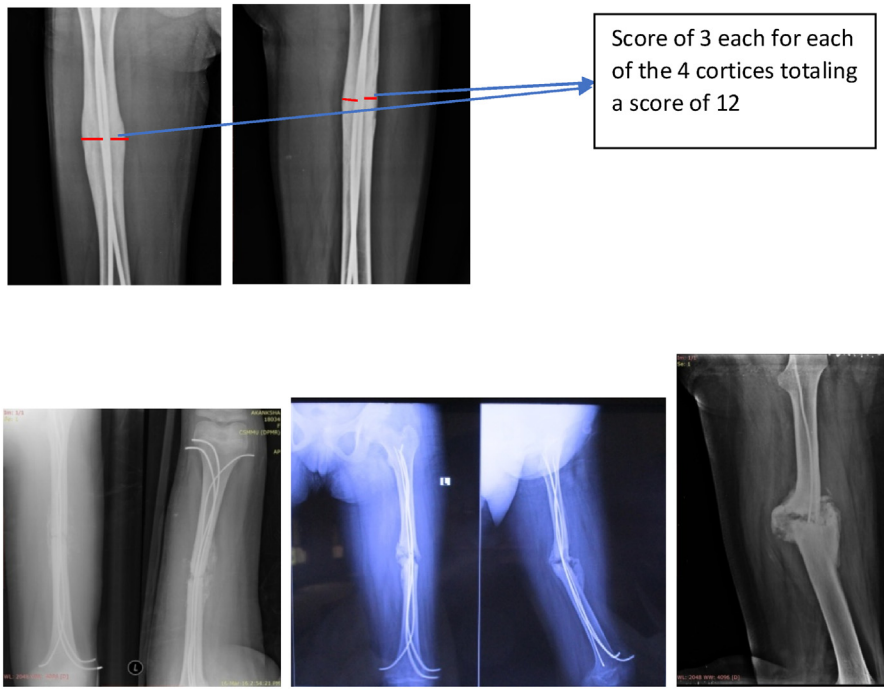
3. Results

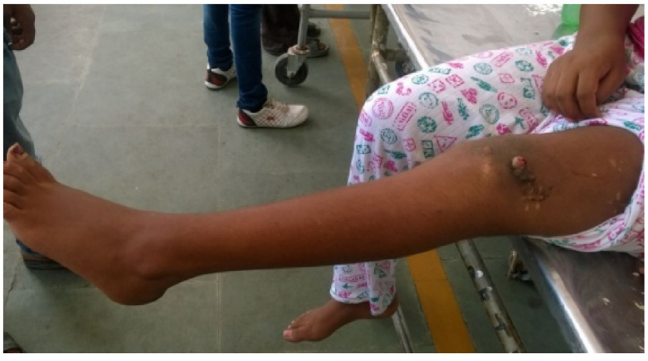
The 37 patients were divided into three groups based on the fracture location on the diaphysis as proximal, mid and distal 1/3rd. Two patients had a Grade 1 compound fracture shaft femur. Road traffic accidents (72.9%) followed by fall from a height (21.6%) was the most common cause of injury. The average time of union was found to be 11.2 weeks (7.2–13.2 weeks). Two wires of the same size were used in all cases but one. The average duration of hospital stay was found to be 7.3 days (Table A1).

Partial weight bearing (RUST score of 6) was started at an average of 6.3 weeks in group A, 5.6 in group B and at 9 weeks in group C. Full weight bearing was allowed at a mean of 9.4 weeks in group A patients, 9.1 weeks in group B and 12 weeks in group C.

The average time of attaining a RUST score of 6 was 6.27 weeks and a score of 8 at 9.74 weeks. When classified as per the location of the fracture on the diaphysis, proximal fractures achieved a RUST score of 6 at 6.5 weeks and a score of 8 at 9.8 weeks. The mid shaft fractures had score of 6 at 7.2 weeks and 8 at 9.7 weeks. The distal shaft fractures had RUST score of 6 at 5.1 weeks and 8 at 11 weeks.

The average range of motion at the final follow up was compared between the different groups and best results were obtained for fractures in the middle one third. The difference though was not found to be statistically significant. ($P > 0.05$) Similarly the average range of motion at the final follow up was compared between patients with different fracture patterns. The best results were obtained with A3 type of fractures but the difference was not found to be statistically significant. ($P > 0.05$)





Pic 7–12. Patient with 3 TENS nails with complication of Non uion.

Five patients (13.5%) during the course of treatment developed entry point wounds of which 2 recovered with a short duration of antibiotics. The other 3 healed after implant removal post fracture healing. One patient developed non union and had implant breakage during the removal. Another patient developed infection at the fracture site which required another surgery in the form of debridement, implant removal and sequestrectomy.

The final outcome was evaluated at the final follow up at 1 year using the Flynn's criteria. Twenty-eight patients (75.6%) had an excellent outcome, 7 had a satisfactory outcome (18.9%) and 2 (5.4%) had a poor outcome.

