

Abductor muscle weakness in elderly patients, with intertrochanteric fractures treated with Proximal Femoral Nail: A Prospective, Non Randomized study

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Abstract

Introduction: Intertrochanteric fractures are frequently operated with cephalomedullary nails among hip especially in the elderly and biomechanics of hip may change due to sliding compression which can lead to abductor muscle weakness.

Aim of Study: The aim of this study is to calculate the abductor muscle weakness in intertrochanteric fractures treated with the proximal femoral nail in elderly patients and to correlate it with neck-shaft angle and type of fracture as per Evans classification as limited studies are available for the same.

Materials and Methods: A total of 106 elderly patients diagnosed with intertrochanteric fractures were treated with Proximal Femoral Nail. Fractures were classified using modified Evans classification. Muscle strength and neck-shaft angle were evaluated at 1 month and 3 months postoperatively using Medical Research Council grading and X-rays, respectively, and then functional assessment was done at the final follow-up using the subjective Modified McKay's criteria. All statistical analyses were done using SPSS software version 14.0 mean and standard deviation values were calculated for the neck-shaft angle and femoral neck length in the injured and un-injured hip. A comparison between muscle strength of operative and non-operative sides was done using the Chi-square test with 95% confidentiality intervals.

Results: Out of 106 consecutive patients, after application of the exclusion criteria, 80 patients were included in our study. The study included 46 males (52.5%) and 34 females (47.5%). As per Evans classification, 15 patients (18.7%) were type 3, 22 patients (27.5%) were type 4, and 43 patients (53.7%) were type 5. On evaluation with modified McKay Criteria, 55 patients (68.7%) had excellent, 10 patients (12.5%) had good, 8 patients (10%) had fair, and 7 patients (8.7%) had poor outcomes. Taking significance value $P < 0.005$, on a statistical analysis of the neck-shaft angle with abductor strength as per McKay criteria, we found a significant correlation with $P < 0.005$. However, no significant correlation was found between the fracture pattern and abductor muscle strength.

Conclusion: We can conclude that the restoration of the neck-shaft angle of the femur is an important factor for the strength and recovery of abductor muscles. Proximal Femoral Nail restores neck-shaft angle to near normal irrespective of the fracture angle, hence helps restores almost normal functionality in elderly patients with intertrochanteric fractures.

Keywords: Proximal femoral nail, Modified McKay's criteria, Abductor muscle weakness, Neck-shaft angle.

Introduction

Intertrochanteric fractures are of serious global interest as they are the most frequently operated among hip fractures and have the highest morbidity and mortality rate in the world [1]. Out of

the many implants available, cephalomedullary nails are now quite commonly used by many for the fixation of intertrochanteric fractures [2]. Biomechanics of the hip joint are significantly altered due to fractures in this region and an intramedullary nail such as a Proximal Femoral Nail with a short lever arm can convert the shearing force into compressive force by controlled sliding [3]. This

sliding is what helps cause compression at the fracture site and promotes healing, thus helping in early rehabilitation and weight-bearing [4]. However, it is important to note that theoretically and experimentally speaking, as per human physiology, this sliding may cause a reduction in muscle strength around the hip [4]. This corresponds to many studies that show that 6 months after an intertrochanteric fracture fixation, 50% needed serious assistance in walking, and 90% needed assistance to climb after 1

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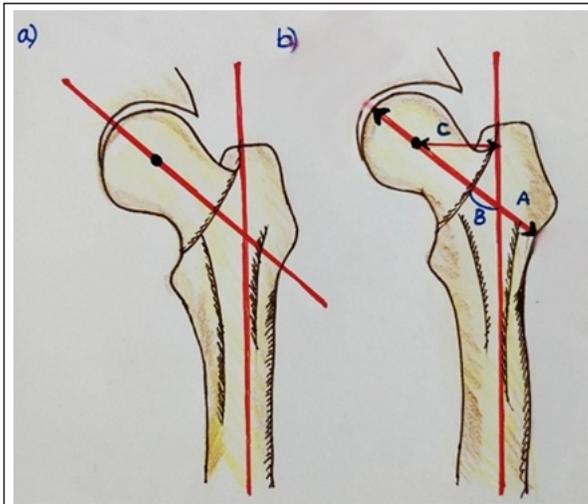


Figure 1: Two lines have been drawn to help evaluation of hip parameters, one crosses through center of rotation of femoral head and center of femoral neck and the other parallel to shaft of femur where (a) femoral neck length (a) femoral neck-shaft angle (b) and hip offset (c) were measured (b).

