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Unstable length femur fracture in pediatric group using SBP In Misurata medical center

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Abstract

Pediatric shaft femoral fractures are common injuries and account for between 1.4 to 1.7% of all fractures seen in this population.[1] surgical intervention is the treatment of choice for pediatric femur fractures in patients age ≥5 years to skeletal maturity. [2] The surgery is dependent on many factors, such as age, fracture location, fracture pattern, and surgeon preference. [3] The surgery can be more challenging for length unstable comminuted and long oblique fracture patterns. Sub muscular bridge plating restores length and alignment and rigidly stabilizes the unstable pediatric femur fracture. The technique is minimally invasive, "bridges" the fracture leaving the soft tissue intact. [4] The technique is described here in detail.

I) Introduction

Femoral shaft fractures are one of the most common major injuries in paediatric age group managed by the orthopedic surgeon.[5] They account for between 1.4% and 1.7% of all fractures seen in this pediatric age group.[1] Despite this, there has been much controversy accoeding to the management of these fractures, most notably in the 5 – 13 year of age group, with a plethora of research failing to reach a consensus regarding the treatment strategy of choice.[6]

Historically the majority of paediatric femoral shaft fractures have been managed conservatively.[10] Conservative managements include harnesses, hip spicas as well as applying traction to the femur. Although most femoral fractures unite regardless of fracture configuration, displacement and treatment method used, complications are not infrequent. These include delayed unions, non-unions, leg length discrepancies as well as angular and torsional deformities.[11] These factors as well as economic pressures and hospital resources have driven this traditionally conservative approach towards a more surgical one. The most appropriate surgical option, particularly in children between 5 and 13 years, is still, controversial.

Titanium Elastic Nailing System (TENS) is the most appropriate option for length stable fractures (transverse or short oblique) in children who weigh below 45kg.[33, 39] However, larger patients with

length unstable fractures remain a challenge, given the ability of flexible nails to maintain fracture length in these cases may be less than optimal.[40]

External fixation has been supported by some as safe and effective[29, 41, 42], yet others have noted significant refracture rates, pin tract infections, quadriceps contractures and unsightly scars.[9,16] compression plating provides excellent stability and maintains fracture length and alignment. It is complicated by a high risk of hardware failure and non-union rate as high as 10%.[44, 45] These disadvantages as well as the large incision and with considerable blood loss have limited its acceptance.[34, 45]

Although the locked intramedullary nailing technique is the treatment of choice in adults, reports of avascular necrosis of the femoral head in children using the piriformis entry point makes its use difficult to justify.[46] Studies using the relatively new lateral trochanteric entry nails for children older than 8 years of age are not reports of avascular necrosis or significant alteration in the neck shaft angle.[8,47] Further studies as well as long term follow up are, however needed.

Submuscular bridge plating is a minimally invasive technique that allow relative stability to the diaphyseal femoral fractures while maintaining length and angulation.[36] There is minimal disruption of the healing media at the fracture site.[30]

It avoids the growth plates and does not disrupt the blood supply to the femoral head.[30] This technique potentially avoids the complications associated with the other surgical methods of treatment, such as the stability with titanium elastic nails in length unstable fractures; the refracture rate and pin site infections with external fixation; the wound complications as well as non-union rates with compression plating as well as the potential for avascular necrosis with the piriformis-entry intramedullary nail.

The aim of the study was to prospectively and comprehensively evaluate the outcome of submuscular bridge plating of length unstable femoral shaft fractures in children between 5 and 13 years of age.

After evaluating all the available literature, we hypothesized that submuscular bridge plating is a good option to treat these fracture. We assume that this technique should allow earlier mobility and discharge from hospital with excellent union rates and relatively few complications, particular malunions, sepsis and refractures post hardware removal. [9]

II) METHODOLGY

A) Study Population, Sample Size & Inclusion / Exclusion Criteria

The study was conducted at Misurata medical center in Orthopaedic Department in Misurata, and AL Hayat hospital in private clinic in Misurata, libya . All children between the ages of 5 and 13 who were admitted to the orthopaedic department with a length unstable femoral shaft fractures, were asked to participate in the study.

All the available treatment options (conservative and surgical) and the advantages and disadvantages of each option were discussed parents or legal guardians so that an informed decision could be made. Informed consent was obtained from all the parents and/or legal guardians before the children could participate in the study. The Health Research Ethics Committee of hospital granted ethical approval for the study. The study was conducted over a period of 3 years, starting on the 1st January 2019 and finishing on the 31st December 2021.

