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Dr. Balaji Douraiswami
Associate Professor,
Department of Orthopaedics,
SRM Medical College & Research Centre, Chennai, India.

Dr. Vijay Anand Balasubramanian
Assistant Professor,
Department of Orthopaedics,
SRM Medical College & Research Centre, Chennai, India.

Dr. Suresh Subramani
Assistant Professor,
Department of Orthopaedics,
SRM Medical College & Research Centre, Chennai, India.

Dr. Ramakanth Rajagopalakrishnan
Assistant Professor,
Department of Orthopaedics,
SRM Medical College & Research Centre, Chennai, India.

Correspondence
Dr. Balaji Douraiswami
Associate Professor,
Department of Orthopaedics,
SRM Medical College & Research Centre, Chennai, India.

Does the functional outcome of unstable pertrochanteric fractures improve with proximal femoral nailing? A prospective study of its usage in 50 patients

Dr. Balaji Douraiswami, Dr. Vijay Anand Balasubramanian, Dr. Suresh Subramani and Dr. Ramakanth Rajagopalakrishnan

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Abstract
Background: Proximal Femoral Nail (PFN) provides tangible evidence for its usage in unstable pertrochanteric fractures. There are a veritable number of references which show that PFN by virtue of its intramedullary fixation reduces the tensile strain thereby mitigating implant failure. Ours is a prospective study done on 50 subjects to assess the outcome of PFN usage in unstable pertrochanteric fractures.
Methodology: 50 patients with Jensen Michaelsen type III, IV, V intertrochanteric and reverse oblique fractures were included in the study. The reduction obtained intra operatively was assessed using the modified criteria of Baumgaertner. Follow up evaluations were done at 6, 12, 24 and 52 weeks thereafter. Clinical evaluation was done using the Mobility score of Parker and Palmer. Radiographic parameters like fracture union, screw slide and degree of varus collapse were also assessed. Statistical analysis was provided by Friedman test.
Results: Jensen Michaelsen type IV was the most common pattern observed (44%). The mean pre-injury parker score was 8.4. Patients with reverse oblique fracture morphology, type V fractures and patients with osteoporosis were treated with Long PFN (19 cases). The mean operating time was 92 minutes (range 60 - 180), and the mean blood loss during the surgery was 145 ml (range 100ml - 320 ml). The reduction was good in 40 patients (80%) and acceptable in the rest. The average time taken for fracture union was 15 weeks. It was observed that patients reached their preoperative mobility score of Parker and Palmer by 6 months post-surgery which was statistically significant ($\chi 2$ = 217.642, p < .001). **Discussion:** Proximal Femoral Nailing is done through a minimally invasive approach not disturbing the fracture hematoma which is a vital in fracture consolidation. The biomechanics of intramedullary fixation in cases of destabilised medial cortex is optimised by medialization of the fulcrum point and resultant reduction of the bending moment with respect to proximal fixation. Fracture reduction was good in 80% cases and in 10 cases the reduction was acceptable with a mean varus malalignment of 13.2 degrees.The mean intraoperative blood loss of 145 ml in our series compares favourably with previously reported values in the literature. Most of the fractures in our series (66%) united by 12-14 weeks. The mean preoperative mobility score of Parker was 8.4, which was reached by patients on their 6th postoperative month (p & lt; 0.001). Each period showed statistically significant improvement over the previous period as evident from the rank total of the scores and the critical ratio.

Keywords: Proximal femoral nail (PFN), Intertrochanteric fractures, Parker mobility score, Jensen Michaelsen classification, Baumgaertner criteria

1. Introduction

Intertrochanteric fractures are defined as fractures extending from the base of the neck of femur to the lesser trochanter before commencement of the medullary canal [1]. These fractures are commonly seen in people in their sixties and seventies following trivial trauma, albeit seen in younger population following a high energy injury [2]. These fractures when treated conservatively with modified Russell's traction are associated with significant increase in complications, viz. pneumonia, bed sores, thromboembolism, urinary tract infection, soft tissue contracture, shortening and varus deformity [3]. Dynamic Hip Screw provides stable fixation in these fractures with controlled impaction.

