TITLE

FUNCTIONAL OUTCOME OF PROXIMAL FEMORAL NAILING IN UNSTABLE INTERTROCHANTERIC FRACTURES

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INTRODUCTION

Intertrochanteric fractures are those occurring in the region extending from the extracapsular basilar neck region to the region along the lesser trochanter before the development of the medullary canal [1]. Inter trochanteric fractures are among the most common fractures encountered in orthopaedic practice. These fractures are common in the elderly around the sixth and seventh decade. They are usually caused by trivial trauma and are associated with osteoporosis. Nevertheless they can be seen in younger patients too following high energy injury [2].

Before the introduction of suitable fixation devices, these fractures were treated non - operatively with modified Russell's traction. This was associated with high complication rate including decubitus ulcer, pneumonia, thromboembolism, urinary tract infection, soft tissue contracture, shortening and varus deformity [3].

Several types of compression hip-screws with a plate have gained increased popularity for the treatment of intertrochanteric fractures. These implants provide secure fixation and controlled impaction of the fracture. But their use in unstable intertrochanteric fractures has not been satisfactory due to the excessive sliding of the lag screw within the plate causing medialization of distal fragment and subsequent fixation failure [4, 14, 15, 16, and 17].

In the early 1990s, a new fixation device was introduced for the treatment of unstable intertrochanteric fractures to circumvent the disadvantages of dynamic hip screw. The earliest version of this device was the Gamma nail (introduced by Howmedica, Rutherford, New Jersy). The proposed advantages were insertion through a minimally invasive incision, shorter operative time and improved fracture fixation biomechanics [5]. In 1997, the proximal femoral nail (PFN, Mathys Medical, Bettlach, Switzerland) was introduced for treatment of unstable pertrochanteric fractures. Biomechanically, the shorter lever arm of the proximal femoral nail decreases the tensile strain on the implant by 25-30% and thus reduces the risk of failure of the implant. The PFN has an additional anti-rotational screw (hip pin) placed in the femoral neck to avoid rotation of cervicocephalic fragments during weight bearing [6].

In a prospective study, we intend to find out the functional outcome of PFN in the treatment of unstable proximal femoral fractures.

MATERIALS AND METHODS

This was a prospective study done in 20 patients with unstable inter trochanteric fractures.

INCLUSION CRITERIA:

1. Unstable intertrochanteric and reverse oblique fractures
2. Fresh fractures within 2 days of trauma

EXCLUSION CRITERIA:

1. Intertrochanteric fractures with fracture neck femur
2. Ipsilateral shaft of femur fracture
3. Open fractures
4. Pathological fractures

All patients participating in the study were admitted and a detailed work up for anaesthetic fitness done. All patients were informed about the study and a written informed consent was obtained. Skin traction was applied immediately to relieve pain. The fractures were classified as either stable (types I and II) or unstable (types III, IV, V) on the basis of the classification of Jensen and Michaelsen, which is a modification of Evans classification. All patients were taken for surgery within 5 days of trauma. Clearance from the Institution's ethics committee was obtained for this study.

Operative technique:

Patient positioning

Patients were shifted to a fracture table to obtain and maintain indirect fracture reduction. The contralateral leg was positioned flexed and abducted over a thigh post to allow unimpeded fluoroscopic visualization of the involved hip. The torso is shifted towards the uninvolved side. The affected limb was slightly adducted to allow access to the trochanteric region.

Fracture reduction

The fracture was reduced with traction and internal rotation. The quality of reduction was assessed by fracture displacement, neck shaft angle, anteversion of the femoral neck and femoral shaft sag using anteroposterior and lateral images.

