Trauma Monthly 2019 Dec;24(6): 32-37

10.30491/TM.2019.104271

Trauma Monthly

Original Article

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

Adel Ebrahimpour, Amin Karimi, Mehrdad Sadighi, Mohammadreza Minator Sajjadi, Mohammad Ali Okhovatpour, Amir Sabbaghzadeh, Reza Zandi *

Taleghani Hospital Research Development Committee, Department of Orthopedics, Shahid Beheshti University of Medical Science, Tehran, Iran

*** Corresponding Author:** Taleghani Hospital Research Development Committee, Department of Orthopedics, Shahid Beheshti University of Medical Science, Tehran, Iran. Email: Reza.zandi@sbmu.ac.ir

Received June 28, 2019; **Accepted** August 18, 2019; **Online Published** November 24, 2019

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).

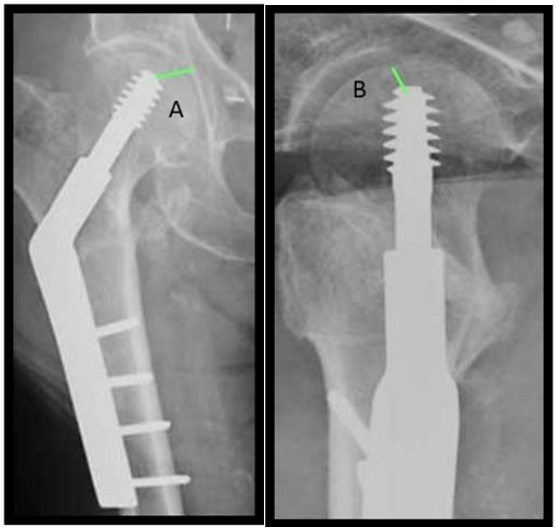

Figure-1. Tip-Apex Distance is sum of A+B

Figure-2. Seventy-year-old man with intertrochanteric fracture treated with dynamic hip screw (TAD+23.1)

Figure-3. Same patient, 6-month X-Ray, TAD=28.6 mm

Figure-4. Center-trochanteric Distance (red line)

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 1. Demographic and operative characteristics of the study population (n=24)

Characteristic	
Age mean±SD (yreas)	69.9±12.0
Male gender, n (%)	15 (62.5 %)
Side of DHS	
right	17 (70.8 %)
left	7 (29.2 %)
Duration of operation, min	87.1±25.3
Bleeding volume, ml	268.8±108.1
Weight-bearing day	7 [2, 19]

Table-2. Comparison of postoperative and follow-up measurements (CTD: Center trochanter distance; TAD: Tip apex distance; NSA: neck shaft angle)

Postoperative measurements	
CTD	2.2 [0, 4.2]
NSA	134.5±9.2
TAD	19.8±5.3
Follow-up measurements	
NSA	133.2±13.5
TAD	19.8±5.3

Table-3. Correlation of TAD and NAS differences with study variables

	ΔTAD		ΔNSA	
Characteristic	Pearson's correlation	p-value	Pearson's correlation	p-value
Age	-0.242	0.255	-0.276	0.192
Gender	-0.126	0.556	-0.218	0.307
Post-operative CTD	0.666	<0.001	0.294	0.163
HHS	-0.76	0.724	0.003	0.991
Bleeding volume	-0.43	0.841	0.139	0.517
Weight-bearing day	0.112	0.603	0.175	0.414
Duration of operation	-0.112	0.602	0.201	0.347

CTD: Center trochanter distance; HHS: Harris hip score; NSA: neck shaft angle

A TAD more than 25 mm is confirmed to be the most influential factor for DHS cut-out (5). According to our experience, however, TAD is not the only important radiological factor in achieving satisfactory clinical results, and TAD can lead surgeons to make the wrong decision if it is considered as a single necessary factor. Despite acceptable post-operation TAD, the current results suggest that TAD may change over time, and according to past studies, these changes can lead to loss of reduction and device failure. In this study, no single case of cut-out was recorded. The results showed a statistical correlation between post-op CTD and TAD changes after six months (p<0.001). Abnormal post-op CTD increases the risk of TAD changes. Based on the current results, it was hypothesized that postoperative CTD may

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.