However, profound slide of the lag screw with medialization of distal fragment and consequent fixation failure seen when used in unstable intertrochanteric fractures precludes its usage [4, 15, 16, 17]. When used, a medial displacement osteotomy has to be added to aid the mechanical disadvantage. Intramedullary fixation for unstable pertrochanteric fractures has its origin in the early 1990s, when Gamma nail was introduced by Howmedica, Rutherford, New Jersy. The merits of its usage include ease of insertion through a minimally invasive approach, shorter operative time and an enhanced fracture fixation biomechanics [5]. Proximal femoral nailing (PFN) was introduced in the year 1997 by Mathys Medical, Bettlach, Switzerland, for the management of unstable pertrochanteric fractures. The biomechanical advantage being the shorter lever arm of the proximal femoral nail which reduces the tensile strain by 25-30% thereby mitigating implant failure. It also has a derotation screw placed superiorly to avoid rotation of cervicocephalic fragments during physiological loading of the hip joint [6]. This prospective study was done to assess the functional outcome of PFN in the management of unstable pertrochanteric fractures.

Methodology

This was a prospective study done in 50 patients diagnosed with unstable pertrochanteric fractures.

Inclusion criteria

1. Unstable pertrochanteric fractures (including intertrochanteric and reverse oblique fractures)

Exclusion criteria

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

Patients included in the study were admitted and a detailed work up for anaesthetic fitness done. Skin traction was applied immediately to relieve pain and appropriate radiographs taken. 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 [7]. All patients were explained about the study and a written informed consent in patient's native language was obtained. Patients were all also informed about the usage of his / her data for educational and publication purposes. The procedures performed in this study involving human participants were in accordance with the ethical standards of the Institution and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Operative procedure

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

Fracture reduction

The fracture was reduced with traction and internal rotation. The reduction was assessed for displacement of fracture fragments, caput collum diaphyseal angle, femoral neck ante version and posterior sag of femoral shaft. Intra operative fluoroscopic anteroposterior and lateral images were used to assess the aforementioned parameters. In cases where closed reduction was not achievable, open reduction was done using the anterolateral approach to hip and femur.

Nail insertion

The standard PFN (length 240 mm) or long PFN (320–420 mm) as the case may be, was inserted using a 5-cm skin incision placed above the tip of the greater trochanter. After incising the fascia and splitting the muscles, a 2.8 mm threaded K-wire was inserted at the tip of the greater trochanter under image intensifier control. The nail entry site was reamed to 17-mm over the K-wire. The K-wire removed and a guide wire was inserted into the femoral shaft and the canal reamed sequentially. The appropriate sized nail was then introduced manually into the femoral shaft. Hammering in all cases was avoided. Guide wire for the neck screw was placed in the femoral neck engaging the lower part of the neck on the anteroposterior view and positioned centrally on the lateral view. The guide wire for the antirotational screw was introduced superiorly. The 10.7 mm neck screw and the 6.4 mm derotation screw were then introduced. Distal static interlocking was done using the same aiming device in short PFN and using free hand technique in the long PFN. The reduction obtained intra operatively was assessed using the modified criteria of Baumgaertner [8]. 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 millimeters 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.

Post-operative care

Antibiotic prophylaxis of 1g Cefazolin was given 20 minutes prior to skin incision and continued every 12 hours for 48 hours post operatively. Intravenous 1g paracetamol infusion every 8 hours was given for pain relief. Patients received chest physiotherapy and isometric quadriceps exercises on the first post-operative day. Patients were mobilized out of bed on the second day and weight bearing as tolerated started. Radiographs were taken. Sutures were removed at the end of 2 weeks.

Follow up

Patients were evaluated at 6 weeks, 12 weeks, 6 months and 1 year both clinically and radiologically.

Clinical evaluation included assessing the following:

1. Mobility score of Parker and Palmer.
2. Hip range of motion.
3. Pain as assessed on a 4-point scale.

1. point indicated no pain.
2. slight pain.
3. moderate pain affecting ability to walk / necessitating analgesics.
4. severe intractable pain even in bed.

Radiographic evaluation involved

1. Any change in the position of the screw.
2. Fracture union.
3. Amount of screw slide.
4. 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 to shopping, to a restaurant or to visit family	3	2	1	0

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

Statistical analysis

The Friedman test was used to assess the parker scores over time.

