Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol. (7) Issue (1) (2022), (147- 154) **online: ISSN 2356–976x**
http://bjas.journals.ekb.eg

Management of femoral shaft fracture in children by using minimal invasive plate

M.A.Mikhael, A.I.Ali and M.M.El Karmany
Orthopedics and Traumatology, Dept., Faculty of Medicine, Benha Univ., Benha, Egypt
E-mail: maher3101988@gmail.com

Abstract

Background: Pediatric femoral shaft fracture is a common injury. Casting, external fixation, elastic intramedullary nail, intramedullary nails, compression plating and submuscular plate have all been used as a treatment option. However, The treatment of pediatric femoral shaft fractures, particularly in the 6 to 13 year age group, has in recent times moved away from the traditionally conservative approach to a more surgical one. Depending on the fracture pattern, patient age and other patient and economic and psychological 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. The aim of the study was to evaluate the outcomes as well as advantages of minimally invasive bridge plating of femoral shaft fractures in children between 6 and 12 years of age. Methods: It is a comprehensive prospective case series study. It was conducted at Trauma unit Al Eman general hospital, Assiut, Egypt. All children between the ages of 6 and 13 who were admitted to the orthopedic department with femoral shaft fractures, were asked to participate in the study. Results: The mean operating time for the index procedure in this study was 62±20.6minutes with the average total incision length being 11.3±2.7 Cm and average radiation exposure of 59±25seconds. We found the average blood loss during the index procedure to be 99.7±34.4 ml (60-200ml) with no requirements for blood transfusions exceoy . All fractures in our series united by 5-9 weeks with mean of 6.6±1.1 week post-surgery. Plates in our series were removed at an average of 9.8±1.4months. The average surgical time was 35±3 minutes and blood loss 48 ml. At final follow up (9 month) there was no significant difference between the operated and non-operated sides in terms of leg length discrepancy; range of motion of the hip and knee as well as alignment in the axial and coronal planes. In our view external fixation should be reserved for polytrauma patients or in patients with high-grade open femur fractures. The technique of femoral shaft plating has evolved with a better understanding plate mechanics. This series indicates that submuscular bridge plating is an alternative to treat length unstable femoral fracture lit 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. Conclusion: This series provides evidence supporting the use of submuscular bridge plating in length-unstable femoral shaft fractures in children between the ages of 6 and 12 and the Cluster technique simplifies application of the screws through the small incisions. From this study cluster technique gives good stability for healing of pediatric fracture shaft femur.

Key words: Femoral shaft fracture – Children – Minimal invasive plate**.**

1. Introduction

Paediatric femoral shaft fractures are common injuries and account for between 1.4 to 1.7% of all fractures seen in this population [1] and represent 1.6 % of fractures in childhood with males are commonly affected than females [2]. Femoral shaft fractures are 2.6% more common among boys than girls [3].As regard to age, there was a bimodal distribution, with peaks at two and seventeen years with boys had higher rates of fracture than did girls at all ages, and blacks had higher rates than did whites [2,3). There is also a seasonal distribution, with a higher incidence during the summer months (2).

The purpose of the study was to evaluate the outcomes as well as advantages of minimally invasive bridge plating of femoral shaft fractures in children between 6 and 12 years of age.

2. Patients and Methods

Study design

It is a comprehensive prospective case series study .

Study population

The study was conducted at Trauma unit Al Eman general hospital, Assiut, Egypt .

All children between the ages of 6 and 13 who were admitted to the orthopedic department with femoral shaft fractures, were asked to participate in the study.

All the available treatment options (conservative as well as surgical) and the advantages and disadvantages of each option were discussed with 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.

Sample size:

The study had been conducted in ten patients in the last half of 2019,the year of 2020and the first half of 2021.

Inclusion criteria

Children aged **6 to 13** years come to Al Eman general hospital Trauma unit and diagnosed to have a "**closed or open grade I according to Gustello and Andreson classification"** femoral shaft fracture during the last half of 2019 as well as the year of 2020.

