Article

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Is calcar referenced tip-apex distance a better predicting factor for cutting out in biaxial cephalomedullary nails than tip-apex distance?

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Abstract

Purpose: To test the significance of calcar referenced tip-apex distance (CalTAD) and the length of anti-rotation screw (AR screw) as predictors for failure after biaxial cephalomedullary (CM) nailing of intertrochanteric fractures. **Methods:** We retrospectively reviewed 190 consecutive fractures that had undergone biaxial CM nailing. Of these, 67 met the inclusion criteria of a non-pathological fracture with a minimum of 90 days radiological follow-up (mean 458 days; 91 days to 4.9 years). **Results:** The overall failure rate was 15% (10 of 67). Failure was associated with a higher CalTAD in most of the patients (13%, $p < 0.001$). A higher tip-apex distance (TAD) was not significantly associated with failure ($p = 0.132$), when the CalTAD was less than 25 mm. When the AR screw length exceeded a line connecting the tip of the nail and the lag screw, screw cutout occurred only in one patient ($p = 0.095$). **Conclusion:** Our data provide the first reported clinical evidence that the CalTAD is a better predictor of cutout in biaxial CM nailing than TAD measurement. However, the length of anti-rotational element does not seem to be an independent predictor of CM nailing failure.

Keywords

calcar referenced tip-apex distance, cutout, lag screw, trochanteric fracture

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As intertrochanteric hip fractures are frequently fixed with cephalomedullary (CM) nail, the most common cause of mechanical failure of fixation is cutout of the lag screw.[1] Tip-apex distance (TAD) has been shown to be an important predictor for cutout in CM nails[2] and it was suggested that keeping TAD <25 mm reduces the cutout rate.[3] This would favor central–central placement of the lag screw.[4] But, it was found that positioning of the lag screw inferior in the head and neck was found to be at least as biomechanically stable as the center–center group, even if the TAD was greater than 25 mm.[5] Moreover, as a second element called an anti-rotation screw (AR screw) is introduced above the lag screw to strengthen rotational stability in the biaxial CM system, inferior placement of the lag screw is mandatory for proper placement of the AR screw.[6]

It is therefore useful to evaluate the alternative measurement techniques for predicting cutout, which favors a more inferior placement of the lag screw. The calcar referenced tip-apex distance (CalTAD) is a newer measurement tool that favors inferior–central lag screw placement in biaxial CM nails.[7]

Furthermore, considerable load on the AR screw is thought to facilitate cutout and some studies suspect that the AR screw length might be the most relevant measurement influencing the risk for implant perforation in biaxial proximal femoral nails (PFNs).[6,8]

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Table 1. Predictors of failure.

Factors	All	No cutout ($n = 57$)	Cutout ($n = 10$)	p Value
Age	75.21 (48–92)	75.1 (48–92)	84.5 (53–89)	0.435
Side				0.21
Right	35	32	1	
Left	31	15	9	
Gender				0.63
Male	24	21	5	
Female	43	36	5	
TAD (mm)	25.19	24	32	0.132
CalTAD (mm)	20.5	22.13	30	<0.001
AR length				0.095
AR (zone 1)	47	39	8	
AR (zone 2)	10	8	2	
AR (zone 3)	0	0	0	

AR: anti-rotation; CalTAD: calcar referenced tip-apex distance; TAD: tip-apex distance.

The purpose of this study was to test the significance of CalTAD and the length of AR screw as predictors of cutout and cut through failure after biaxial CM nailing of intertrochanteric fractures.

Patients and methods

All patients who were treated with a biaxial CM nail for an intertrochanteric fracture between January 2011 and February 2015 were retrospectively reviewed ($n = 190$). Patient records were reviewed for age at the time of operation, gender, date of operation, date of final clinical follow-up, and type of CM nail used. Exclusion criteria included patients with a pathological fracture and those who did not have a radiological follow-up at least 90 days postoperatively. In all, 67 of the 190 fractures reviewed (24 men and 43 women), with a mean age of 75.21 years (48–92), met the inclusion criteria for the study (Table 1).

Surgical technique

Patients were placed in a supine position under spinal or epidural anesthesia, with the trunk deviated to the opposite side. Closed reduction was achieved in 65 patients, whereas 2 underwent joystick maneuvers.

A 3-cm incision was made 2 cm proximal to the greater trochanter parallel to the femoral shaft. A guide wire was passed through the trochanteric tip across the fracture site. Proximal femur was reamed to the size of 15 mm. Femoral shaft was reamed in none of the patients. The short PFN (Nebula, Gujarat, India) was inserted after mounting on a radiopaque 135 jig. Proximal locking was achieved through one lag screw and one AR screw. Distal interlocking entailed single static locking bolt, irrespective of the fracture configuration.