Results

This prospective study was done in fifty patients with unstable pertrochanteric fractures. The study population included twenty-three males and twenty-seven female patients with 46% of the fractures on the left side. 76% of the patients were in the age group 60-80 years (Bar chart: Table 1). Trivial trauma was the mechanism to cause fracture in 85% of cases (43 patients). Regards the fracture morphology, type IV was the most common pattern observed (44%) followed by type III (28%) (Bar chart: Table 2). The mean pre injury parker score was 8.4. Closed reduction was done in forty-four cases and the remaining six required open reduction. Patients with reverse oblique fracture morphology, type V fractures and patients with osteoporosis were treated with Long PFN (19 cases).

The mean operating time was 92 minutes (range 60 - 180), open reduction and long PFNs requiring longer procedure time. The mean blood loss during the surgery was 145 ml (range 100ml - 320 ml). The reduction as assessed using the modified criteria of Baumgaertner was good in 40 patients (80%) and acceptable in the rest. The 10.7 mm neck screw was inserted in all cases, however, the 6.4 mm derotation hip screw could not be placed in seven cases. 13 nails were locked dynamically and in the remaining 74%, static locking was done. There weren't any postoperative complications like deep vein thrombosis or pulmonary atelectasis. Serous hematoma (culture negative) was seen in seven patients, which was subsequently drained. All fifty patients were started on weight bearing as tolerated on the second post-operative day. The time taken for fracture union and the distribution of patients in each group is depicted in pie chart (Table 3). The mean time taken was 15 weeks.

Limb shortening was seen in seventeen of our patients (1cm - 2 cm). This was clinically insignificant except in one patient who had a 2 cm shortening which was eventually corrected with shoe raise. The parameters of varus malalignment, thigh pain and screw slide are presented in Table 4. Line diagram (Table 5) depicts the mean mobility score of Parker and Palmer preoperatively and its progression at each follow up visit postoperatively. It was observed that patients reached their preoperative mobility score by 6 months post-surgery.

Statistical analysis of the parker scores

The statistical analysis provided by Friedman test is given by the equation:

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

where 'n' is the number of patients, 'k' the matrix of Parker scores obtained over a period from the 'n' patients; 'r' is the rank order. '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 of 7.81473 at $\alpha = 0.05$

Since the Friedman test-statistic is found to be significant [p<.001; Critical value 16.266], 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 ($\chi^2 = 217.642$, $p < .001$) 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 (Table 6).

Discussion

In stable pertrochanteric fractures, Dynamic Hip Screw is a reliable option with good results. In unstable fractures there is loss of posteromedial cortical buttress with impaction and shortening of the neck of femur reducing the lever arm of the hip abductors. Most of the body weight is borne by the calcar and plate applied to the lateral cortex would be at a distance away from weight bearing axis producing considerable tension on the implant. Cephalomedullary nailing by virtue of its proximity to the calcar region is subjected to less tension and adds to the stability of the construct [5]. Proximal Femoral Nailing is done through a minimally invasive approach not disturbing the fracture hematoma which is a vital in fracture consolidation [10]. It also reduces intra operative blood loss, rate of infection allowing early rehabilitation and shorter hospital stay. The biomechanics of intramedullary fixation in cases of destabilized medial cortex is optimized by medialization of the fulcrum point and resultant reduction of the bending moment with respect to proximal fixation [11]. Also the large proximal diameter of the nail (17mm) together with the compression screw gives it a six-fold greater moment of inertia, significantly increasing the resistance to bending. With decreasing fracture stability, PFN becomes more load bearing reducing calcar strain [12].

We used PFN to treat unstable pertrochanteric fractures in fifty of our patients. 54% of these fractures were seen in women and 76% were in the age group of 60-80 years. Jensen and Michaelsen system of classification was used [7]. Our study population consisted of a high percentage of fractures with type IV (44%), where there is loss of posteromedial contact between fracture fragments.