Exclusion criteria

- unfit patient for surgery.
- open grade (ll) and (lll) fractures.
- pathological fractures.
- metaphyseal and epiphyseal fractures.

Methods of evaluation

It includes:

- History taking including the date of trauma, Mode of trauma, mechanism of injury as well as associated other injuries.
- clinical assessment in the form of examination of involved limb including hip and knee examination, assessment of neurovascular status, as well as routine primary trauma survey to detect extra skeletal associated trauma .
- Radiological evaluation including "plain AP, Lat. views of the involved femur demonstrating both hip and knee joint" demonstrating both the fracture type as regard to its location in femoral diaphysis, fracture morphology and the AO/OTA fracture dislocation classification of the fracture.

Operative Data

Type of fracture, other associated injuries, timing of surgical interference, No. of surgeons estimated blood loss during operation, estimated intra-operative time, estimated fluoroscopic time,plate length,number of screws used, additional internal or external fixation, as well as intra-operative complications were recorded and documented

Post-operative Data

Include length of hospital stay, Onset of post-operative rehabilitation, post operative complications were recorded .Also the length of the surgical wound, early immediate post-operative fronto- sagittal angulation, rotational deformity and amount of limb length discrepancy were recorded

Follow up

As regard **timing** and **methods**

Follow up **period** ranges from 6 to 20 month with average 10 month and in general all the patients had been followed up in regular visits at 2 weeks,6 weeks and 6 months and every 6 month up to 20 month postoperatively.

The follow up methods include :

Clinical examination for assessment of any complications till complete bone healing, and disappearance of pain, full weight bearing as well as Knee full ROM.

Radiological evaluation "AP and Lat. Radiographs " at six week & six month intervals as well as at time of implant removal"

- Recording of residual **complications as non union,** gross deformity in sagittal or frontal plane or rotational deformity as well as leg length discrepancy.
- Determination of the need for as well as timing of **metal removal.**

Outcome and results:

The **results** had been evaluated for each of the following:

- The time of radiographic union "bridging callus formation in 3-4 cortices"
- Return of full function as regard full free non-assisted weight bearing. "period in weeks" and full free active range of motion of both knee and hip.
- Amount of any persistent deformity if present including frontal or sagittal angulation or rotational deformity as well as amount of limb length discrepancy if present .
- Any unplanned return to surgery.
- The time interval till hardware removal if done as well as the morbidity of its removal if present.

Operative intervention details

Patients were assessed on admission and kept in balanced skin traction until the surgical intervention. All patients were treated by a specialized pediatric orthopaedic surgeon and/or any of the other senior orthopedic trauma surgeon.

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

All patients were positioned supine on a conventional radiolucent operative table without traction system and conventional draping technique for femoral shaft fracture had been followed by draping the contralateral limb to make clinical assessment of the length, rotation as well as alignment available intra-operatively. "fig.1"

Fig. (1) Draping the contralateral limb.

3. Results

Patients underwent surgery after variable time from injury with arrange between 0-8 days, with mean 3.4±2.6 SD,with estimated intra-operative time range between 34-100 min. with mean 65.5±19.8 SD, and estimated fluoroscopy time average between 24-140 sec. with mean 59.0±34.7SD.The intra-operative blood loss vary from 60 to 200 CC with mean of 108.0±39.4 SD table (1).