Nail insertion

The standard PFN (with a length of 240 mm) or other lengths (320–420 mm) were implanted by using a 5-cm skin incision which extended from the tip of the greater trochanter cranially. After incising the fascia and splitting the muscles, a 2.8 mm K-wire was inserted at the tip of the greater trochanter under fluoroscopic control in both planes. The proximal part of the femoral shaft was reamed to 17-mm. The nail was then introduced manually into the femoral shaft. Hammering the nail was avoided. Using C-arm control, the first guide wire for the neck screw was placed in the femoral neck so that the screw could be placed in the lower half of the neck on the anteroposterior view and centrally on the lateral view. Then the guide wire for the antirotational screw was introduced. The 8 mm neck screw and the 6.4 mm derotation screw are then introduced. Depending on the type of fracture, distal static or dynamic interlocking was done using the same aiming device.

The quality of the reduction of the fracture that was achieved intraoperatively was assessed on the basis of displacement and alignment of the fracture as seen on the immediate postoperative radiographs. The reduction was categorized as good, acceptable, or poor. For a reduction to be considered good, there had to be normal or slight valgus alignment on the anteroposterior radiograph, less than 20 degrees of angulation on the lateral radiograph, and no more than four millimetres of displacement of any fragment. To be considered acceptable, a reduction had to meet the criterion of a good reduction with respect to either alignment or displacement, but not both. A poor reduction met neither criterion. Wound was irrigated and closed in layers. Suction drainage used when necessary.

Postoperative care

All patients received antibiotic prophylaxis with intravenous administration of 1.5 g of cefoperazone before induction of anaesthesia and every 12 hours thereafter till drain removal. Tramadol was given for relief of early postoperative pain, and paracetamol was administered in the later recovery period.

Suction drainage was removed on day 2. Patients were permitted to get out of bed and sit in a chair on the second postoperative day and were allowed to bear weight as tolerated by the fourth postoperative day. Radiographs were taken to assess reduction and implant positioning. Sutures were removed at the end of 2 weeks.

Follow up

Patients were evaluated at 1, 3, 6 and 12 months postoperatively.

Clinical evaluation

The following parameters were analysed

1. Mobility as assessed with the score of Parker & Palmer
2. Range of motion of the involved hip

3. Pain about the hip and in the mid portion of thigh graded on a 4 point scale.
    a. 1 point indicated no pain
    b. 2, slight pain
    c. 3, moderate pain affecting ability to walk / necessitating analgesics
    d. 4, severe intractable pain even in bed.

<u>Radiographic evaluation</u>

Plain radiographs were made at each follow up visit to note

1. Any change in the position of the screw
2. Union of the fracture
3. Shortening of the femur
4. Amount of screw sliding
5. Degree of varus collapse

MOBILITY SCORE OF PARKER AND PALMER

Walking Ability	No Difficulty	Alone with an Assistive Device	With Help from Another Person	Not at All
Able to walk inside house	3	2	1	0
Able to walk outside house	3	2	1	0
Able to go shopping, to a restaurant, or to visit family	3	2	1	0

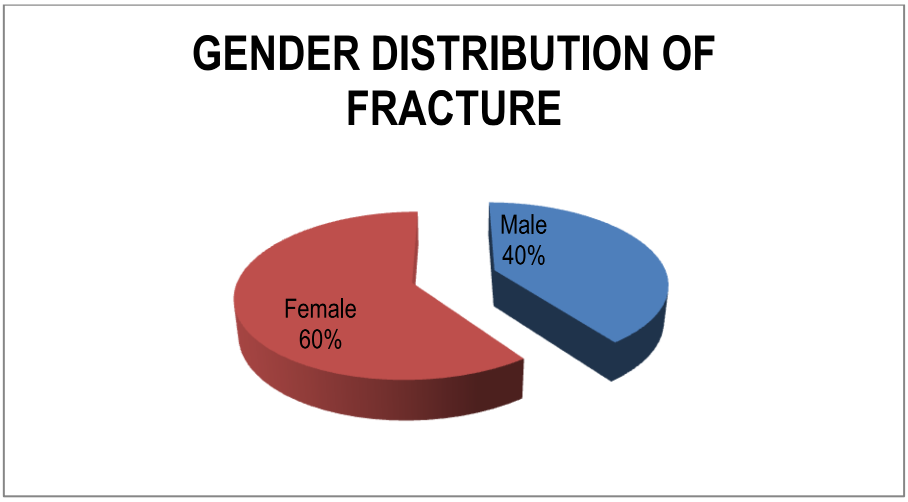
The values are given as the number of points assigned for that answer. The maximum possible score is 9 points [18].