Immediately, 45 days and 90 days postoperative radiographs were used to measure the TAD and CalTAD through the help of an in-house picture archiving and communication system tool (Figure 1). To specify the length of the AR screw, a three-category classification using the AR screw tip in the anteroposterior (AP) view as a reference was used.[6] The AR screws were considered to be in zone 3 if not reaching the border between femoral head and neck. On the other hand, the AR screws crossing an imaginary line between the proximal end of the nail and the tip of the lag screw were classified as in zone 1. Any AR pin length in between has been considered as in zone 2 (Figure 2). The purpose of this classification was to objectively describe the position of the AR screw and investigate the role of AR screw length in the failure of short PFN.

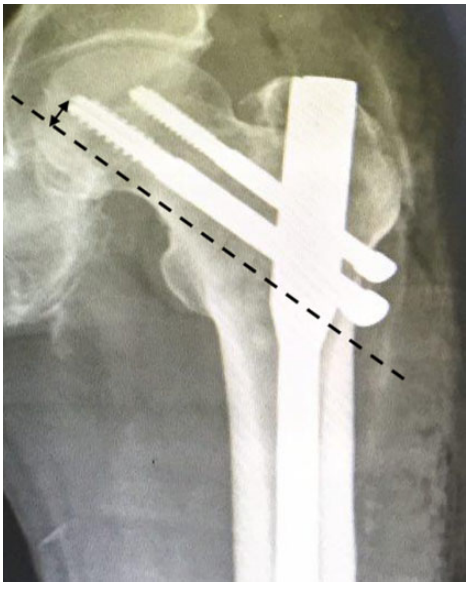

Figure 1. CalTAD in the AP view (CalTADAP) is measured (in mm) using a line drawn adjacent to the medial cortex of the femoral neck. TAD in the lateral view (TADLat) is added to both these measurements to obtain CalTAD. CalTAD: calcar referenced tip-apex distance; TAD: tip-apex distance; AP: anteroposterior.

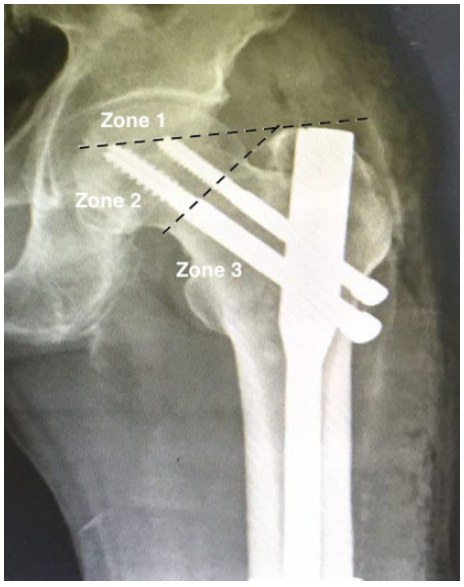

Figure 2. Classification of AR screw length. AR screw not reaching the femoral head is considered "too short," whereas AR pins crossing the line between nail tip and lag screw tip are regarded "too long." Any length in between is considered "correct." AR: anti-rotation.

Statistical analysis

Statistical analysis was performed using PSPP (GNU PSPP 0.10.2). Binary logistic regression was used for a univariate analysis of the continuous parameters and χ^2 was used for categorical variables.

Results

There were a total of 67 intertrochanteric fractures in 67 patients. The intertrochanteric fractures were further subcategorized, according to the AO classification, into 40 A1 (60%), 8 A2 (12%), and 19 A3 (28%). A total of 48 of the 67 (72%) fractures classified as intertrochanteric were considered to be stable.

The mean radiological follow-up time for the fractures was 458 days (91 days to 4.9 years). Of 67 patients, 43 were females (64%) and 24 were males (36%). Mean age affected was 75.21 years, lowest being 48 years and oldest was 92 years. Thirty-seven patients had right side fracture and 30 had left side fracture.

A total of 10 cutouts occurred (15%), for which the mean follow-up was 283 days (44–602 days). Age ($p = 0.425$), gender ($p = 0.63$), and fracture side ($p = 0.21$) in these patients were not statistically different from those without cutout. In most patients with cutout, CalTAD was >25 mm and was a significant ($p < 0.001$) parameter. Although TAD was associated with cutout, eight patients (12%) had TAD >25 mm with a CalTAD <25 mm; yet none of them had screw cutout. The AR screw was reaching zone 1 in 57 patients (85%) and zone 2 in 10 patients (15%). The AR screw was reaching only up to zone 3 in none of the patients. AR screw length ($p = 0.095$) and TAD ($p = 0.132$) were not statistically associated with cutout based on a p-value cutoff of 0.01.