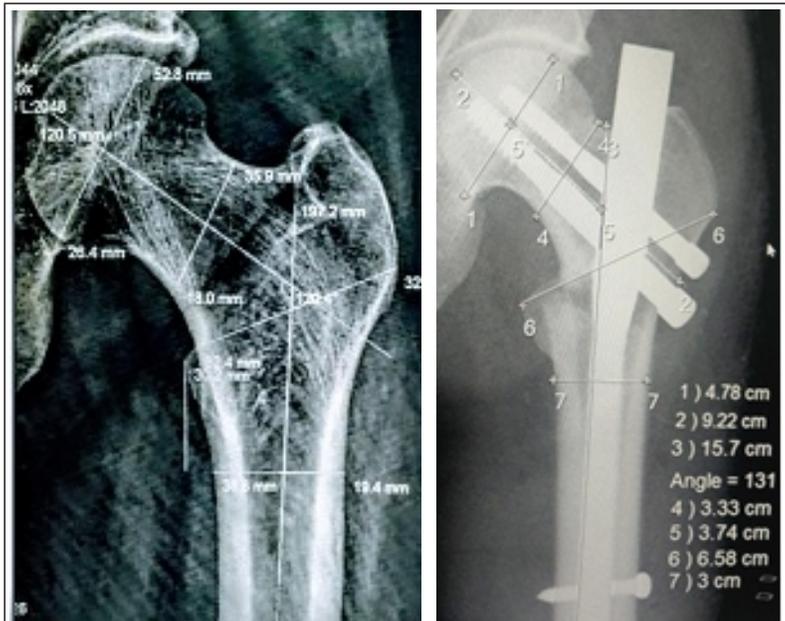


Figure 2: (a and b) DICOM images showing the various parameters calculated in the interrupted and uninterrupted hip in unstable intertrochanteric fractures.

year [3]. In fact many articles suggest that post-operative decrease in mobility is directly related to hip muscle strength [2].

The pathology of fractures (whether stable or unstable), the type of implant used, the operative techniques, and the comorbidities in elderly patients are all factors that may affect the functional outcome of intertrochanteric fractures. The neck of the femur forms an angle with the shaft of the femur (Fig.1) known as the neck-shaft angle which varies anywhere between 120 and 145 degrees.

The role of neck-shaft angle as an independent risk factor for hip fractures has been studied [5]; however, the importance of its restoration and its clinical value and abductor muscle weakness has not been variedly explored or in fact explained.

There are studies that show a correlation between neck-shaft angle and the functional outcome of hip fractures [4]. Many studies also show the presence of abductor muscle weakness in intertrochanteric fractures [6]. Thus, even though abductor muscle weakness

s biomechanically and experimentally explained, there are limited publications that have evaluated the correlation of neck-shaft angle of the femur in intertrochanteric fractures treated with the proximal femoral nail with abductor muscle weakness clinically and radiologically.

Aim of the study

The aim of the study was to calculate the abductor muscle weakness in intertrochanteric fractures treated with the proximal femoral nail in elderly



Figure 3: Immediate post-operative



Figure 4: Post-operative 1



Figure 5: Post-operative at 3 months.



Figure 6: Post-operative at 1 month.



Figure 7: Post-operative at 3 months follow-up.

patients and to correlate it with neck-shaft angle and type of fracture as per Evans classification.

Materials and Methods

From 2017 to 2019, in a prospective non-randomized study, 106 elderly patients diagnosed with intertrochanteric fractures were treated with the proximal femoral nail. The patients excluded from the study were: (1) Pathological intertrochanteric fractures, (2) bilateral hip fractures (e.g., neck of femur and intertrochanteric fracture in same patient), (3) open intertrochanteric fractures, (4) stable intertrochanteric fractures, (5) associated fractures interfering with rehabilitation, (6) inability to walk/non-ambulatory patients pre-fracture, and (7) any other pathology that may affect hip muscle power through physical examination and radiological assessment (e.g., neuroparalytic disorders). All patients were stabilized with skin traction, and plain radiographs in

anteroposterior and lateral views were obtained. After the application of the exclusion criteria, out of 106 patients, 80 patients were included in our study. The study included 46 males (52.5%) and 34 females (47.5%). The mean age of fractured patients in our study was 67 years and the right side affected in 44 patients (55%). The patients were evaluated by clinically and radiological means in 1 month and 3 months after fracture fixation and all fractures were classified using Modified Evans Classification [7]. At the final follow-up, radiological evaluation was done and correlation was done using McKay’s criteria and neck-shaft angle at the final follow-up.