Statistical Analysis

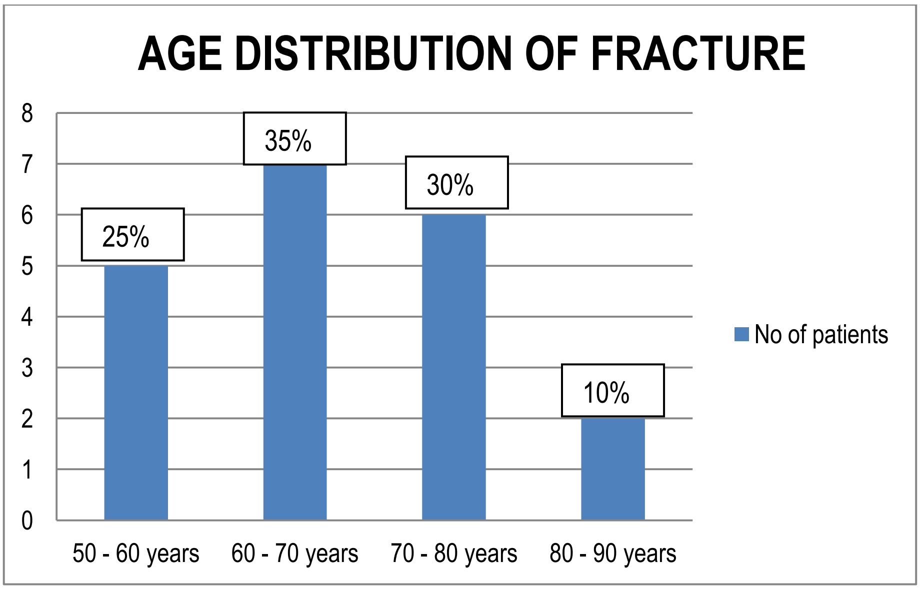
The Friedman test was used for statistical analysis of the parker scores.

OUTCOMES

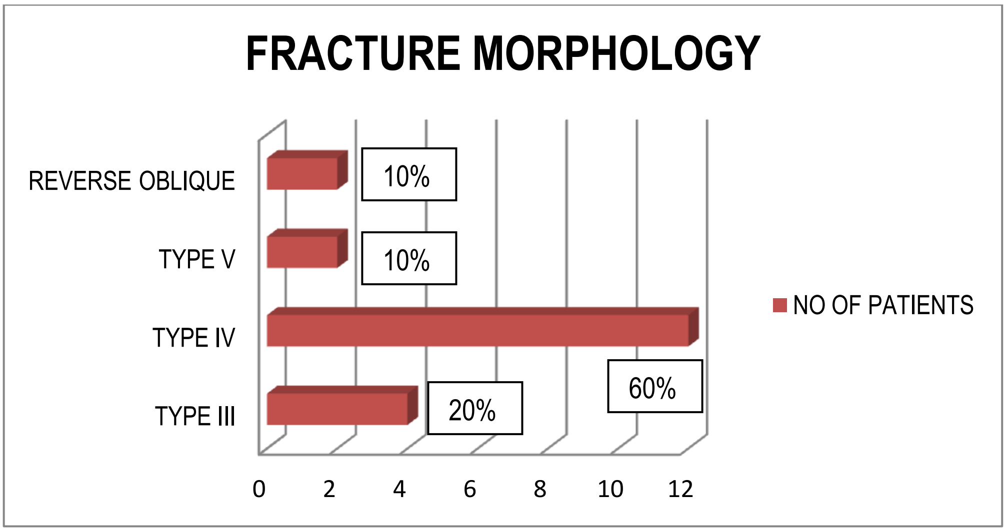
This prospective study was done in 20 patients of unstable intertrochanteric fracture, of whom 8 were males and 12 females. 11 patients had fracture on the left side (55%) and 9 (45%) on the right.