B) Operative intervention details:

Patients were assessed on admission and kept in balanced Thomas traction until the surgical intervention. All patients were treated by the specialized pediatric orthopaedic surgeon and/or any of the other senior (post-intermediate examinations) registrars within 4 days after the admission to the hospital.

All patients were fasted for 6 hours prior to the surgical intervention. The correct weight appropriate doses of prophylactic intravenous cefazolin (1st generation cephalosporin antibiotic) and general anaesthesia without muscle relaxant was given and monitored by an anaesthetist. The patient was

positioned on the traction table and preoperative fluoroscopy was used to reduce the fracture as best as possible.

The operation site was then sterilized and draped. An incision of about 5 cm was made at the location of the greater trochanter (Figure 1) or at the lateral distal femoral metaphysis depending on the fracture site. A greater trochanteric incision was used when the fracture was more proximal and a distal incision for a more distal fracture. Blunt dissection was performed to the plane between the periosteum and surrounding musculature.

A Synthes® 4.5mm staggered Low Contact-Dynamic Compression (LC-DC) plate with locking

Figure 1: An incision of about 5 cm made at the location of the greater trochanter.

options was used. It was bent using a bending press to the shape of the femur using the preoperative radiographs as well as the intraoperative screening radiographs as templates.

The plate was then advanced submuscularly along the femoral shaft. (Figure 2)

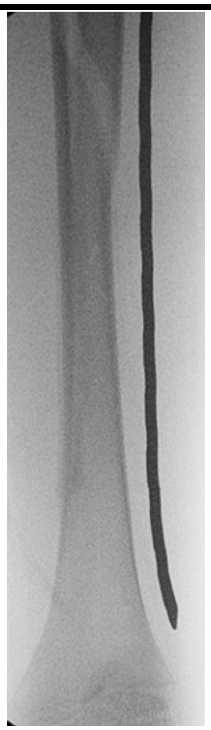


Figure 2: Advancing the plate submuscularly along the femoral shaft

After ensuring that the plate was in the centre of the bone, screws were inserted through stab incisions placed over the desired holes using fluoroscopy. The fracture was reduced to the plate.

Figure 3: Fracture reduction to the plate using cortical screws through stab incisions.

(Figure 3)

The aim was to obtain fixation into 6 cortices on either side of the fracture. Compression screws were used unless the fracture extended into the metaphysis and the desired 6 cortices could not be obtained. In these cases, locked screws were used on that side. The wounds were closed meticulously in layers with subcutaneous absorbable sutures for the skin. The surgical wounds were dressed with an adhesive dressing.

A postoperative radiograph was taken prior to discharge to assess the initial fixation. Patients were discharged once they were able to mobilize partial weight bearing with either crutches or a walking frame. Progressive weight bearing was allowed once fracture callus was seen on follow up radiographs.

The children were followed up at 2 weeks post-surgery for a wound inspection and then at 6 weeks; 3 months and 6 months post procedure. X-rays as well as physical examinations were performed. The plates were removed at 6 months post-surgery.

Final follow up was at 9 months post-surgery.

C) Assessment

Both AP and lateral radiographs were taken on admission as well as after the application of the balanced Thomas traction. The fractures were classified according to the anatomic and descriptive classification systems described above.3 Theatre time, blood loss, the length of the surgical wound, screening time and intra-operative complications were recorded during the operation. At 2 weeks, 6 weeks and 3 months, patients returned to the hospital for follow-up assessments. During these visits the wound was inspected and an X-ray was taken to assess for union of the fracture and check for any hardware complications. Six months post-operatively patients returned to the hospital for the removal of the plate during a second surgical intervention. During this operation, theatre time, blood loss, screening time and complications were again recorded .

A final follow assessment was performed at 9 months post-surgery. In addition to the normal clinical assessment of range of motion and rotational profile, long leg standing AP and lateral X-rays were taken to assess the mechanical lateral distal femoral angle (mLDFA). These were

compared to the non-operated side using the PACS system. Leg length differences between the operated and non-operated side were also assessed with the use of these x-rays as well as clinically, while any wound related complication were also recorded.

D) Statistical Analysis

STATISTICA version 11.0 (Sta-soft Inc., Tulsa, OK, USA). Mean basic descriptive statistics were used to describe pre-and postsurgical outcomes. All data were expressed as mean ± standard deviation. Differences between the affected and unaffected side were analyzed with a T-test for independent samples. A significant difference was accepted at a p< 005 .