Implant type and operative techniques

The nail used in our study was a standard proximal femoral nail of size 250 mm made of either 316 L steel or titanium alloy. It has a 14 mm proximal head diameter to increase the stability of the

nail and has a distal diameter of either 10mm, 11mm, and 12mm to prevent stress concentration distally. It also has a 6-degree mediolateral valgus angle to prevent varus collapse. Proximally 8 mm compression screw and 6.4mm anti-rotation screw were used. The standard fixation technique was used as per AO/OTA manual [8] and none of the fracture sites were opened.

Post-operative rehabilitation was started on post-operative day 1. The physiotherapy protocol [9] was kept the same in all patients, which included muscle coordination, isometric training, and early weight-bearing without limitation using assisted devices for 30 min a day under supervision.

Measurement of muscular strength

The maximum isometric forces around the hip in flexion, extension, and abduction at zero degree were measured in the follow-up period. Muscle strength was checked at 1 month and 3 months post-surgery using the Medical Research Council (MRC) grading, and then functional assessment was done at 3 months using McKay’s criteria [9].

Radiological evaluation

Post-operative radiographs were obtained during the first post-operative day and were analyzed with the un-

| Table 1: Abductor muscle power as per the MRC grading at various time intervals | | | | | |
|--|---------|---------|---------|---------|---------|
| MRC grade | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 5 |
| Time | | | | | |
| Immediate | 4 | 51 | 25 | 0 | 0 |
| 1 month | 0 | 0 | 17 | 21 | 42 |
| 3 months | 0 | 0 | 2 | 8 | 70 |

MRC: Medical Research Council

injured hip with regard to the length of the femoral neck and the neck-shaft angle (Fig. 2). All these measurements were done by one author. Fracture reduction was considered satisfactory if a neck-shaft angle was within 5–7 degrees of the neck-shaft angle as compared to the uninjured hip (Fig.1). Even among patients with restored neck-shaft angle and less femoral neck shortening, values of muscular strength were considered for statistical significance. All statistical analyses were done using SPSS software version 14.0 mean and standard deviation values were calculated for the neck-shaft angle and femoral neck length on the injured and un-injured hip. Comparison between neck-shaft angle and muscle strength and that between neck-shaft angle and type of unstable fracture of operative sites were compared using the Chi-square test with 95% confidentiality interval and $P < 0.005$ was obtained.

Observation and Results

In this study of 106 consecutive patients, after application of the exclusion criteria, $n=80$ patients were included in our study. The study included 46 males (52.5%) and 34 females (47.5%). The mean age of fractured patients in our study was 67 years with the right side affected in 44 patients (55%). As per Evans classification, 15 patients (18.7%) were type 03, 22 patients (27.5%) were type 04, and 43 patients (53.7%) were

type 05. The muscle power was evaluated as per MRCMRC criteria (Table 1). On evaluation with modified McKayMckay criteria, 55 patients (68.7%) had excellent, 10 patients (12.5%) had good, 8 patients (10%) had fair, and 7 patients (8.7%) had poor outcomes (Table 2).

On radiological evaluation, all patients underwent radiographic analysis on the immediate post-operative day, at 1 month of follow-up and at 3 months. In our study, 4 patients with Z effect were seen and were excluded from the study. The average Neck-Shaft angle significantly decreased during the first post-operativemonth by mean of $3.2 \pm 1.6^\circ$; however, the measured mean values remained virtually unaffected during the period of from 1 month to 3 months.

On comparing the neck-shaft angle and abductor muscle strength, and the neck-shaft angle and type of unstable fracture of operative sites using Chi-square test with 95% confidentiality interval with $P < 0.005$, it was found that there was a significant correlation $P < 0.001$ between the abductor muscle weakness and the restoration of neck-shaft angle of femur to near normal (Table 3). We also found no significant relationship between the type of unstable fracture and abductor muscle weakness.

