Correlation between Post-Operation Center-Trochanteric Distance (CTD) and Tip Apex Distance (TAD) changes in Intertrochanteric Fractures Treated by Dynamic Hip Screw

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Abstract

Background: One of the most common injuries and an important cause of mortality and morbidity in the elderly is intertrochanteric fracture. The dynamic hip screw (DHS) is one of the best procedures for fixation of these fractures; however, using DHS is accompanied by failure risk.

Objectives: Therefore, with the purpose of reducing failure risk, this study aimed to evaluate the correlation between post-operation CTD and TAD, NSA changes in patients with intertrochanteric fractures.

Methods: In this case series study, patients with intertrochanteric fracture treated with DHS between September 2015 and January 2016 were included. The exclusion criteria were pathologic fracture, multiple fractures, greater trochanter fracture, soft-tissue issues, A3OTA type, patients who missed the follow-up period, history of previous hip fracture or dislocation, and TAD>25mm. Ultimately, 24 patients were included in this study. Two surgeons reviewed the anteroposterior (AP) and lateral (Lat) radiographs. The measures of TAD, CTD, and NSA after six-months of follow-up were assessed. In addition, variables such as demographic data, fracture side, duration of operation, blood loss volume, weight bearing day, and Harris hip score (HHS) were analyzed. The relationship between post-operation CTD and TAD, NSA changes after six months of follow-up was analyzed. All data was analyzed using SPSS 20 software (SPSS, IBM Inc., USA). The significance level for all tests was considered to be 0.05.

Results: This study evaluated 24 patients. The mean age of the patients was 69.9 ± 12.00 years, and 15 (62.5%) of them were male. No significant correlations were seen in the collected data, especially CTD and NSA changes after six-months of follow-up (p>0.05). Maximum and minimum TAD values after surgery were 25.6 and 11.0, respectively. Maximum and minimum TAD values at the six-month follow-up were 34.9 and 11.0, respectively. Mean TAD was constant at 19.8±5.3 in postoperative and follow-up measurements. This shows that patients experienced increases in TAD and others experienced decreases in TAD within the six months of follow-up.

Conclusion: The results showed that despite the abnormal CTD after surgery, the risk of TAD changes increased. Generally, TAD is a well-established radiographic measurement for predicting the risk of cut-out. CTD and TAD can be used together or separately to predict the risk of DHS screw cut-out in patients with intertrochanteric fractures in future studies.

Keywords: Intertrochanteric fracture, Center-Trochanteric Distance, Tip Apex Distance, Dynamic Hip Screw.

Introduction

Hip fractures are one of the important causes of mortality and morbidity in the elderly (1). Intertrochanteric fractures are prevalent injuries in the aging population and are frequently a result of sudden influence to an osteoporotic hip, for example that experienced in a fall (2). About 20-30% of patients with intertrochanteric fractures have complications, and mortality is about 17% (3-5). Intertrochanteric fractures are frequently a mortal event subsequent in death due to pulmonary, cardiac, or renal complications. The mortality rate in these patients within one year after fracture is about 10-30% (6).

The frequency of these fractures differs in different counties. Gulberg et al. predicted that the total number of hip fractures will increase to 2.6 million by 2025 and to 4.5 million by 2050 (7).

Successful treatment of these fractures is critical to returning these frail and debilitated patients back to maximal function (8). Failure of treatment has many problems and costs for the patient as well as the healthcare system. Several devices may be used for fracture fixation (9, 10). Dynamic hip screw (DHS) has been a popular device in treating intertrochanteric fractures since the 1970s (11).

However, use of a DHS is accompanied by failure risk. Madsen et al. (12) demonstrated that there is an inferior fracture disorder during a six-month follow-up in 9% of
patients getting a DHS. These complications often include a lag screw cut-out, varus malunion, or excessive lag screw sliding with medialization of the distal fracture fragment.

Additionally, postoperative complications are frequent in rigorously osteoporotic patients (2). Kim et al. treated 178 intertrochanteric fractures with DHS and followed up with them in a minimum of one year. They reported that the complication rate was greater than 50% in osteoporotic bone. There are many risk factors for intertrochanteric fractures; poor bone quality is a major risk factor and could cause increased failure rate for collapse, implants, or lag screw cut-out in older patients (2).

DHS has failed earlier than all types of intramedullary nails in cadaver studies; however, because of availability and low cost, it is still used by many surgeons for fixation of intertrochanteric fracture (13). DHS placement is not devoid of complications. DHS failure rate has been previously reported as 8%-13% (14). Predisposing factors for DHS failure are unstable fractures, severe osteoporosis, poor fragment reduction, and especially, inaccurate lag screw position (15).