Summary statistics were used to describe the variables. Medians or means were used as the measure of central location for ordinal and continuous responses and standard deviations and quartiles as indicators of spread.±Furthermore, complication rates were analyzed using proportions and appropriate 95% confidence intervals were given for all measured and dichotomous outcomes .

The relation between two nominal variables was investigated with contingency tables and likelihood ratio chi-square

III) Results:

Thirty consecutive patients between the ages of 6 and 13 with length unstable femoral shaft fractures participated in the study. 1 child could not be contacted for final follow up and was excluded from the results. The descriptive statistics of the remaining 29 participants are shown in Table 1.

Table 1. Descriptive statistics of the participants (n=29)

Variable	Mean ± SD (%)
Age (years)	8 ± 2
Gender (male / female)	20 (69 %) / 9 (31 %)
Fractured side (right / left)	17 (59%) / 12 (41 %)
Mechanism causing the fracture Road traffic accident	12 (41%)
hit by an object	6 (21%)
Low energy fall	5 (17%);
Sports injury	4 (14%)
Post fighting	2 (7%).
Fracture type Spiral fracture	15 (52%)
Oblique fracture	6 (20%);
Long oblique fracture	2 (7%)
Comminuted fracture	4 (14%)
Transverse fracture	2 (7%).

All children were admitted to the hospital with closed fractures except for one patient who sustained a Gustillo and Anderson grade 1 open femur fracture. Most children (59%) waited over 72 hours in

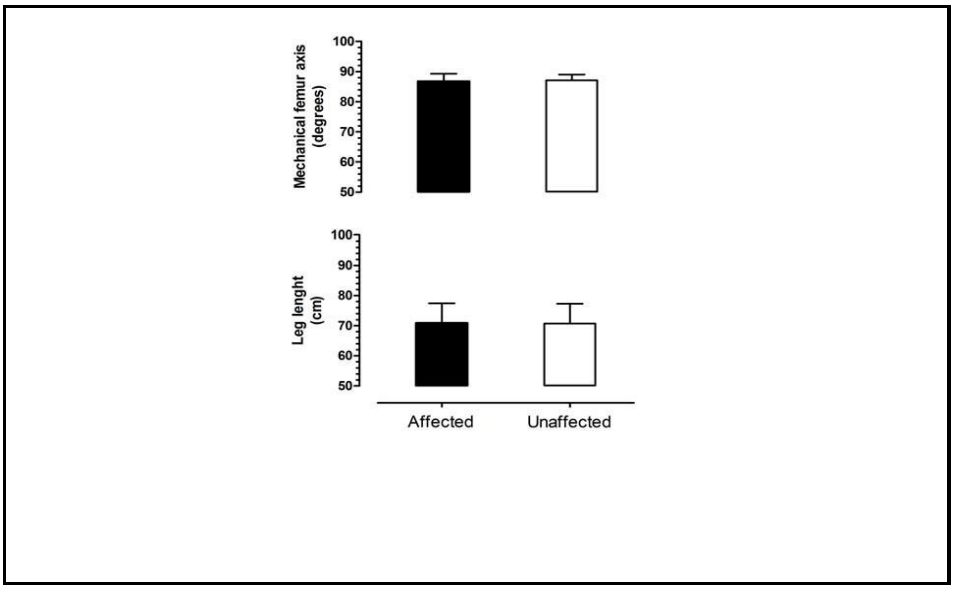
balanced traction before the surgery. The mean operating time was 66 ± 15 minutes with average total incision length of 10.4 ± 2.7 cm (6 – 16 cm), while the average radiation exposure amounted to 88 ± 28 seconds (23 – 138 s). 13-hole plates were used most frequently. The average blood loss during the procedure amounted to 121 ± 83 ml (20 – 400ml). Children were discharged at an average of 8 days post-surgery and ranged from 4 to 31 days.

Unfortunately, 1 fracture site (3%) had to opened in order to obtain reduction as indirect reduction was deemed impossible.

A) Follow up assessments:

All 30 patients revisited the hospital for their 2-week, 6 week and 3-month follow-up assessment. X-rays showed that all fractures were fully united by 3 months post-surgery.

