Lateral femoral wall thickness

A RELIABLE PREDICTOR OF POST-OPERATIVE LATERAL WALL FRACTURE IN INTERTROCHANTERIC FRACTURES

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Although the importance of lateral femoral wall integrity is increasingly being recognised in the treatment of intertrochanteric fracture, little attention has been put on the development of a secondary post-operative fracture of the lateral wall. Patients with post-operative fractures of the lateral wall were reported to have high rates of re-operation and complication. To date, no predictors of post-operative lateral wall fracture have been reported. In this study, we investigated the reliability of lateral wall thickness as a predictor of lateral wall fracture after dynamic hip screw (DHS) implantation.

A total of 208 patients with AO/OTA 31-A1 and -A2 classified intertrochanteric fractures who received internal fixation with a DHS between January 2003 and May 2012 were reviewed. There were 103 men and 150 women with a mean age at operation of 78 years (33 to 94). The mean follow-up was 23 months (6 to 83). The right side was affected in 97 patients and the left side in 111. Clinical information including age, gender, side, fracture classification, tip–apex distance, follow-up time, lateral wall thickness and outcome were recorded and used in the statistical analysis.

Fracture classification and lateral wall thickness significantly contributed to post-operative lateral wall fracture (both p < 0.001). The lateral wall thickness threshold value for risk of developing a secondary lateral wall fracture was found to be 20.5 mm.

To our knowledge, this is the first study to investigate the risk factors of post-operative lateral wall fracture in intertrochanteric fracture. We found that lateral wall thickness was a reliable predictor of post-operative lateral wall fracture and conclude that intertrochanteric fractures with a lateral wall thickness < 20.5 mm should not be treated with DHS alone.

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103 males (49%) and 105 females (51%) with a mean age at operation of 78 years (33 to 94). Their mean follow-up was 23 months (6 to 83). The right side was affected in 97 patients (47%) and the left side in 111 (53%).

Fracture fixation was undertaken in a conventional manner using a DHS according to the manufacturer’s instructions on a fracture-table under fluoroscopic control. No other fixation devices were used except for the DHS and barrel-plate.

Under the supervision of physiotherapists, all patients were mobilised at between 24 and 72 hours post-operatively with a walking frame or crutches. Unrestricted weight-bearing was allowed as tolerated. Clinical follow-up was mandatory at the first, second, third and sixth month. Post-operative lateral wall fracture was defined as the presence of new fracture lines occurring at the site of insertion of the barrel-plate or lateral displacement of fracture fragment on the radiographs.

Failure of the treatment was defined when the following events occurred: 1) penetration of the screw into the hip joint or loosening within the femoral head; 2) breakage of the barrel-plate or its screws; or 3) patient underwent a second operation due to other cause of implant failure. Successful treatment was defined as continuous bridging callus seen on the anterolateral and lateral radiographs, and no pain during the movement of the injured hip. The TAD was measured according to the method described by Baumgaertner et al: this is the sum of the distance from the tip of the screw to the apex of the femoral head on anteroposterior (AP) and lateral radiographs. Poor fracture reduction was defined as >20° angulation on the lateral radiograph, and >4 mm of displacement of any fragment.9 The lateral wall thickness was defined as the length of the channel created by the triple reamer on the lateral wall (Fig. 1). Two blinded observers (CEH, CTH) performed measurements of TAD and lateral wall thickness on the Picture and Communication System monitor. We performed a reliability analysis and the intraclass correlation coefficient (ICC) was good (ICC 0.724). One observer was a trauma surgeon and the other was a resident in our department. The mean value of the two observers’ measurements was used for statistical analysis. All measured lengths were corrected by the radiological magnification ratio of 120%.10

Statistical analysis. Clinical information including age, gender, fracture classification, TAD, follow-up time, thickness of lateral wall, and treatment outcomes of the patients were subjected to statistical analysis. Fisher’s exact test, Student’s t-tests, and Receiver Operating Characteristics (ROC) curves were used to investigate the potential relationship between the nominal measures using SPSS 20.0 software (SPSS Inc., Chicago, Illinois). Findings were considered significant if p-value was <0.05 (two-sided).