No intra-operative complication occurred in 7 patient, and only 3 cases needed intra-operative blood transfusion varied from 150 to 250 CC, the length of the patients hospital stay range6d from 1-12 day including the surgery day with mean of 4.4±3.3 SD. The Rehabilitation post-operatively starts in the first day in most cases with range of 0-4 day and mean of 2.1±1.4 SD. Only one case(10%) had shown post-operative complication in the form of persistent fever > 38.5˚C for more than two days, and the resulting Surgical wound length average was 7-16 Cm with mean of 11.2±2.8 SD, Table (2)

The alignment, rotation as well as length immediately post-operative were within the accepted range for age group as the following, table (3)

- As regard alignment, the immediate post-operative frontal angulation ranged between 0-9˚ with mean of 3.3±2.8 SD while the sagittal angulation varied from 0 ˚ to 26˚ immediately post-operative with mean of 12.2 ±8.2 SD.
- As regard rotation immediately post-operative whatever external or internal it was varied from 1˚ to 21˚ generally with a mean of 8.2+6.8 SD, with inside rotation had occurred in 6 case (60%) with mean of 6.3±1.2SD for the inside rotation itself,and outside rotation had occurred in the remaining 4 case (40%) with mean of 8.25 ±1.0 SD for the outside rotation itself.
- As regard limb length discrepancy whatever lengthening or shortening it vary between 3 mm. to 9 mm with mean of 9.9±5.7 SD for LLD in general, with shortening occurring in 8 patient (80%) with mean of 7.75+ 1.0 SD for shortening itself,meanwhile 2 patients only had shown lengthening (20%) with a mean of 11.5 ±0.7 SD for the lengthening itself.

Table (1) operative data analysis.

Days from injury to surgery	
Range	0-8
Mean±SD	3.4±2.6
Estimated intra-operative time in min	
Range	34-100
Mean±SD	65.5±19.8
Estimated flouroscopy time in sec.	
Range	24-140
Mean±SD	59.0±34.7
Estimated blood loss in CC	
Range	60-200
Mean±SD	108.0±39.4

Table (2) post-operative data analysis.

Intr-op. complication	**No.**	**%**
Nil	7	70.0
Blood transfusion 150 CC	1	10.0
Blood transfusion 200 CC	1	10.0
Blood transfusion 250 CC5	1	10.0
Length of hospital stay in days		
Range	1-12	
Mean±SD	4.4±3.3	
Rehabilitation onset in days		
Range	0-4	
Mean±SD	2.1±1.4	
Post_op complication		
Nil	9	90.0
Presistant post op. fever >2 days	1	10.0
Length of surgical wound		
Range	7-16	
Mean±SD	11.2±2.8	

Table (3) Alignment, rotation and Length immediately post operative

Frontal angulation in degrees	NO.		%
Range		0-9	
Mean±SD		3.3±2.8	
Sagittal angulation in degrees			
Range		0-26	
Mean±SD		12.2±8.2	
Rotation in degrees			
Range		1-21	
Mean±SD		8.2±6.8	
Rotation side			
In	6		60.0
Mean±SD		6.3±1.2	
Out	4		40.0
Mean±SD		8.25±1.0	
Limb length discrepancy in mm			
Range		3-19	
Mean±SD		9.9±5.7	
Limb length D_A			
Decrease	8		80.0
Mean±SD		7.75±1.0	
Increase	2		20.0
Mean±SD		11.5±0.7	

Radiographic union occur within 5 to 9 weeks with mean of 7.0±1.5SD, full weight bearing had reached between 6 to 9 weeks with mean 7.3±1.2 SD, and full range of motion to hip and knee had been obtained within 3 to 7 weeks with a mean of 4.5±1.3 SD,(table 4).

Clinical as well as radiological Follow up done at six weeks, sex month as well as 9 month including assessment of Limb length discrepancy by pain AP long Radiograph at 9 month whatever the implant removed or not had shown statistical significance decrease in the limb fronto-sagittal angulation, rotation either internal or external as well as the resulting lengthening or shortening (table5)

Table (4) Union, Full weight bearing, Full Range of motion in weeks.

Radiographic union time in weeks	
Range	5-9
Mean±SD	7.0±1.5
Full weight bearing in weeks	
Range	6-9
Mean±SD	7.3±1.2
Full Range of motion in weeks	
Range	3-7
Mean±SD	4.5±1.3

Table (5) Alignment, Rotation and Length at six weeks.