Acknowledgments

Thanks to Taleghani hospital research development committee, department of orthopedics, Shahid Beheshti University of medical science, Tehran, Iran. Code number: Ir.sbmu.msp.rec.1394.470. All patients have informed consent to precipitate in this research as well as to publish their own data for scientific reasons.

Authors’ Contribution

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

Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

Funding/Support

The authors received no financial funding or support for the research.

References

1. Johnell O, Kanis JA. An estimate of the world wide prevalence, mortality and disability associated with hip fracture. OsteoporosInt. 2004;15(11):897–902.
2. Yang JC, Chen HC, Lai YS, Cheng CK. Measurement of Tip Apex Distance and Migration of Lag Screws and Novel Blade Screw Used for the Fixation of Intertrochanteric Fractures. PloS one. 2017;12(1).
3. Campbell WC, Canale ST, Beaty JH.Campbell's operative orthopaedics. 11th ed. Philadelphia, PA: Mosby/Elsevier; 2008.
4. Paganini-Hill A, Chao A, Ross RK, Henderson BE. Exercise andother factors in the prevention of hip fracture: the Leisure Worldstudy. Epidemiology. 1991;2(1):1625.
5. Rockwood CA, Green DP, Bucholz RW. Rockwood and Green's fractures in adults. 7th ed. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2010.
6. Aashish Raghu, Pavankumar H Patil, Hiranya Kumar. Study of the functional outcome following surgical management of intertrochanteric fractures with either proximal femoral nailing or dynamic hip screw fixation. International Journal of Orthopaedics Sciences. 2019; 5(2): 1050-1054.
7. Minos Tyllianakis, Andreas Panagopoulos, Andreas Papadopoulos et al. Treatment of extracapsular hip fractures with the proximal femoral nail (PFN): Long term results in 45 patients. Acta Orthop. Belg. 2004; 70:444-454.
8. Geller JA, Saifi C, Morrison TA, Macaulay W. Tip-apexdistance of intramedullary devices as a predictor of cut-out failurein the treatment of peri-trochanteric elderly hip fractures. Int Orthop. 2010;34(5):719–722.
9. Baumgaertner MR, Curtin SL. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am. 1995;77(7):1058-64.
10. Baumgaertner M, Solberg B. Awareness of Tip-Apex Distance reduces failure of fixation of trochanteric fractures of the hip. J Bone Joint Surg. 1997;79-B:969–71.
11. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure offixation of peritrochanteric fractures of the hip. J Bone JointSurg Am. 1995;