The poorest bone quality is in the anterosuperior aspect of the head and neck (16). A middle/middle placement of the lag screw in the anteroposterior and lateral radiographs of the hip is suggested by many studies (17, 18).

The depth of lag screw insertion has a very important predictive role in DHS cut-out, more than the position of the lag screw (19). A simple estimation has been extended to define the position of the screw in femoral head termed as the tip apex distance (TAD) (20-22). TAD is the sum of the distance from the tip of the lag screw to the apex of the femoral head on anteroposterior and lateral radiographs after controlling for magnification (21-23) (Figure-1).

Baumgaertner et al. suggested that a TAD higher than 25 has a significant correlation with DHS cut-out (19). To decrease the risk of lag screw cut-out, it is important to ensure proper fracture reduction and placing the lag screw with a TAD less than 25 mm (19). In our clinical experience, we encountered cases in which TAD had changed, despite those with a post-operation distance of 25 mm or less. In our opinion, two conditions may be the cause of this situation.

Andruszkow et al. established that the TAD was a proper prognosticator of cut-out after intra-medullary, extra-medullary, and stabilization in both stable and unstable intertrochanteric fractures. They recommended that the TAD be assessed for routine clinical use (20).

The first theory was that the neck-shaft angle (NSA) is not similar in different patients. Then, the normal anatomy cannot be rebuilt using 135 DHS in all patients. Therefore, TAD changes because of excessive force.

The next theory was that, despite an acceptable postoperative TAD, fracture reduction is commonly in varus or rarely in valgus, and this malreduction can cause TAD changes (Figure-2, Figure-3). The amount of varus and valgus angulation can be measured with center-trochanteric distance (CTD).

The "center-trochanter distance" (CTD) is the distance between two parallel lines, one from the greater trochanteric tip and one from the center of the head, both orthogonal to the femur anatomical axis. In the normal population, CTD is considered zero (Figure-4).

The CTD is represented by the vertical line drawn to the femoral shaft axis among two parallel lines that cross the middle of the tip of the greater trochanter (T) and the femoral head (20). The measure of CTD is expressed in millimeters and presents as a negative or positive value based on the position of point C, that is, below or above point T, respectively. The center-trochanter distance demonstrates as a useful method in radiographic assessment in several hip disorders, including Legg-Calvé-Perthes disease and developmental dysplasia of the hip. In brief, the CTD is used as an anatomical, objective, and simple assessment pressure for radio-graphical measuring of the proximal femur (21).

Figure-1. Tip-Apex Distance is sum of A+B
Objectives

Therefore, with the purpose of reducing the failure risk of DHS, the current study evaluated the correlation between post-operation CTD and TAD, NSA changes in patients with intertrochanteric fractures who referred to the orthopedic department of Taleghani Hospital (Shahid Beheshti University of Medical Sciences) and were treated by DHS.

Materials and Methods

This case series study was conducted in the orthopedic department of Taleghani Hospital (Shahid Beheshti University of Medical Sciences). Patients with intertrochanteric fractures who were treated by DHS between September 2015 and January 2016 were included in the study, which was approved by the Taleghani Hospital Research Development Committee, Department of Orthopedics, Shahid Beheshti University of Medical Science, Tehran, Iran. The exclusion criteria were pathologic fracture, multiple fractures, greater trochanter fracture, soft-tissue issues, A3OTA type, patients who missed the follow-up period, history of previous hip fracture or dislocation, and TAD>25 mm. Twenty-four patients were suitable for this study, and two surgeons reviewed their anteroposterior (AP) and lateral (Lat) radiographs. The measures of TAD, CTD, NSA before and after six months of follow-up were assessed in post-operation radiographs. Variables such as demographic data (gender, age), fracture side, duration of operation, blood loss volume, weight bearing day, and Harris hip score (HHS) were recorded and analyzed. The relationship between post-operation CTD and TAD, NSA changes after six months of follow-up was analyzed. All data was analyzed using Pearson’s correlation test and SPSS 20 software (SPSS, IBM Inc., USA). The significance level for all tests was considered as 0.05

Results

Twenty-four patients were evaluated in the current study. Mean patient age was 69.9±12.0 years, and 15 (62.5%) patients were male. Table 1 shows the demographics and operative characteristics of the samples. There was no screw cut-out, but changes in NSA and TAD were seen.

Table 2 presents pre- and post-operative measurements. Maximum CTD was 10 mm, and in eight patients, the CTD was zero. Maximum and minimum NSA after surgery were 155 and 120, respectively. The NSA average was 134.5±9.2
mm post-operation and 133.2±13.5 at the six-month follow-up (Table-2).