Discussion

Despite either sliding hip screw or CM nail fixation is associated with equivalent outcomes for most intertrochanteric femur fractures, the CM nail has emerged as the preferred construct. Moreover, though without literature support, many orthopedic surgeons believe CM nails are a superior construct to sliding hip screws.[9] This may be due to a shorter operating time, reduced visible intraoperative blood loss, and improved walking ability in unstable hip fractures associated with CM nail.[1]

Current CM concepts may be classified as monoaxial and biaxial. In monoaxial systems, special lag screw designs have been introduced to strengthen rotational stability, whereas in biaxial systems, a second element, an AR screw, is meant to achieve this.[6] Currently available biaxial fixation systems include nails with two lag screws (Expert Lateral Femoral Nail; Synthes, West Chester, Pennsylvania, United States), with intercalated lag screws (TRIGEN INTERTAN; Smith & Nephew, London and Hull, United Kingdom), and with the use of AR pins (Platon, Tantum, or Targon PF/PFT; Aesculap, Center Valley, PA, United States).[6]

There are only few publications dealing with the biomechanics of CM fixation systems. Though more commonly used, even with the latest monoaxial fixation system, the problem of implant perforation is still not resolved.[9,10] In a finite element analysis by Helwig et al., three monoaxial systems (PFN-A, gamma nail, gliding nail) were compared to a biaxial system (Targon PF) with regard to distributions of stress and strain on the fracture surfaces, investigating both cranial and caudal implant positions. The authors reported that only the biaxial system demonstrated better fracture healing conditions in the cranial position and some advantages in the caudal position.[11]

In the study that we describe in this article, a short PFN with a length of 180 mm and a proximal diameter of 15 mm was used in all patients. The nail has a 6° mediolateral angle for easy insertion and a flexible distal tip. Our main reason for pursuing the use of short PFN was due to ease of insertion and reduced risk of femoral fracture.[9,12]

A total of three previous studies found high TAD values to be a significant predictor of cutout in CM nails .[1,13,14] Yet more recent studies suggest that the cutout complication is very low even in patients with high TAD, if the lag screw was positioned inferior in the head and neck.[5,15] A biomechanical study by Kuzyk et al.[7] found that inferior placement of the lag screw gives the highest axial and torsional stiffness. In a finite element study, Goffin et al.[16] have also shown that inferior middle and inferior posterior positions are to be preferred. This argues against the accuracy of a TAD >25 mm cutoff for the prediction of

cutout, as TAD measurement suggests a higher rate of cut-out with a more inferior placement of the lag screw and favors a central–central placement.

CalTAD differs from TAD only in the AP view, with the apex of the femoral head determined using a line parallel to the femoral neck that runs adjacent to the calcar instead of the center of the femoral neck.[1] It therefore favors inferior–central placement of the lag screw.[1] In our study, a lower CalTAD resulted in lesser cutout and a statistically significant ($p < 0.001$) association supports its use as a predictor of cutout in biaxial CM nails.

In a study by Zirngibl et al., the length of the AR pin was found to play a crucial role in predicting cutout and cut through. They found that the AR screws, which either in zone 1 or zone 3, were associated with increased risk for cutout or cut through. In our study, the three-category classification system developed by them was used to investigate the role of AR screw length in the failure of short PFN.[6] Unlike in their study, AR screw length was not a relevant measurement influencing the risk for implant perforation in short PFN.

The limitations of our study include its retrospective design and the limited sample size owing to poor patient compliance with follow-up. This can be explained by the older patient population studied (mean 75.21 years old, 48–92). As a result, only 67 of the 190 fractures reviewed met the inclusion criterion of at least 90 days of follow-up. Our investigation shows that AR screw length is a poor predictor of cutout in this patient population. Although no significant association ($p = 0.095$) was seen, prospective studies are needed to investigate the impact of AR screw length on the mechanical behavior of biaxial CM nail. Further, poor bone quality and neck screw instability in older patient population we studied might have adversely affected the results,[17] and this was not addressed in our study.

Conclusion

Our study suggests that TAD is a less reliable predictor of cutout in biaxial CM nail fixation of intertrochanteric fractures. It supports the findings from previous studies that the inferior placement of the lag screw reduces cutout.[7,16,1,18] It provides the first clinical evidence behind the validity of CalTAD as a better predictor of cutout than TAD in biaxial CM. It questions the validity of the length of AR screw as a predictor of failure of biaxial CM nail and suggests further investigations to study its impact on such constructs.

Author contributions

Kishore Puthezhath and Chundarathil Jayaprakash contributed to the manuscript writing and revision.

Declaration of conflicting interests

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