Frontal angulation in degrees (6 weeks)	NO.		%
Range		0-8	
Mean±SD		2.3±2.2	
sagittal angulation in degrees (6 weeks)			
Range		0-17	
Mean±SD		8.3±5.3	
Rotation in degrees (6weeks)			
Range		0-15	
Mean±SD		6.4±4.9	
Rotation side (6weeks)			
No rotation	2		20.0
In	4		40.0
Mean±SD		5±0.6	
Out	4		40.0
Mean±SD		6.0±0.7	

Limb length discrepancy in mm (6weeks)		
Range	1-12	
Mean±SD	6.6±3.5	
Limb length D_A (6weeks)		
Decrease	8	80.0
Mean±SD	6.1±0.7	
Increase	2	20.0
Mean±SD	7.2±1.0	

Till now metal removal to the implant done for 8 cases (80%), and all of them done smoothly, through the same approach without extension beyond the scar of the previous operation between 8-13 month post-operatively with a mean of 9.7±1.5 SD, and there is no unplanned return to surgery either before or after implant removal, table (6)

As regard to **age** and **sex** effect on the reached results there was no statistical significance effect before 6 weaks on the alignment while it was statistically significant on the later on follow up visits and also it resulted in statistically significant difference in both radiographic union in weeks, full weight bearing, full range of motion also in weeks and in the time interval till hardware removal table (7).

Table (6) Time interval till hardware removal in month and unplanned return to surgery.

	Age		Weight in kg	
	r	**P. value**	**r**	**P. value**
Frontal angulation in degrees				
Post operative	0.082	0.822	0.217	0.547
After 6 weeks	0.281	0.432	0.272	0.447
After 6 months	0.711	0.021*	0.894	0.001**
After 9 months	0.777	0.008**	0.768	0.009**
Sagital angulation in degrees				
Post operative	-0.412	0.236	-0.477	0.163
After 6 weeks	-0.407	0.244	-0.481	0.160
After 6 months	-0.443	0.199	-0.410	0.239
After 9 months	-0.379	0.281	-0.493	0.148
Rotation in degrees				
Post operative	-0.304	0.393	0.170	0.638
After 6 weeks	0.186	0.607	0.224	0.533
After 6 months	0.784	0.007**	0.916	0.001**
After 9 months	0.615	0.059	0.687	0.028*
Limb length discrepancy in mm				
Post operative	-0.558	0.093	-0.561	0.092
After 6 weeks	-0.672	0.033*	-0.738	0.015*
After 6 months	-0.468	0.173	-0.323	0.363
After 9 months	-0.537	0.109	-0.470	0.170
Radiographic union time in weeks	0.920	0.001**	0.806	0.005**
Full weight bearing in weeks	0.813	0.004**	0.732	0.016*
Full Range of motion in weeks	0.810	0.005**	0.702	0.024*
Time interval till hardware removal in month	0.671	0.034*	0.584	0.076

*** Statistically significant correlation (p<0.05)** **** Statistically significant correlation (p<0.01)**

Table (7) Statistical significance of Age and weight on results.

	Mechanism							
	Falling down stairs	**Falling from hight**	**Falling on ground**	**Heavy object trauma**	**Motor bike accident**	**Motor car accident**	**Pedestrain injury**	**P. value**
Frontal angulation in degrees								
Post-operative	1±1.41	1±0	1±0	3±1.41	3±0	7±2.83	6±0	0.259
After 6 weeks	1±1.41	1±0	1±0	2.5±0.71	1±0	2.5±0.71	8±0	0.071
After 6 months	0.5±0.71	0.5±0	1±0	2.5±2.12	2±0	1.5±0.71	1±0	0.783
After 9 months	0.25±0.35	0.25±0	0.75±0	1.5±0.71	1.5±0	0.68±0.81	1.75±0	0.465