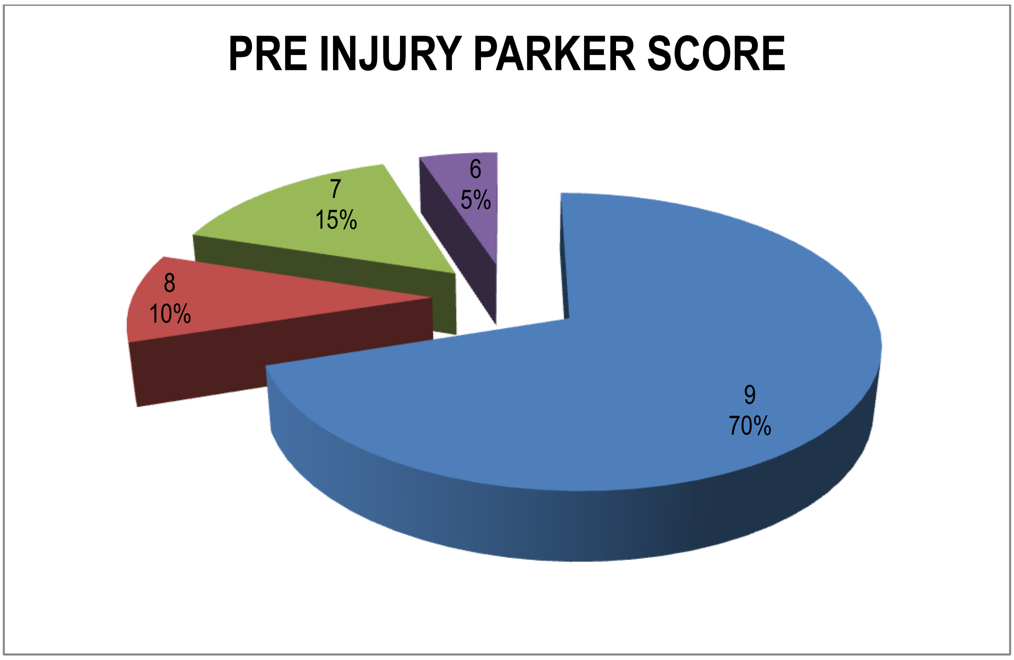
The following bar diagram shows the age distribution of the fracture in our study. 65% of the patients were in the age group of 60 – 80 years.



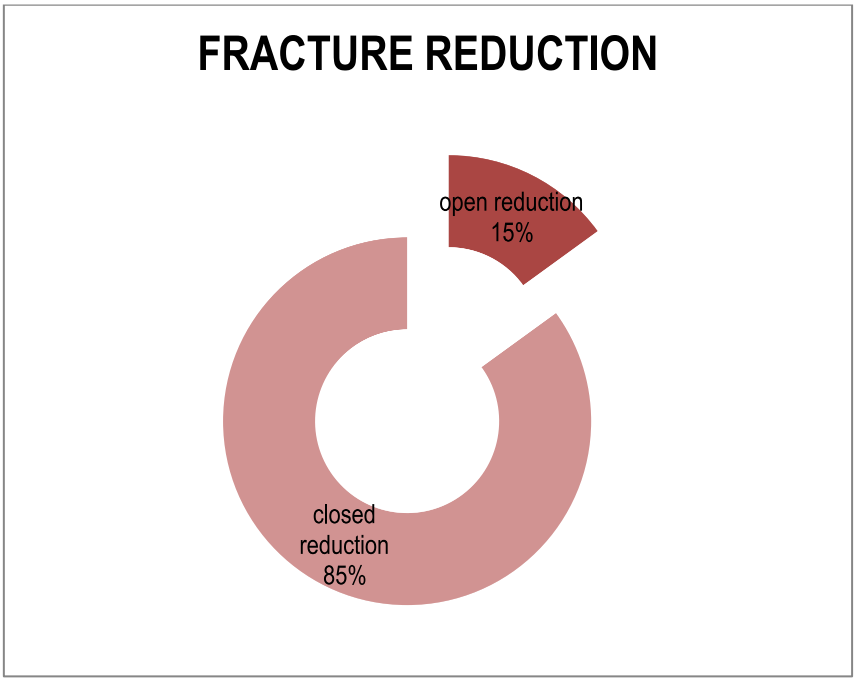
In 17 patients the mechanism of trauma was a trivial fall at home (85%) and in the rest it was road traffic accident (15%). The following bar shows the distribution of fracture types in the study group.



