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Prospective Research on the "Functional Outcome of Diaphyseal Femur Fractures in Children Aged 5-10 Years Treated with Titanium Elastic Nailing System (TENS)"

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: A common injury in youngsters is a femoral shaft fracture. Motor vehicle accidents, sports trauma and physical assault are the most common causes of injury. In children, it is usually treated conservatively, but intra-medullary nailing with Titanium Elastic Nailing System (TENS) is becoming more popular in teens, therefore we chose this age group for study regarding management of femoral shaft fracture.
Aim: To study the functional outcome in children with shaft of femur fracture, treated with TENS.
Materials and Methods: A prospective observational study was conducted between May, 2018 to November, 2020 among patients of 5-10 years age group with shaft of femur fracture admitted in orthopaedics department of Government Medical College, Kota, Rajasthan.
Results: TENS nailing is a comparatively simple, less invasive, as well as less time-consuming technique and has reasonably good clinical and radiological results. The end outcome in our study was outstanding in 18 cases, good in 16 cases, and bad in just 6 cases.

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Conclusion: From our research, we believe that CRIF with TENS nail is the standard treatment for femoral shaft fractures in children between the ages of 5 and 10. It is a minimally invasive and less time-consuming procedure that does not damage the growth plate in growing children. As a result, the fractures unite earlier.

Keywords: TENS nail; Close Reduction and Internal Fixation (CRIF); children; fracture shaft femur.

1. INTRODUCTION

Orthopaedic surgeons handle fracture shaft of femur as one of the most frequent cases in paediatric injuries. Throughout the paediatric age group, they account for 1–12% of all fractures [1]. Traditionally the outcome has been associated with age, site and type of fractures, as well as any associated illnesses. Many shafts of femur injuries involving toddlers can be treated conservatively with immobilization such as with hip spica brace, either immediately or after a period of traction which leads to rapid healing and spontaneous angulation correction, with favourable long-term results [2,3]. Surgical stabilization is required when conservative techniques fail to achieve or maintain adequate fracture reduction. If there is an open fracture or the patient has a head injury or there are several injuries then external fixation or compression plating or strong intra - medullary nails are the options regarding surgical stabilization of juvenile femur shafts fracture [4-8]. Pin tract infection, failure of reductions, refracture following implant removal, growth stop and avascular necrosis of the capital femoral epiphysis are complications and consequences of these procedures [9]. There is little disagreement about how to handle younger children (usually under the age of 5) and adults (over the age of 16). For children aged 5 to 16, there are numerous surgical and nonsurgical therapeutic options available, but there is no clear consensus on the best treatment [10]. Patients in this age group have a higher risk of shortening and malunion than younger children when early closed reduction and a spica cast are used. The negative effects of prolonged immobility have prompted the development of surgical techniques that allow for rapid mobilization. When conservative treatments fail to create and maintain enough compression at the fracture site, surgical stabilization becomes essential.

Nancy group created an elastic, stable intra-medullary nail for femur fractures in 1979, which received a lot of attention over the next two decades [11]. They act as load-sharing devices and are flexible enough to bend without the need for physis crossing during insertion. The use of comparatively small incisions for both the insertion & removal of implant offers a cosmetic benefit over other typical operating procedures and early ambulation is possible within 48 to 72 hours due to the less invasive method. It is still the treatment of choice for paediatric long bone fracture stabilisation because of its positive results and lack of major complications. Elastic nails have been found to be useful and acceptable in the treatment of juvenile femoral fractures in several trials. TENS fixing in children aged 5 to 10 years with femoral shaft fractures is the focus of this short-term prospective research.

2. MATERIALS AND METHODS

During the months of May, 2018 to November, 2020, this hospital-based observational prospective study was done at the Department of Orthopaedics, Govt Medical College and Associated Group of Hospitals, Kota, Rajasthan. This research covered all new instances of diaphyseal femur fractures in children.

2.1 Inclusion Criteria

1. Age group of 5 to10 years.
2. Diaphyseal femur fractures.
3. Single sided fractures.
4. Compound fractures of grades 1 and 2.
5. Instable alignment due to a failed closed reduction.

2.2 Exclusion Criteria

1. Patients with non-united or malunited femur fractures.
2. Patients having some medical condition which puts them at a greater risk of anaesthesia.
3. Open fractures of Gustilo-Anderson type 3c.
4. Patients who have a tibial fracture on the same side of body.
5. Both sides of the femur fractured.
6. Children between the ages of less than 5 and more than 10.
7. Fracture is a metaphyseal fracture.

All cases underwent a thorough scrutiny with particular attention paid to age, gender, manner of injury, duration of reporting after injury and time between injury and treatment. General examination, local examination, neurovascular status and systemic examination for related injuries such as head, chest-visceral injuries, and other skeletal injuries was part of the clinical assessment. Antero-posterior (AP) and lateral femur radiographs were obtained. All the relevant information was recorded in pre-defined proforma.