Patients with reverse oblique fractures / type V fractures and patients with osteoporosis were treated with Long PFN for better fracture stability. Short PFN were used in the rest of cases. 88% of cases were treated closed and open reduction was done in cases where closed reduction was technically not feasible. The mean operative time was 92 min. When compared with 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 in our series was longer [4,10]. This may be because of the longer operative time required for the six cases treated by open reduction which could have shifted the mean scale towards a higher value. When these six cases were excluded, the mean procedure time was 75 min.

The mean intraoperative blood loss of 145 ml in our series compares favourably with previously reported values in the literature [4, 13]. The quality of fracture reduction as assessed by modified criteria of Baumgaertner [8] was good in 80% cases. In ten patients the reduction was acceptable with a mean varus malalignment of 13.2 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 screw could not be placed inside the neck in seven of such cases. In the rest patients, the femoral neck screw was placed inferior in the neck on anteroposterior view and central as seen on lateral radiograph; allowing placement of the derotation screw superiorly.

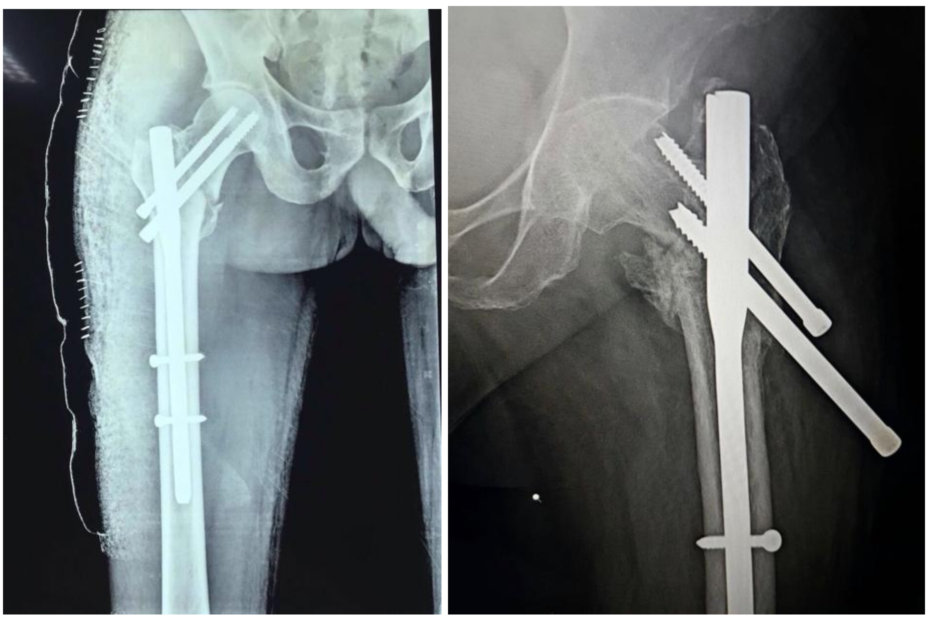
None of the patients had complications like chest infection, deep vein thrombosis, pulmonary embolism, lower limb joint stiffness post-surgery. This could plausibly be due to the rapid rehabilitation program instituted by us after the procedure. Patients were mobilized and weight bearing as tolerated was initiated on the second post-operative day. seventeen of our patients had shortening after the surgery, due to a combination of fracture comminution (types IV, V) and collapse in osteoporotic bone. The technical error of varus malalignment in ten cases also contributed to the shortening. The maximum shortening observed was 2 cm which wasn't clinically significant.

The PFN is fixed with 2 screws; the larger femoral neck screw is designed to carry most of the load, and the smaller screw (derotation screw) is to provide rotational stability. If the derotation screw is longer than the neck screw, vertical forces would increase on the derotation screw and start to induce cut - out or z – effect [6]. Screw cut out was seen in one patient (Figure 1). In our study, the derotation screw was 10 mm shorter than the neck screw, and this may have prevented overloading of the derotation screw and cut-out in our series.

Most of the fractures in our series (66%) united by 12-14 weeks. Those that required open reduction took 16-20 weeks to unite. The mean preoperative mobility score of Parker was 8.4, 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. In 37 patients the nail was locked statically where rotational control was thought to be more problematic and shortening more likely. Type III fractures with good reduction and bone stock were locked dynamically. Nine patients had thigh pain during follow up visits. The association of thigh pain and cortical hypertrophy seen with static locking as seen in the study done by Dominique C. R. Hardy, Pierre *et al*. [4] could not be explained in our study as thigh pain was also seen in cases where long PFN was used and in those locked dynamically.