The pre injury parker score of the 20 patients is shown below. The mean pre injury score was 8.45. 70% of the patients had a score of 9 before the trauma.



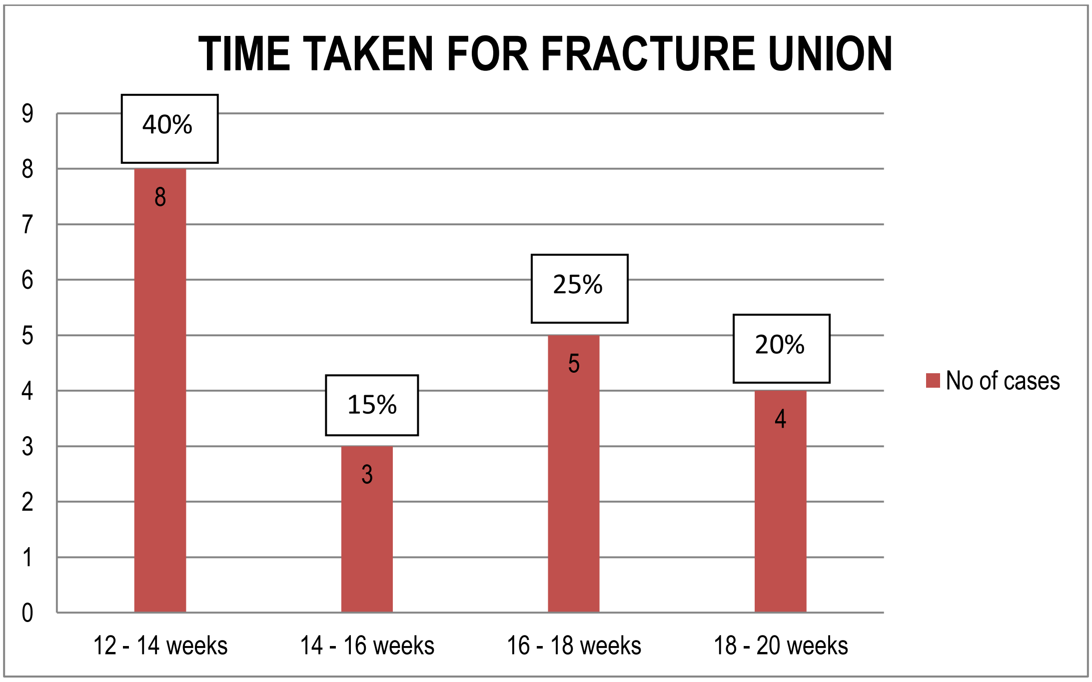
All patients were operated within 5 days and all were treated with Proximal Femoral Nailing. 8 fractures were treated with long nails and 12 with short proximal femoral nails. Long PFN was applied in patients with reverse oblique fracture pattern and in patients with osteoporosis. Closed reduction was done in 17 cases and open reduction in the rest.



The mean operative time was 107.5 minutes (range: 90 min – 180 min), open reduction requiring longer operative time. The mean blood loss during the procedure was 178 ml (range: 120 ml – 320 ml). Reduction was considered good in 16 patients (80%) and acceptable in 4 patients (20%), according to the modified criteria of Baumgaertner.

The 8 mm neck screw was applied in all 20 patients. The 6.5 mm hip pin could be placed in 16 cases only (80%). 5 cases were locked statically (25%) which included the 2 reverse oblique fractures. 15 nails were locked dynamically (75%).