Sagittal angulation in degrees								
Post-operative	11±7.07	3±0	9±0	5±7.07	13±0	22.5±4.95	20±0	0.318
After 6 weeks	7.5±3.54	3±0	6±0	3.5±4.95	8±0	14.5±3.54	15±0	0.297
After 6 months	1.75±1.77	0.5±0	1±0	1±1.41	2±0	3.75±4.6	2±0	0.948
After 9 months	2.55±3.46	0.1±0	1±0	0.15±0.21	0.5±0	0.15±0.07	0.2±0	0.865
Rotation in degrees								
Post-operative	15±8.49	5±0	13±0	10.5±9.19	1±0	5±2.83	2±0	0.651
After 6 weeks	2±2.83	2±0	2±0	7.5±0.71	6±0	10±5.66	15±0	0.274
After 6 months	0.13±0.17	0.25±0	0.75±0	3.8±3.0	1.75±0	1±1.06	1.75±0	0.596
After 9 months	0.15±0.21	0.05±0	0.55±0	1.3±0.71	1.05±0	0.83±1.03	1.3±0	0.672
Limb length discrepancy in mm								
Post-operative	11±5.66	13±0	9±0	4.5±2.12	5±0	11±8.49	19±0	0.614
After 6 weeks	8.5±3.54	12±0	7±0	5±5.66	3±0	6±2.83	5±0	0.755
After 6 months	2±1.41	2.5±0	0±0	1.75±0.35	0.5±0	4.25±1.06	4±0	0.194
After 9 months	0.8±0.71	1.05±0	0.55±0	0.4±0.57	0.05±0	1.55±2.05	1.8±0	0.901
Radiographic union time in weeks	5.5±0.71	5±0	7±0	8.5±0.71	9±0	6.5±0.71	8±0	0.082
Full weight bearing in weeks	5±1.41	6±0	7±0	9±0	9±0	7±0	9±0	0.085
Full Range of motion in weeks	3±0	3±0	6±0	5±2.83	7±0	3±0	7±0	0.364
Time interval till hardware removal in month	7.8±0	7.8±0	7.8±0	9.8±1.41	9.8±0	7.8±0	13±0	0.075

Meanwhile the **fracture location** by mean the affected diaphyseal segment (proximal, middle or distal) had no statistical significance on any of the follow up parameters (table 8).

Table (8) Statistical significance of fracture location.

	Site			P. value
	Distal	Middle	Proximal	
Frontal angulation in degrees				
Post-operative	1.5±2.12	3.5±3.54	3.83±2.93	0.636
After 6 weeks	0.5±0.71	4.5±4.95	2.17±0.75	0.200
After 6 months	1±1.41	1±0	1.58±1.28	0.764
After 9 months	0.75±1.06	1.25±0.71	0.85±0.71	0.782
Sagittal angulation in degrees				
Post-operative	14.5±2.12	14.5±7.78	10.67±9.99	0.809
After 6 weeks	9±1.41	10.5±6.36	7.33±6.22	0.792
After 6 months	2.5±0.71	1.5±0.71	1.75±2.66	0.897
After 9 months	2.75±3.18	0.6±0.57	0.13±0.1	0.091
Rotation in degrees				
Post-operative	11±14.14	7.5±7.78	7.5±5.13	0.843
After 6 weeks	3±4.24	8.5±9.19	6.83±4.12	0.566
After 6 months	0.87±1.2	1.2±0.7	1.7±2.2	0.864
After 9 months	0.53±0.74	0.93±0.53	0.77±0.76	0.859
Limb length discrepancy in mm				
Post-operative	10±7.07	14±7.07	8.5±5.36	0.550
After 6 weeks	7±5.66	6±1.41	6.67±3.88	0.967
After 6 months	1.75±1.77	2±2.83	2.58±1.46	0.821
After 9 months	0.68±0.88	1.18±0.88	0.88±1.12	0.893

Radiographic union time in weeks				
Full weight bearing in weeks	7±2.83	7.5±0.71	6.83±1.47	0.888
Full Range of motion in weeks	6.5±3.54	8±1.41	7.33±1.37	0.728
Time interval till hardware removal in month	5±2.83	6.5±0.71	3.67±1.63	0.202

4. Discussion

The mean operating time for the index procedure in this study was 62±20.6minutes with the average total incision length being 11.3±2.7 Cm and average radiation exposure of 59±25seconds. This series compares favourably to a study by **Kanlic et al [4]** where 51 patients had surgical times of 106 minutes on average.