2.3 Surgical Management

TENS nail 1.5 to 4 mm diameter was used during surgery. All patients underwent Closed Reduction and Internal Fixation (CRIF) as soon as feasible, ideally within 48 hours. Patients were operated under spinal or general anaesthesia. Positioning of the patient was supine, on a traction table and traction was used to partially reduce the fracture with the use of a c-arm image intensifier. Draping and painting was done according to standard precautions. The fracture site, the distal femur physis, and the beginning locations for nail entry on the skin were marked with fluoroscopy. 1.5 to 2.0 cm proximal to the physis is the beginning place for a nail entry hole. A 2 cm lateral longitudinal incision immediately proximal to the starting sites across the distal femur metaphysis was made. Two nails with the biggest feasible diameter that could fit into the medullary canal were chosen, based on the breadth of the medullary canal. The nails had a bevelled, blunted end, turned at 45° angle to help them pass into the opposite cortex, thus reducing fracture. Following reductions, the whole length of the nails were shaped to a gradual incline at or around the fracture site. To achieve the optimum balance between ease of insertion and stability, the curve's depth should be about three times the canal's diameter. Greater trochanter was maintained on the lateral end and femur neck on the medial end. A soft tissue sleeve and a drill of size 0.5 cm larger than the nail was used to make the entry hole, and verified using fluoroscopy in both AP and lateral views. Starting perpendicular to the physis, a hole was drilled at the middle of the anteroposterior dimension. Drill was angled at 45 degrees from the long axis of femur, under fluoroscopic guidance, being careful to not drill out the distant cortex and progress towards the physis. A prebent nail was inserted on a T handle and introduced in an antegrade manner from side opposite the femur displacement. The nail was slid down to contralateral cortex under fluoroscopic guidance till the fracture is reached. The fracture was reduced and bridged with the nail. The nail was inserted through the metaphysis of the proximal femur without damaging the cortex or physis. In a similar manner, the second nail was placed from the opposite side. After passing the fracture site, the bent ends of the nails to affect an anatomic reduction, being careful not to distract the fracture site. The proximal ends of the nails were bent and chopped approximately 1 cm from the cortical surface such that the end of the nail inserts deeply into the soft tissue while still remaining protruded enough to be easily retrieved. Absorbable fascial as well as subcuticular sutures were used to close the wounds.

2.4 Post Operative Management

After surgery, adequate analgesia and intravenous (i.v) antibiotics were administered for 3 days in closed fractures and for compound fractures i.e. of grades 2 and 3, i.v antibiotics were given until the 5th post-operative day, following which oral antibiotics were given until the sutures were removed. X-rays were taken after the operation. The next day after surgery, static quadriceps exercises were gradually started. On the 5th day after surgery, suture site dressing and a long leg knee brace were placed. Sutures were removed on the 12th post-operative day and active knee and hip mobility exercises were started on the 5th post-operative day. Patient was allowed to walk with a walker 3 weeks following surgery. Partial weight bearing was allowed at 6 weeks. Full weight bearing was commenced after the fracture had been united. The patient was followed up at 3 weeks, 6 weeks, 12 weeks and 6 months after surgery. The patients were clinically and radiologically assessed at each session. The ultimate outcome after 6 months was rated as exceptional, good or terrible using the criteria established by Flynn et al.

3. RESULTS

All (n=40) of the patients were monitored until the fractures healed. The follow-up period lasted from 6 to 18 months. Clinically and radiologically, the findings were analysed. 17 (42.5%) patients, were between the ages of 5-8 years. The youngest patient was 5 years old and the oldest was 10 years old, with an average age of 8 years. The majority (33, 82%) of the patients were men, with only 7 (17%) women. RTA is the

most common cause of fractures in our series (55 %). Also, in 55% of patients, the right femur was affected. Transverse fracture was the most common pattern (70%). The middle third of shaft was involved in 24 incidents (60%). After 2 weeks, we operated on a patient who had a head injury and required an open reduction. Patients with compound fractures also required open reduction. 4 patients with a superficial infection were in the hospital for more than 12 days. In our study, the average length of stay in the hospital was 10.1 days. The period between the procedure and complete weight bearing without external support and a radiographically healed fracture was designated as the time of union. The average time for union is 8.2 weeks. All of the patients had complete hip joint range of motion, and the 6 patients who had a nail protrusion and bursitis experienced some knee stiffness that was quickly resolved with physiotherapy. A limb length discrepancy (LLD) was found in 2 (5%) individuals, 1 of them exhibited limb length discrepancies of less than 5 mm, while 1 had discrepancy of up to 1cm. There was no substantial limb length disparity (i.e., > 2cm) in any of the patients in our study. In our study, 4 individuals had a superficial infection that was treated with antibiotics. In our study, there were no occurrences of delayed or non-union. In our series, we found 4 cases of varus malalignment of 10 to 12 degrees. There were no signs of valgus, anteroposterior or rotational misalignment. We used the TENS evaluation score given by Flynn et al. to analyses our final results.