Screw sliding seen in PFN is usually small because of the minimal telescoping displacement of proximal aspect of femur, preventing its complete impaction. Screw slide was seen in 10 patients post-surgery due to the impaction of the fracture fragments, rather than migration of the screws. The average slide was 13.8 mm which did not compare favourably 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, 14]. The higher mean slide seen in our series could be because of one case which showed a slide of 50 mm, with a lopsided tilt to a higher value (Figure 2).

The proximal femoral nail used in our series to treat unstable pertrochanteric fractures performed well both functionally and radiographically. The union rates and the mobility scores seen in our series were statistically significant and comparable with the studies in literature. The lack of controls is a limitation of our study.



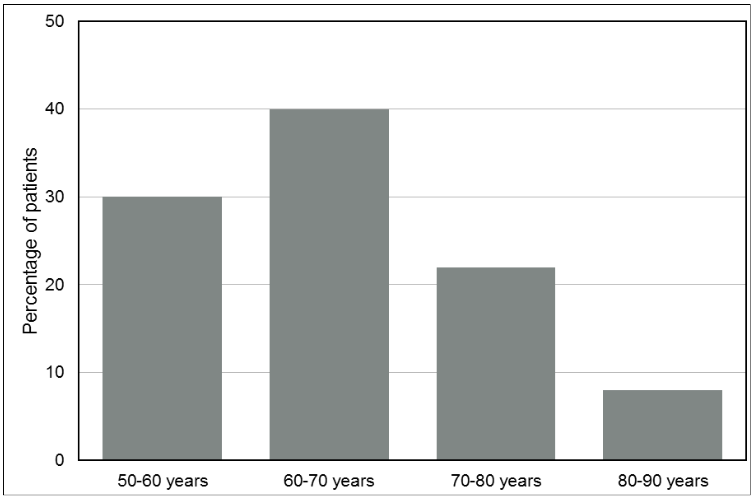


Illustration 1: Age distribution of fracture

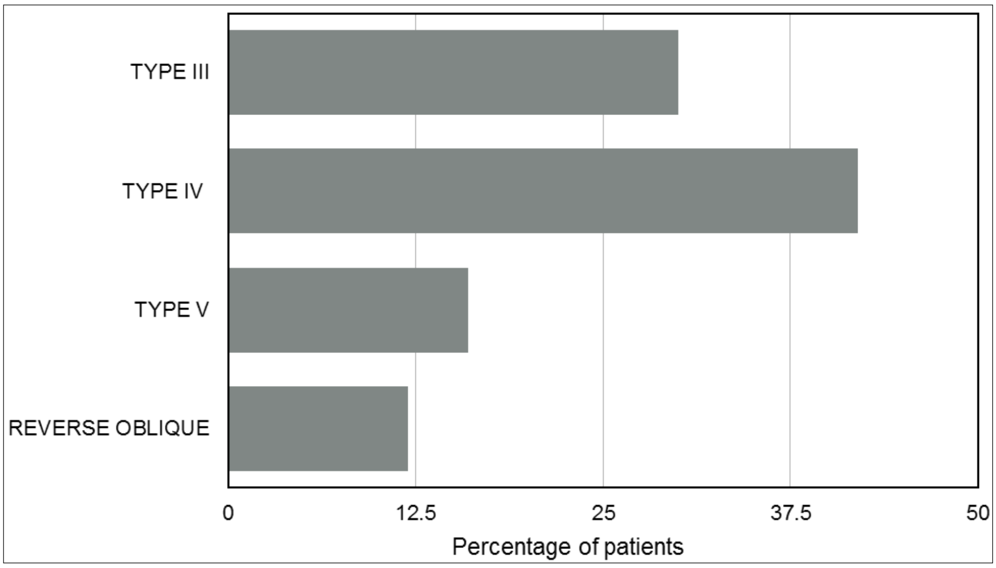


Illustration 2: Fracture Morphology

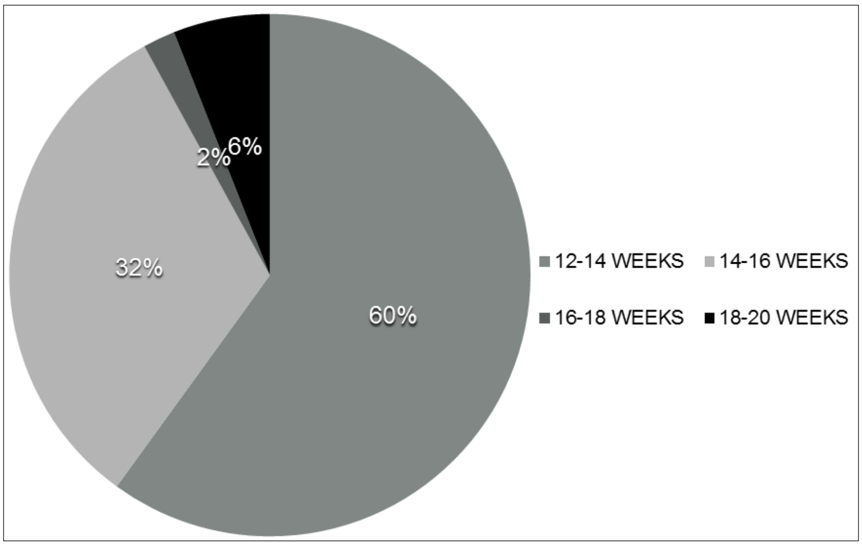


Illustration 3: Time taken for fracture union

Illustration 4: Fracture complications

Parameter	No. Of cases
Varus malalignment	10 (20%)
Thigh pain	9 (18%)