Immediate post-operative abductor muscle power was Grade 1 in 04 patients, Grade 2 in 51 patients, and Grade 3 in 25 patients. A significant increase in muscle

power was seen after 1 month of follow-up. After 1 month, only 17 patients had Grade 3 power and only 21 patients had Grade 4 power while the rest had Grade 5 power. At the final follow-up, only 02 patients had Grade 3 muscle power, only 08 patients had Grade 04 muscle power, and the rest had Grade 05 power.

Hence, those who had a neck-shaft angle close to near normal (within the above defined parameters) recovered well in with respect to the abductor muscle power while in those patients who did not show good or excellent results as per McKay Criteria which has been depicted in the graph as well (Fig. 1).

Discussion

It is important to realize that in Proximal proximal Femoral femoral fractures, particularly intertrochanteric fractures, less than half the individuals regain physical functionality equal or close to the pre-operative states [10]. The fractured hip is known to be at least 20% weaker than the non-fractured hip post-operatively, especially between 3 and 36 months which may affect early post-operative rehabilitation as per Natalja Ivanova et al. [1]. This clearly emphasizes the importance of early mobilization and physiotherapy in a surgically fixed intertrochanteric fracture.

In recent times, proximal femur nail has become more common for the treatment of intertrochanteric fractures [11] and hence we used a proximal femoral nail as our fixation device of choice in unstable fractures. The fractures were classified as per modified Evan's criteria because he classified fractures based on stability. According to him, posterior-medial continuation is important in restoring stability to intertrochanteric fractures [7].

In our study, although all patients were elderly, we excluded those with severe debilitating co-morbidities such as dementia, stroke, and cardiovascular disease, etc. they were known to hinder

Table 2: Functional assessment at final follow-up (3 months) using McKay's criteria

| Evans classification | Excellent | Good | Fair | Poor | Total |
|----------------------|-----------|------|------|------|-------|
| Type 3 | 10 | 3 | 4 | 1 | 18 |
| Type 4 | 14 | 1 | 3 | 2 | 20 |
| Type 5 | 31 | 4 | 3 | 4 | 42 |
| Total | 55 | 8 | 10 | 7 | 80 |

Table 3: Neck-shaft angle versus abductor muscle strength

| Neck-shaft angle | Excellent/good muscle power (%) | Fair or poor muscle poor (%) |
|---|---------------------------------|------------------------------|
| Modified McKay criteria | | |
| Neck-shaft angle near normal achieved | 61 (96.8) | 2(11.8) |
| Neck-shaft angle near normal not achieved | 2(3.2) | 15(88.2) |

Chi-square value=57.883, Degree of Freedom: 1, $P < 0.001$

the functional outcome and early rehabilitation which corresponds to there search conducted by NodaNada et al. and Wale et al. [3, 6, 10]. All patients underwent the same physiotherapy protocol and the muscle power was calculated using MRC Medical Research Council grading and evaluated using Modified modified McKay criteria. This differs from the research done by Ivanova et al. and Portgejis et al. [3, 12] who tested the muscle strength using hand held dynamometer.

Modified McKay's criteria through subjective measures pain, stability, limp and Trendelenburg gait and is are functionally more efficient. Also Further more, since most of our patients achieved near-normal flexion, extension, and adduction, which correlates with the study conducted by Ivanova et al. and Nada et al, we did not include it in our statistical analysis.

It is important to note that post-operative muscle strength is not evaluated by many trauma surgeons, the reason for which probably is that in many of the major hip scoring systems muscle strength is not exclusively evaluated. This is also another advantage of McKay's criteria.