B) Plate removal

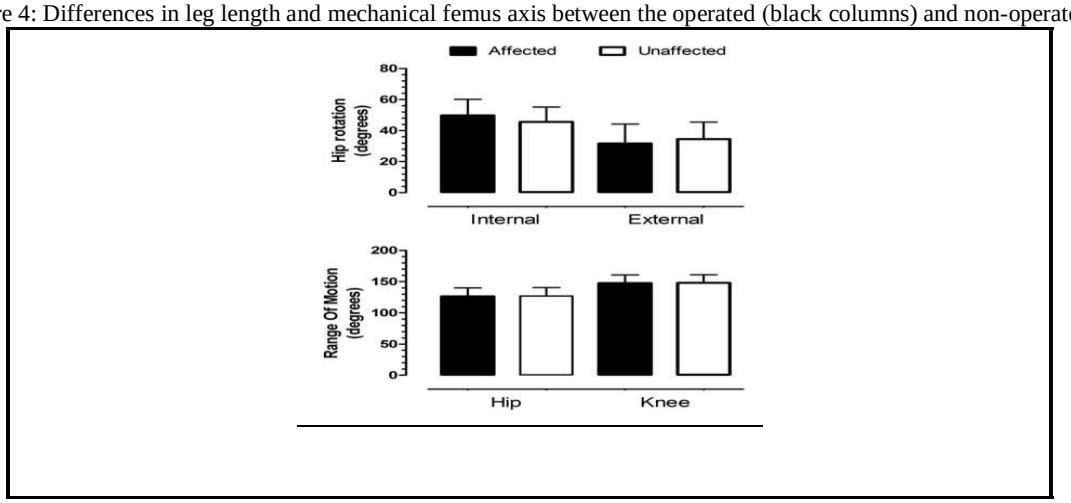


Plates were removed at an average of 8 ± 3 months post plating. Average surgical time was 32 ± 9 minutes and blood loss 48 ± 39 ml. Screening time ranged from 0.01 to 60 seconds with the average being 6 ± 12 seconds.

C) Nine month follow up assessment

No significant overall leg length discrepancy (p=0.94) or mechanical axis deviation (p=0.51) were found between the affected and unaffected lower limbs at 9 months post-surgery. There was no significant mechanical axis discrepancy between the operated and non-operated sides. (Figure 4)

Figure 4: Differences in leg length and mechanical femus axis between the operated (black columns) and non-operated side (white



columns).

Clinical assessment at 9 months showed no significant differences in hip flexion (126±14° vs 127±13°, p=0.88), hip external rotation (32±12° vs 35±11°, p=0.36), hip internal rotation (50±10° vs 46±9°, p=0.12) and knee flexion (147±13° vs 148±13°, p=0.96) between the operated and non-operated side. (Figure 5)

Figure 5: Differences in range of motion and rotation between the operated (black columns) and non-operated side (white columns)

D) Complications

There was difficulty removing 1 plate that was inserted 10 months prior due to severe bony overgrowth, necessitating the prolonged screening time of 60 seconds. One minor and 1 major complication were found at final follow up. 1 child developed hypertrophic scars which did not cause the patient any concern and was treated conservatively.

The major complication was that one child's femur was plated in 25 degrees of internal rotation. This did not, however, cause the child any functional disturbance.

IV) Discussion:

The treatment of paediatric femoral shaft fractures, particularly in the 5 to 13 year age group, has in recent times moved away from the traditionally conservative approach to a more surgical one.[10] Depending on the fracture pattern and other patient and economic factors, several different methods of fixation are available, including flexible intramedullary nailing, external fixation, open compression plating, lateral entry intramedullary nails and submuscular bridge plating.

Given our results, we conclude that submuscular bridge plating is a viable and predictable method of fixation for more complex length-unstable paediatric femoral shaft fractures. Bridge plating was utilized in 30 patients with length unstable fractures where other methods were deemed to be less effective. Fracture reduction was maintained and no significant leg length discrepancy or malalignment in the axial or coronal plane was found. There were also very few complications.

The mean operating time for the index procedure in this study was 67±14 minutes with the average total incision length being 10.4±2.7cm and average radiation exposure of 90 seconds. This series compares favourably to a study by Kanlic et al[36] where 51 patients had surgical times of 106 minutes on average. A study by Bar-on et al[48] comparing external fixation and TENS nails in a similar cohort (19 children with 20 fractures) found an average surgical time in the external fixation group of 56 minutes and in the TENS nails group of 74 minutes. Fluoroscopy averaged 84 seconds in the external fixation group and 156 seconds in the TENS group. Open compression plating allows minimal radiation exposure due to direct reduction[10], however the large surgical incision and consequent scar makes its use unfavourable particularly with the development of newer techniques available nowadays.