A study by **Bar-on et al [5]** 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 [6], 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 99.7±34.4 ml (60-200ml) with no requirements for blood transfusions exceoy . In the largest compression plating series to date of 60 children, **Caird et al [7]** found an average of 200ml (40 – 1500ml) blood loss with 2 polytrauma patients requiring blood transfusions.

All fractures in our series united by 5-9 weeks with mean of 6.6±1.1 week post-surgery. This was comparable to similar bridge plating studies where bridging callus on 3 of 4 cortices was noted at 11.7 and 12.4 weeks respectively [8].

Plates in our series were removed at an average of 9.8±1.4months. The average surgical time was 35±3 minutes and blood loss 48 ml. In a similar study by Sink et al 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 of 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 [4]**.

Although TENS nails are the treatment of choice for length stable fractures.[9] A proven complication in length unstable fracture configurations is that of loss of reduction, particularly femur length. A study by **Sink et al [9]** 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. the overall complication rate for length-unstable fractures compared with length-stable fractures was 80 as opposed to 50%. Length-unstable fractures were defined as comminuted or long oblique fractures; for the latter, the length of the obliquity was twice as long as the femoral diameter at the fracture level. Major complications, requiring operative revision, were significantly higher in the length-unstable group (66 compared with 12.5%). A decreased incidence of complications was reported when at least 80% of the canal diameter was filled by the combined diameter of the nails.

In addition to length-unstable fracture patterns, older age and increased body weight have been associated with an increased incidence of complications after stabilization with TENs. Flynn led another multicentre TEN study from six centers, with 234 femur fractures in 229 patients. Ninety percent of patients had excellent or satisfactory results, with excellent or essentially perfect results in 64%. There were 23 cases classified as poor for a 10% significant complication rate – many of these were classified as poor based on radiographic malalignment that was not always clinically relevant. The outcome was better for central third fractures, and a significantly higher complication rate was noted in older (>11 years) and heavier (>108 lbs) patients [10].

External fixation is complicated by high refracture rate, pin tract problems, and unsightly scars.

In our view external fixation should be reserved for polytrauma patients or in patients with high-grade open femur fractures. In a study by **Aronson et al. [11]** of 42patients 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.

Also 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% as mentioned by **Skaggs et al. [12]**.

TENS nails are also not without complications. **Ho et al. [13**] 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.

Traditional compression plating has hardware failures and a non-union rate as much as 10%,(61,82).

In **Caird et al [7]** 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.

Minimally invasive removal of long bone plating in pediatric patients can be successfully performed utilizing the described push-pull technique.

The technique of femoral shaft plating has evolved with a better understanding plate mechanics. **Rozbruch et al [14]** evaluated results of femoral fracture plating over 30 years, emphasizing the evolution of plating techniques, including the use of longer plates, indirect reduction techniques, fewer plate screws, and fewer lag screws. The best predictor of success was the length of the plate. In the comminuted and long oblique fractures treated in this study, the longer plate results in less strain on the plate and screws as the working length of the plate increases. With the soft tissues intact around the fracture, the more rapid callus formation results in earlier load sharing of the bone. This limits the period of the load carried by the plate and the potential for failure. The longer plate also requires fewer screws needed for optimal plate fixation. It was found that if the fracture was of significant length, allowing room for 2 to 3 screws proximal and distal, there was still enough mechanical stability with a long plate to successfully stabilize the fracture [14].

This series indicates that submuscular bridge plating is an alternative to treat length unstable femoral fracture lit 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.