4. Discussion

Casting is considered the gold standard treatment for femur fractures especially in the young up to 11 years of age [3,12–15] Czertak et al. though advised casting as a viable option only up to 6 years of age because it leads to a period of prolonged immobilization and complications like shortening or angulation.[2] Elastic intramedullary nailing, a simple and effective method, has become the treatment method of choice for the age group between 5–15 years with a short learning curve, lesser infection rates and faster rehabilitation.[5,16,17]

The average duration of hospital stay in our study was found to be 7.1 days (4 to 18 days) which is similar to what is reported in literature of 5–10 days.[12,18,19] Greisberg J et al had reported a mean hospital stay of 6 days for TENS nailing versus 29 days for hip spica casting.[20] The duration of hospital stay is greatly reduced with elastic intra medullary nailing and allows quicker return to functional independence. Road traffic accidents (RTA) was the most common mode of injury (72.9%) in our patients. Most studies in literature report the same[2,21,22] but Nisar et al[23] found fall from height as the most common mode of injury.

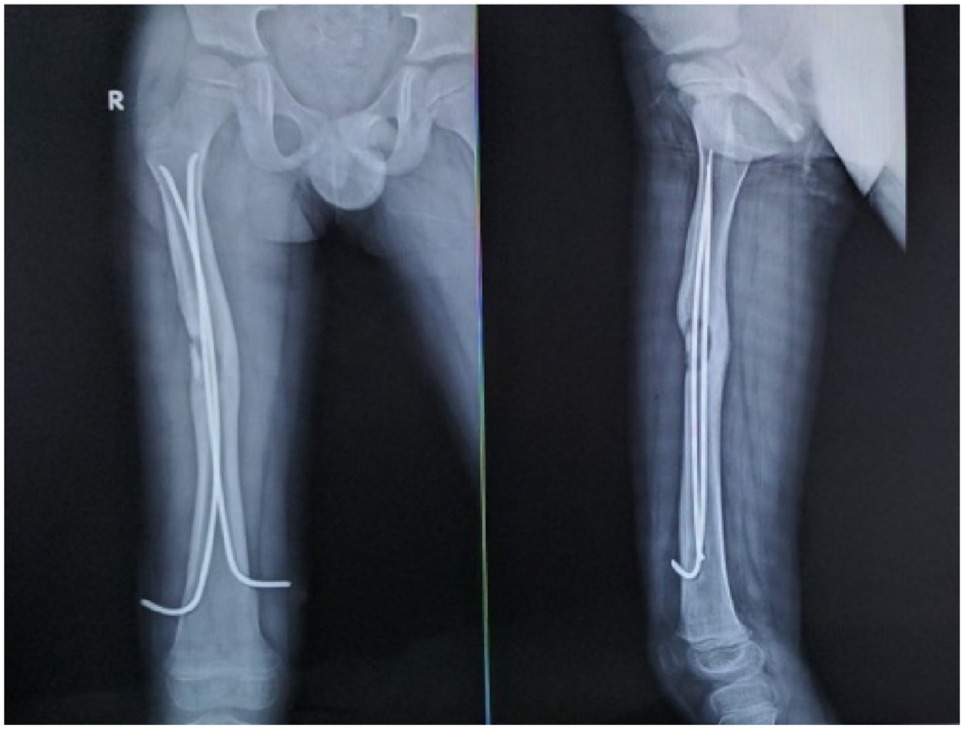
Twenty-eight of our patients (75.6%) had an excellent outcome, seven had a satisfactory outcome and two patients had a poor outcome. Two patients who were managed by open reduction and had good outcomes like those managed by closed reduction. However, the numbers of patients managed by open reduction are too few to be able to compare the outcomes in our study. The difference in the outcome between patients with different types of fractures and location of fracture was not statistically significant. ($P > 0.05$) These findings are in accordance with those reported by Moroz et al [24] and Nascimento et al [18] (Pic 1–3, Pic 4–6).

Different studies have reported varying time periods for resuming weight bearing ranging from a few days to several months. There exists no prescribed objective protocol to guide the post operative rehabilitation. In the present study, we used the RUST score as a guide to rehabilitative care to clearly define a particular time at which we allowed for partial and full weight bearing. We believe that in time this could be standardized and used as a definitive guide for rehabilitation in such patients.