There were no postoperative complications like deep vein thrombosis or pulmonary complaints in any patient. None of the 20 cases got infected. Serous hematoma was present in 3 patients, which was drained. All cases were started weight bearing as tolerated on the fourth postoperative day. The following bar diagram shows the time taken for union and the distribution of cases in each group. The average time taken for fracture union was 14.9 weeks.

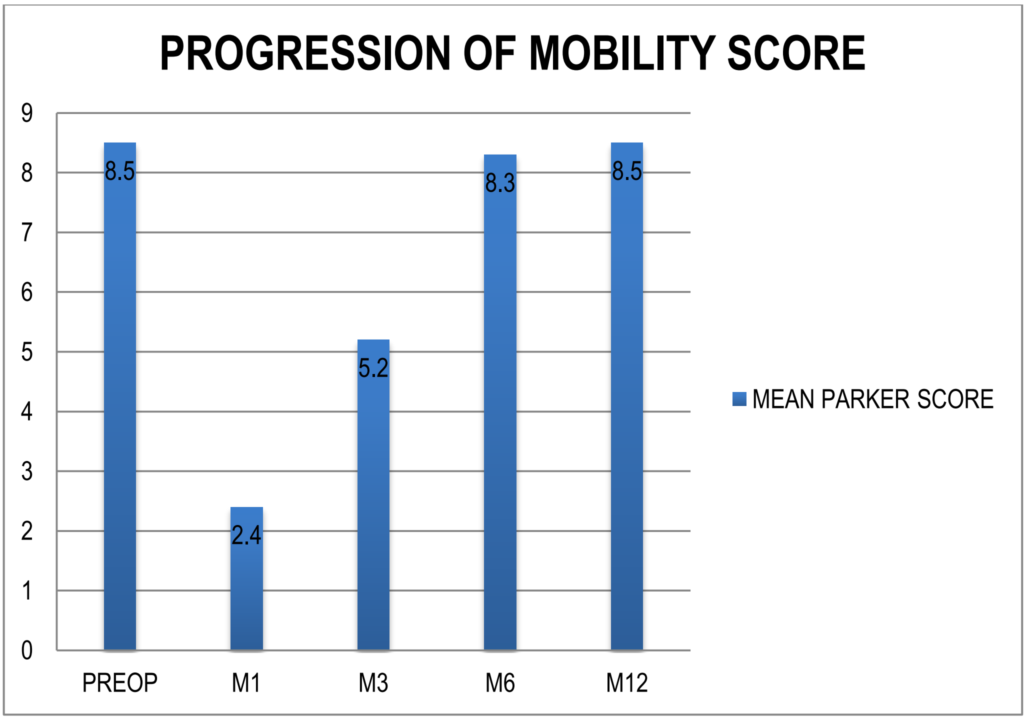


Postoperative Limb Shortening was observed in 9 patients (45%). 5 patients had a shortening of 1 cm, 2 patients had 1.5 cm shortening and the rest had 2 cm shortening. None of these were clinically significant.

Varus malalignment was observed in 4 patients and the mean was 11.7 degrees (range: 10 degrees – 15 degrees). Thigh pain was seen in all 5 cases which were statically locked. The pain was minimal not affecting patient's ability to walk or necessitating analgesics (2 points based on the scoring system we used). The average screw slide seen in 4 out of 20 cases was 7 mm (range: 5 mm – 8 mm).

PARAMETER	**NO. OF CASES**
Varus malalignment	4 (20%)
Thigh pain	5 (25%)
Screw slide	4 (20%)

The following graph shoes the progression of the mean mobility score of Parker and Palmer at each follow up interval according to ability to walk indoors and outdoors, preoperatively (PREOP), and M1, M3, M6, M12 (one , three, six and twelve months postoperatively. The mean preoperative score was 8.5 and the patients reached their preoperative mobility score by 6 months following the surgery.