5. Conclusion

This series provides evidence supporting the use of submuscular bridge plating in length-unstable femoral shaft fractures in children between the ages of 6 and 12 and the Cluster technique simplifies application of the screws through the small incisions. From this study cluster technique gives good stability for healing of pediatric fracture shaft femur. It combines the best characteristics of closed treatment methods (preservation of the biology of the fracture site) with the best characteristics of surgical treatment (stability and preservation of the correct alignment, early mobility and ease of care).

References

[1] MS.Kocher, EL.Sink, RD.Blasier, Treatment of Pediatric Diaphyseal Femur Fractures.Journal of the Academy of Orthopaedic Surgeons.vol.17 (11),pp.718-725,2009.

[2] Egol, J.Kenneth Koval, D.Joseph Zuckerman, Handbook of fractures,5th Edition,Kenneth A. Copyright Wolters Kluwer Health,2014.

[3] RY1.Hinton, A.Lincoln, MM.Crockett, P.Sponseller, G.Smith, Fractures of the femoral shaft in children. Incidence, mechanisms, and sociodemographic risk factors, J Bone Joint Surg Am.vol.Apr.vol.81(4),pp.500-9,1999.

[4] MD.Kanlic, O.PhD Jeffrey, MD.Anglen, G.Douglas Smith, MD,Steven J. Morgan, MD, and Rodrigo F. Pesántez, MD, Advantages of Submuscular Bridge Plating for Complex Pediatric Femur Fractures,Enes M. clinical orthopaedics and related research.vol.426,pp.244–251,2004.

[5] E.Bar-On, S.Sagiv, S.Porat, External fixation or flexible intramedullary nailing for femoral shaft fractures in children. A prospective, randomised study. J Bone Joint Surg Br.vol.79(6),pp.975-8,1997.

[6] MJ.Gardner, BD.Lawrence, MH.Griffith Surgical Treatment of Pediatric Femoral Shaft Fractures. Current Opinion in Pediatrics.vol.16(1),pp.51-57,2004.

[7] MS.Caird, KA.Mueller, A.Puryear, FA.Farley, Compression plating of pediatric femoral shaft fractures. J Pediatr Orthop.vol..23(4),pp.448–452,2003.

[8] TJ.Lujan, CE.Henderson, SM.Madey, DC.Fitzpatrick, JL.Marsh, M.Bottlang, Locked plating of distal femur fractures leads to inconsistent and asymmetric callus formation. J Orthop Trauma.vol.24(3),PP.156-62,2010.

[9] EL.Sink, J.Gralla, M.Repine, Complications of pediatric femur fractures treated with titanium elastic nails: A comparison of fracture types .J Pediatr Orthop.vol.25(5),PP.577-580,2005.

[10] JM.Flynn, T.Hresko, RA.Reynolds, Titanium elastic nails for pediatric femur fractures: A multicenter study of early results with analysis of complications. J Pediatr Orthop.vol.21,PP.4–8,2001.

[11] J.Aronson, LO.Hughes, RD.Blasier, EA.Turskey, External Fixation of Pediatric Femur Fractures: Indications and Technique for Successful Results. Operative Techniques in Orthopaedics.vol.5(2),PP.132-144,2004.

[12] DL.Skaggs, AI.Leet, MD.Money, BA.Shaw, JM.Hale, VT.Tolo, Secondary Fractures Associated with External Fixation in Pediatric Femur Fractures. Journal of Pediatric Orthopaedics.vol.19(5),PP.582,1999.

[13] CA.Ho, DL.Skaggs, CW.Tang, RM.Kay, Use of Flexible Intramedullary Nails in Pediatric Femur Fractures. Journal of Pediatric Orthopaedics.vol.26(4),PP.497-504,2006.

[14] SR.Rozbruch, U.Müller, E.Gautier, R.Ganz, The evolution of femoral shaft plating technique. Clin Orthop Relat Res.vol.(354)

[15] ,PP.195-208,1998.