77(7):1058-64.
12. Madsen JE, Naess L, Aune AK, Alho A, Ekeland A, Strшmsшe K. Dynamic hip screw with trochanteric stabilizing plate in the treatment of unstable proximal femoral fractures: a comparative study with the gamma nail and compression hip screw. J Orthop Trauma. 1998; 12(4): 241–248.
13. Sommers MB1, Roth C. A laboratory model to evaluate cutout resistance of implants forpertrochanteric fracture fixation.J Orthop Trauma. 2004;18(6):361-8.
14. Bannister GC, Gibson AG. The fixation and prognosis of trochanteric fractures: Arandomized prospective controlled trial.Clin Orthop Relat Res. 1990;(254):242-6.
15. Parmar V, Kumar S, Aster A, Harper WH. Review of methodsto quantify lag screw placement in hip fracture fixation. Acta Orthop Belg. 2005; 71:260-3.
16. Gagała J, Kołodziej R, Blacha J, Blicharski T. [Intramedullarylocked nailing in the treatment of proximal femoral fractures].Chir Narzadow Ruchu Ortop Pol. 2006; 71:211-5.
17. De Bruijn K, den Hartog D, Reliability of predictors for screw cutout in intertrochanteric hip fractures.J Bone Joint Surg Am. 2012;94(14): 1266-72.
18. Gьven M, Yavuz U. Importance of screw position in intertrochanteric femoral fractures treated by dynamic hip screw. Orthopedics & Traumatology: Surgery & Research. 2010;96(1):21-7.
19. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. Thevalue of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am. 1995; 77: 1058-64.
20. Andruszkow H, Frink M, Frшmke C, Matityahu A, Zeckey C, Mommsen P, et al. Tip apex distance, hip screw placement, and neck shaft angle as potential risk factors for cut-out failure of hip screws after surgical treatment of intertrochanteric fractures. International orthopaedics. 2012;36(11):2347-54.
21. Omeroglu H, Ucar DH, Tumer Y. A new measurement method for the radiographic assessment of the proximal femur: the center-trochanter distance. Acta Orthop Traumatol Turc. 2004;38(4):261-4.
22. Babhulkar SS. Management of trochanteric fractures. Ind J Orthop. 2006; 40:210-8.
23. Kumar AJ, Parmar VN, Kolpattil S, Humad S, Williams SC, Harper WM. Significance of hip rotation on measurement of'Tip Apex Distance' during fixation of extracapsularproximalfemoral fractures. Injury. 2007; 38:792-6.
24. Hartholt KA, van Beeck EF, Polinder S, van der Velde N, vanLieshout EM, Panneman MJ, et al. Societal consequences of falls in the older population: injuries,healthcare costs, and long-term reduced quality of life. J Trauma. 2011;71(3):748–753.
25. Chirodian N, Arch B, Parker MJ. Sliding hip screw fixationof trochanteric hip fractures: outcome of 1024 procedures. Injury. 2005;36(6):793–800.
26. Hsueh KK, Fang CK, Chen CM, Su YP, Wu HF, Chiu FY. Risk factors in cutout of sliding hip screw in intertrochantericfractures: an evaluation of 937 patients. Int Orthop. 2010;34(8):1273–76.
27. Barton TM, Gleeson R, Topliss C, Greenwood R, Harries WJ, Chesser TJ. A comparison of the long gamma nail withthe sliding hip screw for the treatment of AO/OTA 31- A2 fracturesof the proximal part of the femur: a prospective randomized trial. J Bone Joint Surg Am. 2010;92(4):792–98.
28. Bojan AJ, Beimel C, Speitling A, Taglang G, Ekholm C, Jшnsson A. 3066 consecutive Gamma Nails. 12 years experience at a single centre. BMC Musculoskeletal Disorders. 2010;11(1):133.
29. Mereddy P, Kamath S, Ramakrishnan M, Malik H, Donnachie N. The AO/ASIF proximal femoral nail antirotation(PFNA): a new design for the treatment of unstable proximalfemoral fractures. Injury. 2009; 40(4):428–432.
30. Verhofstad MH, van der Werken C. DHS osteosynthesis for stable pertrochanteric femur fractures with a two-hole side plate. Injury. 2004; 35(10):999–1002.
31. Omeroğlu H, Ucar DH, Tьmer Y. A new measurement method for the radiographic assessment of the proximal femur: the center-trochanter distance. Acta orthopaedica et traumatologica turcica. 2004; 38(4):261-4.
32. Goffin JM, Jenkins PJ, Ramaesh R, Pankaj P, Simpson AH. What is the relevance of the tip-apex distance as a predictor of lag screw cut-out?. PloS one. 2013;8(8):e71195.
33. Kane P, Vopat B, Heard W, Thakur N, Paller D, Koruprolu S, et al. Is tip apex distance as important as we think? A biomechanical study examining optimal lag screw placement. Clinical Orthopaedics and Related Research. 2014;472(8):2492-8.
34. Amini MH, Feldman JJ, Weinlein JC. High Complication Rate in Young Patients With High- Energy Intertrochanteric Femoral Fractures. Orthopedics. 2017;40(2):e293-9.