We found the average blood loss during the index procedure to be 130ml (40 – 400 ml) with no requirements for blood transfusions. In the largest compression plating series to date of 60 children, Caird et al[45] found an average of 200ml (40 – 1500ml) blood loss with 2 polytrauma patients requiring blood transfusions.

All fractures in our series united by 3 months post surgery. This was comparable to similar bridge plating studies by Sink et al[49] and Agus et al[50] where bridging callus on 3 of 4 cortices was noted at 11.7 and 12.4 weeks respectively.

Plates in our series were removed at an average of 8±3 months. The average surgical time was 32 minutes and blood loss 48 ml. In a similar study by Sink et al[49] an average of 56 minutes was taken for plate removal.

At final follow up (9 month) there was no significant difference between the operated and non-operated sides in terms leg length discrepancy; range of motion of the hip and knee as well as alignment in the axial and coronal planes. These results are similar to the series by Kanlic et al.[36]

Other fixation methods used to treat length unstable femoral shaft fractures do not compare as favourably.

TENS nails are the treatment of choice for length stable fractures.[32] A proven complication in length unstable fracture configurations is that of loss of reduction, particularly femur length. A

study by Sink et al[32] proved that titanium elastic nails are not appropriate in length-unstable fracture types. It was found that 6 out of the 8 patients that required unplanned surgery for either loss of reduction or prominent nails prior to fracture union fell into the category of length-unstable fractures.

In our view external fixation should be reserved for polytrauma patients or in patients with high-grade open femur fractures. [12,40] In a study by Aronson and Tursky[41] of 42 patients who underwent external fixation, 20% had greater than 5 degrees varus or valgus malalignment, 66% experienced malrotation averaging 10 degrees and 42% had a leg length discrepancy averaging 6.5mm.

As a result of the difficulty encountered in removing 1 plate that had been in situ for 10 months, we recommend removal at 6 months post surgery provided there is union. We experienced no refractures, hardware failures or wound infections in our series. We did, however, experience 1 minor and 1 major complication.

One child's femur was plated in 25 degrees of internal rotation. This patient was one of the first in our series and was performed by a registrar. In critical review of the case, it was determined that during placement of the child on the traction table, the hip fell off the table into external rotation while the knee was maintained with patella facing anterior. This inadvertently caused the deformity. In order to avoid this complication, we conclude that it is imperative to ensure during patient set up that both the hip and knee face directly anteriorly. In addition, fluoroscopy can aid by ensuring that a true AP image of both the hip and knee are obtained prior to the surgery. We found that there was somewhat of a learning curve to master this minimally invasive technique.

3 significant complications were experienced in Kanlic et al's[36] bridge plating study: 1 hardware failure of a small fragment titanium plate; 1 refracture through a nonossifying fibroma and 1 peroneal nerve neuropraxia.

External fixation techniques have significantly greater complication rates in most series. They have high rates of delayed and non-unions; refracture rates of up to 21%[23] and pin tract infections of up to 73%.[43]

TENS nails are also not without complications. Ho et al[31] reports a complication rate of 17% with complications ranging from skin breakdown and infection, non-union, refracture and leg length discrepancies to hardware malpositioning and peroneal nerve palsies.

In Caird et al[45] series on compression plating, 1 early hardware failure, 2 refractures post plate removal and one patient with a 2.8 cm leg length discrepancy were experienced.

This series indicates that submuscular bridge plating is an alternative to treat lengthunstable femoralIt makes use of a minimally invasive technique with resultant small well-accepted scars and does not disrupt the fracture biology. It allows for early mobilization and discharge. Bridge plating was performed in 30 patients in this study with good results. The reduction was maintained and all fractures went onto complete union within 3 months. There were no symptomatic malalignments or leg length discrepancies and all patients returned to full activities. The 1 major complication of rotational malalignment was due to a preventable technical error.

Weaknesses in our study include lack of a comparison groupIn conclusion,

V) Conclusion:

This series provides evidence supporting the use of submuscular bridge plating in length-unstable femoral shaft fractures in children between the ages of 5 and 13 , SBP was a viable and safe alternative for the treatment of unstable femur fractures and fractures located in the distal and proximal femoral metaphyses in children and adolescents.

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