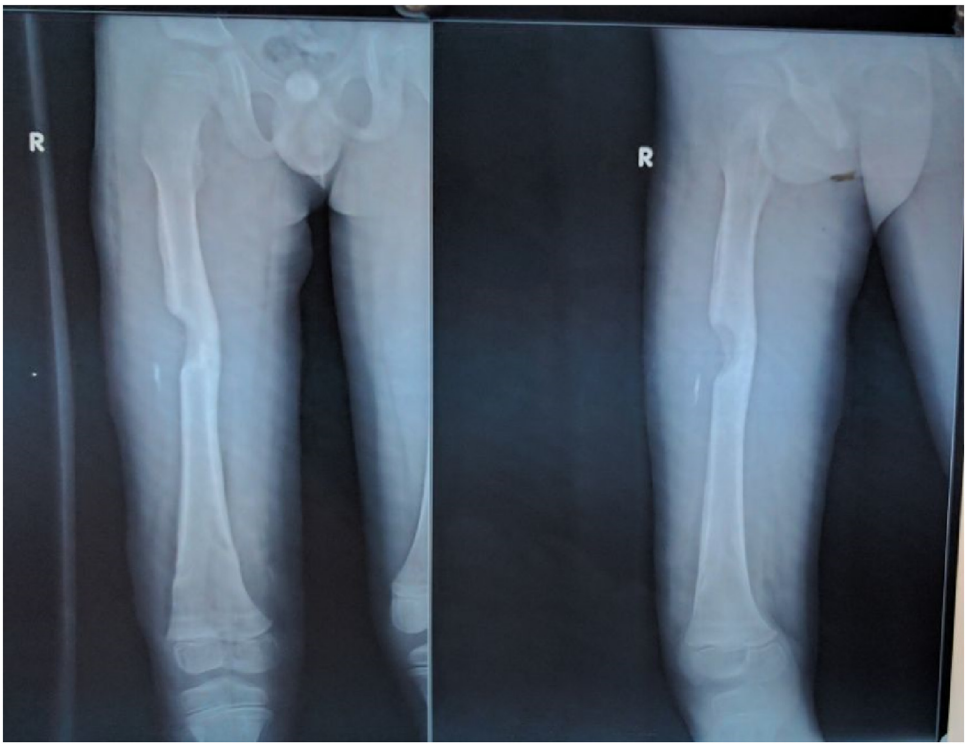
Intramedullary nails provide relative stability and allow for micro motion at the fracture site. This allows for abundant callus formation which, in time, bridges the fracture gap. The RUST score is a method to assess the maturity and completeness of this callus formed and thus function as a guide to rehabilitative decisions (Pic 7, 8).

Partial weight bearing was allowed after achieving a score of 6 and full weight bearing after a minimum score of 8 as per the RUST score. The average time to allow for partial weight bearing was 6.27 weeks and full weight bearing at 9.74 weeks. Bhuyan et al used the Anthoney classification for grading callus formation and guiding rehabilitation. [25] They reported partial weight bearing at an average of 3.5 weeks and full weight bearing at 9.5 weeks. The use of RUST score helped objectively determine a fixed time for resumption of weight bearing. This helps avoid early weight bearing which leads to an increased risk of angulation at the fracture site.

Entry point pain and wound complication were seen in seven patients (18.9%). All the patients had at least 15 degrees of limitation in the terminal range of motion due to nail impingement. Narayanan et al studied 79 patients over a period of 5 years and noted pain at the insertion site in 41 patients (51.8%) due to



Pic 13. Post op X ray at 6 months for patient with infection at fracture site.



Pic 14. Post saucerization x ray at 7 months for patient with infection.

bent or prominent nail ends. [26] They reported complications like malunion, re-fracture, transient neurological deficit and superficial wound infection. They concluded that it had best outcomes with transverse, short oblique and spiral fractures with minimal comminution. Ligier[12] reported more positive outcomes with TENS with only 13 out of 118 patients with local ulceration and none with any functional issues at one year follow up.

We found a high number of patients (~20%) associated with pain and ulceration at entry site with one patient going into non union. The protruding nails lead to irritation of the muscle and the skin and stand the risk of migration as movement is started and the child grows. These complications often necessitate nail removal but it should be delayed until sufficient fracture healing has been attained. If the nails are not left protruding and are adequately bent, the complications can be greatly reduced.

The use of 3 TENS nails in one of our case was associated with a poor outcome with the patient developing entry point wound, limited knee flexion and non union with angulation at the fracture site. Six months post operatively, the nails were removed but it resulted in implant breakage. The broken nail being intra medullary in position was left in situ and the patient was given a thigh brace. The patient eventually recovered 0–110 degrees flexion at the knee joint and resumed weight bearing after 10 months from injury. The patient had 1.5 cms shortening at the final follow up and an anterior angulation of 23 degrees and external rotation mal-alignment (Pic 9–12).

Another patient developed a discharging sinus at the fracture site at the final follow-up but had attained fracture union. The implants were removed and an excision of the sinus tract followed by sequestrectomy and saucerization was done. The patient was disallowed for weight bearing and is under follow up for the same. (Pic 13, 14)

Elastic intramedullary nailing is an effective way to treat femur fractures in the skeletally immature with mostly minor complications that can be treated easily. Meticulous surgical technique can limit complications and can be used safely for all fractures of the femoral diaphysis. The shortcomings of our study are a relatively small sample size and limited follow up.

5. Conclusion

The RUST score can be used as an effective guide to post operative rehabilitative care and help prevent complications of early weight bearing.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Appendix.

Table A1
Number of patients classified as per fracture pattern and site of fracture.

Fracture pattern (AO Classification)	Proximal	Mid	Distal	Total
Group A	4(10.8%)	5(13.5%)	1(2.7%)	10(27%)
Group B	4(10.8%)	14(37.8%)	3(8.1%)	21(56.7%)
Group C	2(5.4%)	4(10.8%)	0	6(16.2%)
Total	10(27%)	23(62.1%)	4(10.8%)	37(100%)

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