PROGRESSION OF MOBILITY SCORE
9
8
7
6
5
4
3
2
1
0
8.5
2.4
5.2
8.3
8.5
PREOP
M1
M3
M6
M12
MEAN PARKER SCORE

STATISTICAL ANALYSIS

STATISTICAL ANALYSIS OF THE PARKER SCORES

Method:

Let the number of patients be 'n' and let the parker scores recorded for each patient be for 'k' periods. Let { x_{ij} }, i = 1, 2, …, n; j = 1, 2, …, k, be the matrix of the parker scores thus obtained from all the n patients, for all the k periods. Let { x_{ij} }, i = 1, 2, …, n; j = 1, 2, …, k, be the rank of the $(i,j)^{th}$ score, when the scores of each patient are ranked over the k periods.

Let

$$\bar{r}_{\cdot j} = \frac{1}{n}\sum_{i=1}^{n} r_{ij}$$

The Friedman test statistic is given by

$$F = \frac{12}{nk(k+1)}\sum_{j} r_{\cdot j}^{2} - 3n(k+1)$$

F follows χ^2 distribution with (k-1) degrees of freedom, for sufficiently large k (k>4), or n > 15.

Null hypothesis:

H_o: The parker score does not change over the periods for which observations were taken.

H_1: The parker score changes over the periods.

Decision: Reject the null hypothesis if ‘F’ surpasses the critical value at α = .05

Result:

Table: The Median and Rank total of the parker scores

Period (weeks after treatment)	**Median**	**Rank total**
Pre injury	9	81
4 weeks	2	20.5
12 weeks	5	39.5
24 weeks	9	78.0
1 year	9	81
χ^2_4		63.73 (p < .001)
Critical ratio		0.05

Conclusion:

Since the Friedman test-statistic is found to be significant ($p<.001$), the null hypothesis that the parker scores did not change over the periods after the treatment, is rejected. In other words, there has been a statistically significant ($\chi^2_4 = 63.73$, $p < .001$) change in the parker score over the periods. In fact, it is seen that 6 months after the treatment, the median parker score resumed to pre-injury level of 9, suggesting that the treatment was fully effective in treating the injury. There was remarkable progress in the recovery as evident from the rank total of the scores and the critical ratio corresponding to the period of 4 weeks after the treatment. Each period showed significant improvement over the previous period.

INTRAOPERATIVE POSITIONING

FRACTURE REDUCTION

FRACTURE UNION AT 14 WEEKS

DISCUSSION

For peritrochanteric fractures of femur, pin and plate fixation has been replaced by a variety of dynamic compression screw plates. These give good results in stable fractures, whereas in unstable fractures with loss of posteromedial cortical buttress; there is impaction with shortening of the neck of femur thereby reducing the lever arm of the hip abductors. Most of the body weight is borne by the calcar and a plate supporting a nail or screw would be at a distance lateral to this weight bearing line which produces considerable tension in the implant. PFN is closer to the calcar, subjected to less tension and is more stable [5].

PFN insertion is accomplished closed through a smaller skin incision preserving the fracture hematoma, an essential element in the consolidation of fracture [7]. The decrease in surgical trauma certainly reduces intra-operative blood loss, infection and wound complications, allowing significantly earlier rehabilitation and a shorter hospital stay.

Multiple cadaveric studies have shown intramedullary devices to provide substantially stronger and more rigid fixation of unstable intertrochanteric fractures than extramedullary devices. The biomechanics of intramedullary fixation in the context of a destabilized medial cortex are optimized by medialization of the fulcrum point and resultant reduction of the bending moment with respect to proximal fixation [8]. Also the large proximal diameter (17mm) makes it resistant to bending. Moreover the compression screw is larger than that used with DHS (12mm vs 7.7mm, respectively) giving it a six fold greater area moment of inertia, resulting in a significantly greater resistance to bending. With decreasing fracture stability, the PFN becomes more load bearing, thereby reducing calcar strain [9].

We report the results of the use of PFN to treat unstable intertrochanteric fractures in 20 patients. 60% of the fractures in our series were seen in females and 65% were in the age group of 60-80 years. We used the Jensen and Michaelsen system to classify intertrochanteric fractures [10]. Our population comprised a high percentage of fractures with type IV (60%), where there is loss of posteromedial contact between fracture fragments.