We compared the outcome of abductor musculature with neck-shaft angle change and came to the conclusion that there is significant a correlation between neck-shaft angle post-operatively and abductor muscle weakness ($P < 0.001$) (Table 1). We found that the mean neck-shaft angle decreased significantly within the first 6 weeks and while there was femoral neck shortening as well, it was not significant. This is in line with the findings by Pajarinen et al. and Bhandari and Deaneet al [13]. Proximal femoral nail restores the near normal neck-shaft angle of the hip through a comparative study with other implants maybe required. The decrease in neck-shaft angle leads to a decrease in abductor muscle length and increase in shearing force which affects the

functional outcome as well [3, 5]. We also found that there was no significant correlation of abductor muscle weakness with the type of fracture which was fixed. Abductors muscle weakness in trochanteric fractures treated with proximal femoral nail maybe accredited to the following reasons. To begin with, compression via through sliding helps fracture healing and speeds up rehabilitation, the negative effects of sliding are considered to be the cause of loss of muscle strength [14]. Since the gluteus medius has a lesser length as compared to the surrounding muscles, the same amount of shortening tends to affect the medius more [16]. It in fact has been demonstrated that shortening of the femoral neck after fixation causes a decrease in abduction strength through flexion, extension, and adduction are near normal. The other reason maybe that the reaming of greater trochanter for proximal femoral nail insertion may cause injury to the gluteus medius. McConell et al. [14] in a cadaveric study of the 34 specimens demonstrated that almost 53% of the incidence of injury to the abductor was observed after using a 17 millimeter reamer, while taking entry for the proximal femoral nail in greater trochanteric tip. These studies were resonated by Gardner et al. who demonstrated a similar result on ten cadavers whose average age was 74 years. Although it can be said that nail insertion with minimal soft-tissue damage may be beneficial [15], a smaller incision may not always guarantee the sparing of abductors. Hence, the damage to the gluteus medius muscle seems to be an unavoidable collateral in proximal femoral nail and is a recognized cause of abductor muscle weakness. Finally, another reason why the abductor muscle strength might be compromised, is the proximal migration of greater trochanter which impairs a normal person's ability to walk [17, 18]. It has been seen that in active patients, especially the young healthy ones, there

was no complaint of any significant muscle weakness even if the muscle was substantially weak [3]. This probably means that such patients adapted well post-operatively and the compensatory mechanisms in these patients using the surrounding hip muscle was were good and adequate. However, this was significantly not seen in our patients, all of whom were elderly, as they all complained of weakness specifically on abduction. This finding coincides with Zlowodoskiet al. [16] who concluded that older patients may develop future functional retardation.

There are a few limitations to our study. While we have tried to reduce as many variables as possible by taking patients of similar age and demographics, all unstable fractures, same implants, and procedures, we did not include comorbidities such as respiratory disease, stroke, cardiovascular defects, and anemia which are known factors to affect early rehabilitation and morbidity of patients. Secondly, while other similar studies have used hand-held dynamometer, we used MRC Medical Research Council grading evaluated with McKay's criteria. This is a subjective criteria criterion with both inter and intra-observer variability [9]. Thirdly, our follow-up period was a maximum of 3 months but did not extend upto 1 year as previously mentioned. As per a study conducted by KostićMitrovic et al. [20], who used a self-dynamisable internal fixator, the average time of union of intertrochanteric fractures was 3.6 months. Another similar study conducted by Marvogeniset al [22], who used a dual-head screw intramedullary hip nail, noticed fracture union in 72 out of 79 patients within 2-3 months' time. Also Further more, a study conducted by Taylor et al., patients after 4 weeks of operation were comfortable, pain-free and were able to weight bear. In a study conducted by Mangione et al. [23] and TsaoTsaot et al. [24], who studied all hip fractures irrespective of the implant used,

evaluated the muscle strength at 3 months 6 months and at 1 year and found no significant difference in muscle recovery and strength after 3 months of physiotherapy.

Conclusion

Despite the limitations of our study, the proximal femoral nail in intertrochanteric fractures causes around 25-30% decreases in abductor muscle strength around the hip joint. However, if the neck-shaft angle is restored to near normal and with good physiotherapy the abductor muscle strength seems to be restored to near normal irrespective of the fracture type. A comparative study

with other implants such as Dynamic Hip Screw or a bipolar prosthesis is further warranted.

Clinical Message

Intertrochanteric fractures will only increase with the increasing life span of the current population. While the type of implants, associated comorbidities and functional outcome have been widely studied, very little material is present on the importance of physiotherapy on abductor muscle weakness and its radiological correlation with neck-shaft angle of femur and fracture pattern. Through this study, we would like to put forward the importance of taking care of

the weakness of muscles postoperatively.

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