No significant correlations were seen in the collected data, especially between CTD and NSA changes at the six-month follow-up (p>0.05) (Table-3). Maximum and minimum TAD values after surgery were 25.6 and 11.0, respectively. Maximum and minimum TAD values at the six-month follow-up were 34.9 and 11.0, respectively. Mean TAD was constant at 19.8±5.3 in both postoperative and follow-up measurements. This shows that some patients experienced increases in TAD and others experienced decreases in TAD within six months. There was a significant positive correlation between post-op CTD and TAD changes (TAD) (p<0.001). No significant correlations were found between other parameters and TAD changes (Table-3).

**Discussion**

Internal fixation of intertrochanteric fracture is related to various complications such as mechanical failure and bone healing issues (24-26). Based on the substantial incidence of preexisting comorbidities, revision surgery of fracture increases the mortality rate (5). Cut-out failure is one of the most significant mechanical complications with a range of 1.4% to 19% depending on fracture type and implants (27-30).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ΔTAD</th>
<th>Pearson’s correlation</th>
<th>p-value</th>
<th>ΔNSA</th>
<th>Pearson’s correlation</th>
<th>p-value</th>
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<tr>
<td>Age</td>
<td>-0.242</td>
<td>0.255</td>
<td>0.556</td>
<td>-0.276</td>
<td>0.019</td>
<td>0.991</td>
</tr>
<tr>
<td>Gender</td>
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<td>&lt;0.001</td>
<td>0.841</td>
<td>0.139</td>
<td>0.517</td>
<td>0.414</td>
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<td>Post-operative CTD</td>
<td>0.666</td>
<td>0.003</td>
<td>0.003</td>
<td>0.175</td>
<td>0.347</td>
<td></td>
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<tr>
<td>HHS</td>
<td>-0.76</td>
<td>0.065</td>
<td>0.065</td>
<td>0.201</td>
<td>0.347</td>
<td></td>
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<tr>
<td>Bleeding volume</td>
<td>-0.43</td>
<td>0.019</td>
<td>0.019</td>
<td>0.201</td>
<td>0.347</td>
<td></td>
</tr>
<tr>
<td>Weight-bearing day</td>
<td>0.112</td>
<td>0.602</td>
<td>0.602</td>
<td>0.201</td>
<td>0.347</td>
<td></td>
</tr>
<tr>
<td>Duration of operation</td>
<td>-0.112</td>
<td>0.602</td>
<td>0.602</td>
<td>0.201</td>
<td>0.347</td>
<td></td>
</tr>
</tbody>
</table>

CTD: Center trochanter distance; HHS: Harris hip score; NSA: neck shaft angle
influence the risk of cut-out by TAD changes. However, in the current literature, no similar article about the relationship of CTD and DHS screw cut-out was found. Hakan et al. found that CTD can be an anatomical and simple measuring method for radiological assessment of proximal femur. They suggest CTD has perfect intra- and interobserver reliability (31).

Based on the current results, in addition to TAD<25, an acceptable CTD must be achieved in the surgery field to prevent screw cut-out. Post-op CTD is an essential variable to measure and may impact TAD changes.

TAD can be changed with hip rotation. Because of various sizes of the femoral head, acceptable TAD is variable among patients. TAD should be adjusted according to patient femoral head size.

Goffin et al. found that TAD lacks mechanical justification and has no relation with bone morphology (32). Kane et al. in their biomechanical study found that if the screw position is in the biomechanically stable zone, Tad>25 is not a risk factor for screw cut-out (33). Amini et al. found a high rate of varus collapse in young patients with high energy intertrochanteric fracture in spite of acceptable TAD (34). We found that TAD is still a valuable predictor of screw cut-out (no case of the cut-out in the current study), but it is not sufficient. In our clinical practice, we confront intertrochanteric fracture cases with acceptable post-op TAD which fails over time. These cases trigger us to ask the question, are acceptable TAD values sufficient for satisfactory clinical results? Our hypothesis is “varus or valgus angulations” can be underestimated because of postoperative acceptable TAD. Subsequently, the current results confirm that TAD is a powerful predictor of cut-out after fixation of an intertrochanteric fracture by DHS. It is suggested that changes in post-op CTD and TAD should be noted and considered as valuable factors as well as post-op TAD.

Conclusions

Our results showed that while we have an abnormal CTD after surgery, the risk of TAD changes increases. TAD is a well-established radiographic measurement for predicting the risk of cut-out. Because of the correlation between CTD and TAD, these two parameters can be used together or separately to predict the risk of DHS screw cut-out in patients with intertrochanteric fractures in future studies.

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Authors’ Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

Conflict of Interest

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