Patients with osteoporosis / reverse oblique fracture pattern (8 patients) were treated with long PFN for better fracture stability. Short nails were used in the rest. 85% of the fractures were treated closed and open reduction was done in cases where closed reduction was technically not possible. The mean operative time was 107.5 min. Comparing to the studies done by Dominique C.R. Hardy, Pierre et al. on Intramedullary hip screw for unstable intertrochanteric fractures (mean operative time 71 min), and Christian Boldin, Franz J Seibert et al (mean operative time of 68 min), the operative time was longer in our series [4,7]. This may be because of the longer operative time required for the 4 cases treated by open reduction which could have tilted the mean towards a higher value.

The mean intraoperative blood loss of 178 ml in our series compares favourably with previously reported values in the literature [4, 11]. The quality of fracture reduction as assessed by modified criteria of Baumgaertner [12] was good in 80% cases. In 4 patients the reduction was acceptable with a mean varus malalignment of 11.7 degrees. We would like to attribute this varus malalignment to technical error in the early stages of our learning curve. This was also the reason why in these cases the derotation hip pin could not be placed inside the neck. In the rest 16 patients, the neck screw was placed inferior in the neck on anteroposterior view and central as seen on lateral radiograph; allowing placement of the hip pin superiorly.

There were no postoperative complications in our series, plausibly because of the early mobilization in our patients and early weight bearing as tolerated. 9 of our patients had shortening postoperatively due to a combination of fracture communition (types IV & V) and collapse in osteoporotic bone. The technical error of varus malalignment in 4 of our cases also contributed to the shortening. This shortening was clinically insignificant as it was less than an inch.

Screw cut out was not seen in our series due to its proper placement within 1 cm of subchondral bone. The PFN is fixed with 2 screws; the larger lag screw is designed to carry most of the load, and the smaller screw (hip pin) is to provide rotational stability. If the hip pin is longer than the lag screw, vertical forces would increase on the hip pin and start to induce cut - out or z – effect [6]. In our study, the hip pin was 10 mm shorter than the lag screw, and this may have prevented overloading of the hip pin and cut-out in all cases.

Most of the fractures in our series (40%) united by 12-14 weeks. Those that required open reduction took 14-18 weeks to unite. Reverse oblique fractures took 18-20 weeks for fracture union. The mean preoperative mobility score of Parker was 8.5, which was reached by patients on their 6th postoperative month (statistically significant, $p < 0.001$). Each period showed statistically significant improvement over the previous period. There was considerable progress in the recovery as evident from the rank total of the scores and the critical ratio. This early mobility score seen in patients of our series after proximal femoral nailing may be explained by the fact that these patients had no / clinically insignificant limb shortening.

Static locking was done in 5 patients where rotational control was thought to be more problematic and shortening more likely. These patients had thigh pain during follow up visits. This association was also seen in the study done by Dominique C. R. Hardy, Pierre et al and they attributed the pain to the cortical hypertrophy seen in those cases [4]. However, cortical hypertrophy was evident only in 2 patients and the thigh pain in the rest could not be explained.

Screw slide was seen in 4 of our patients. The slide was because of the impaction of the fracture, rather than migration of the screws. The average slide was 7 mm favourably comparing with the studies done by Dominique C. R. Hardy, Pierre et al (mean slide 5.6 mm) and K.S.Leung, W.S.So et al (mean slide 6.55 mm) [4,13]. The minimal sliding seen in PFN was because of the minimal telescoping displacement of proximal aspect of femur, preventing its complete impaction. The overall amount of slide was however small to be associated with increased postoperative discomfort.

CONCLUSION &

RECOMMENDATION

New implants must undergo critical evaluation as they are introduced into the orthopaedic surgeon’s practice. The proximal femoral nail used in our series to treat unstable intertrochanteric fractures performed well both functionally and radiographically. The union rates and the mobility scores seen in our series were comparable with the studies in literature. We recommend the use of PFN to treat unstable intertrochanteric fractures.

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