Fig. 1. Pre-operative X-ray of left sided shaft of femur

Fig. 2. Post-operative X-ray of left shaft of femur with intramedullary nail

Fig. 3. Range of motion after 6 months

4. DISCUSSION

The correct treatment approach of shaft of femur fractures has been a source of contention throughout the orthopaedic community. Spica casting is utilised in infants under the age of 5 years; in children aged 6 to 11, early cutaneous or skeletal traction is followed by casting, flexible intramedullary nail fixation, external fixation or compression plating. Locked stiff intramedullary nail fixation, external fixation, compression plate, or flexible intramedullary nail fixation is recommended for children aged 12 and above. Until recently, conservative therapy for paediatric diaphyseal femoral fractures was favoured in children and adolescents. However, in order to prevent the consequences of extended immobilisation, reduce lost school days and improve nursing care, the therapy of juvenile shaft femur fracture has evolved dramatically over the previous two decades. Recent research has also raised awareness about the psychological and economic consequences of spica casting on children and their families. Although external fixators, compression plates, and rigid intramedullary nails have all been successfully used in the surgical management of paediatric long bone fractures, they all have drawbacks, including large exposure and a high risk of fracture at the plate's end or through screw holes after removal, pin-tract infection, and a higher risk of re-fracture and restriction of movement of knee joint with external fixators. Due to disruption of posterosuperior tributaries of medial femoral circumflex arteries, Avascular Necrosis (AVN) of the femoral capital epiphysis/trochanteric epiphysis can lead to enhanced valgus of neck of femur following stiff intramedullary nailing into the piriformis fossa. Between the ages of 5 and 16, internal fixation with an elastic stable intramedullary nail is becoming more popular, replacing conservative treatment and other kinds of internal fixation. TENS is a flexible intramedullary nail that acts as an "internal splint" by distributing loads, preserving length and alignment, and enabling enough fracture site mobility for callus formation. Several studies have found that it allows for fast mobilisation, no danger of osteonecrosis, minimal risk of physeal damage, and a lower risk of refracture. Furthermore, because insertion is a closed operation, there is no disruption of the periosteum or the formation of a fracture hematoma, reducing the risk of infection and the loss of osteogenic cells.

The use of TENS in the repair of the femur fractures in adolescents was described for the first time by Ligier & colleagues [12]. Investigators studied 118 youngsters (123 in all)

over the time periods of 5years. Investigators observed just one fractures in kids ages 5-16 yrs, 13 occurrences of skin ulcers and1case of severe wound infection or a local inflammatory response as a consequence of a protruding nail. Overall, after a year, none of the clients had any complaints. There was no sign of impairment or aberrant gait.

Narayanan et al. [13] revisited his initial five-years expertise employing TENS to highlight the challenges associated with this procedure and to provide recommendations on eliminating those consequences. TENS was used to cure 79 children, 78 of whom had femoral fractures. Complications involved refracture (2.5%), transitory neurological impairments (2.5%), as well as surface wound infection (2.5%), radiological malunion (10%). Prior to union, 10 patients required revision surgery. The use of nails with incompatible widths as well as comminution of greater than 25% were substantially associated with malunion or loss of alignment, necessitating reoperation. Overall, presence of curved or noticeable ends of nail was intimately correlated to pain at the insertion point. Most of the problems were benign and many could be avoided. The best indications for TENS according to them were transverse, short oblique and short spiral fractures with minimal comminution in adolescents between 5 to 12 ears age.

Flynn et al. [14] did a study in which 48 among 49 adolescents (with average age 10.2 yrs.; range 6 to16 years) with femur shaft fractures treated with TENS. A 1 cm inclination, mal-alignment and LLD was not identified. There were 8 instances of nail-tip discomfort, two of them resulted in wound disintegration and early removal of an equipment, 1 refracture resulting premature (6.5-week) nail extraction and one incident involving bending of nail due to falling that was corrected by closed reduction, which led to delayed union, which was treated with external fixation.

In our study, the average length of stay in the hospital was 10.1 days. The period between the procedure and complete weight bearing without external support and a radiographically healed fracture was designated as the time of union. The average time for union was 8.2 weeks. All of the patients had complete hip joint range of motion. The case shown in the above image was an 8-year-old boy who had a fracture shaft of femur on left side and was treated with TENS. He resumed full range of motion after 6 months of surgery.

6 patients who had a nail protrusion and bursitis experienced some knee stiffness that was quickly resolved with physiotherapy. A limb length discrepancy was found in 2 individuals, one of them exhibited limb length discrepancies of less than 5 mm and the other one had discrepancy of up to 1 cm. There was no substantial limb length disparity in any of the patients in our study. In our study, there were no occurrences of delayed or non-union.

5. CONCLUSION

According to our findings, CRIF with titanium elastic nailing is the conventional method for treating for fractures shaft of femur in kids aged 5 to 10, because it is a minimally invasive, less time-consuming procedure which does not harm the growth plate as well as provides comparatively stable fixation. It also allows for early mobilisation that aids in the early development of bone structures.

CONSENT

As per international standard, parental written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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