Screw slide	10 (20%)

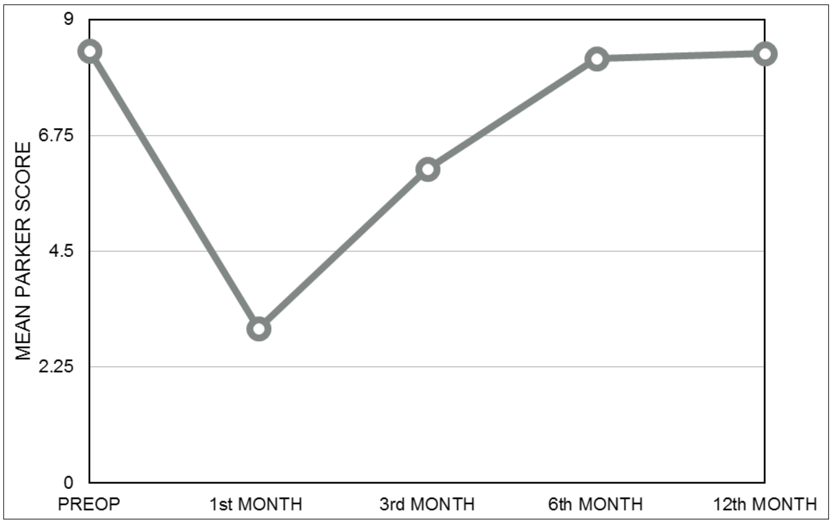


Illustration 5: Progression of mobility score

Illustration 6: The median and rank total of parker scores

PERIOD (Weeks after treatment)	Median	Rank total
4 weeks	3	50
12 weeks	6	100
24 weeks	9	150
1 year	9	152
	X^2	217.642 ($p < 0.001$)
Critical ratio		0.05

Conclusion

PFN gives predictable good functional and radiological results in unstable pertrochanteric fractures with minimal complications. All patients returned early to their preoperative ambulatory status.

Compliance with ethical standards

Conflict of Interest: The authors affirm that there are no potential or existing conflicts of interest that would influence our interpretation of the data in this paper.

Funding: There was no funding or grants for the study.

Ethical approval: The procedures performed in this study involving human participants were in accordance with the ethical standards of the Institution and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: All patients were explained about the study and a written informed consent in patient’s native language was obtained. Patients were all also informed about the usage of his / her data for educational and publication purposes.

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