Results
The data of the 208 patients according to the integrity of the lateral femoral wall is summarised in Table I. A fracture of the lateral wall occurred in 42 patients (20%). The mean pre-operative lateral wall thickness of the 42 patients with lateral wall fracture was 18.4 mm (SD 5.54) compared with 27.0 mm (SD 7.35) in the 166 patients without lateral wall fracture (p < 0.001, Student’s t-test). The incidence of post-operative lateral wall fracture was significantly higher in A2 fractures than in A1 fractures (p < 0.001, Fisher’s exact test). Other variables (age, gender, side, TAD and duration of follow-up) did not have any relationship with the development of a post-operative lateral wall fracture (Table I).

The mean lateral wall thickness of 97 A1 fractures was 29.8 mm (SD 6.63), which was significantly thicker than the mean of 21.2 mm (SD 6.43) found in 111 A2 fractures (p < 0.001, Student’s t-test). Further stratification of the data revealed that lateral wall thickness still significantly contributed to lateral wall fracture in A2 fractures (p < 0.001, Student’s t-test), while no statistical significance for lateral wall fracture in A1 fracture was observed (p = 0.071, Student’s t-test) (Table II). For A2 fractures, the mean lateral wall thickness of 72 patients without lateral wall fracture was 22.9 mm (SD 6.40), which was significantly greater than 18.1 mm (SD 5.25) in 39 patients with lateral wall fracture. The mean lateral wall thickness of 94 patients without lateral wall fracture was 30.0 mm (SD 6.50), which was not significantly different from the mean of 23.0 mm (SD 8.43) in three patients with lateral wall fracture in A1 fractures (Table II). For A2 fractures, the rate of treatment failure for patients with lateral wall fracture was significantly higher than those without lateral wall fracture (p < 0.001, Fisher’s exact test). Of 111 patients, 39 (35.1%) with A2 fractures had a post-operative lateral wall fracture. Of these 39 patients, 19 (49%) had treatment failure and the remaining 20 patients achieved uneventful bone union. Of the 72 patients who
did not have lateral wall fracture, six (8.3%) patients encountered treatment failure and the remaining 66 (91.7%) patients achieved uneventful bone union. Of 97 patients with A1 fracture, three (3.1%) had a post-operative lateral wall fracture but achieved bone union without further surgical intervention. In contrast, neither of the two treatment failure cases in A1 fracture had lateral wall fracture (Table III).

We use an ROC curve to estimate a threshold value that could predict lateral wall fracture. When lateral wall thickness was at 20.5 mm, the sensitivity was 82.7% and specificity was 77.8%. The area under the curve (AUC) was 0.823 (Fig. 2), which was statistically significant ($p < 0.001$).

**Discussion**

To our knowledge, this is the first study to investigate risk factors of post-operative lateral wall fracture in ITF. We found that lateral wall thickness was a reliable predictor of post-operative lateral wall fracture with a threshold value of 20.5 mm being a reliable predictor for secondary lateral wall fracture. From this we suggest that treatment with a DHS is not advisable in the presence of a lateral wall thickness < 20.5 mm.

The lateral wall thickness had no statistically significant effect on lateral wall fracture in A1 fractures because very few patients had lateral wall fractures in this group (Table II). This does not mean that lateral wall thickness is
not important in A1 fractures. In fact, the generally thicker lateral wall greatly reduced the occurrence of lateral wall fracture in A1 fractures. Greater numbers of patients should be evaluated to clarify this observation.

Among the 42 patients with lateral wall fracture in Table III, all three patients in A1 group achieved bone union, while only 20 (51.3%) of 39 patients achieved bone union in the A2 group. The high success rate in the A1 group may be as a result of the posteromedial section of the femur preventing excessive sliding of the screw and proximal fragment after lateral wall fracture. However, when a lateral wall fracture occurs in an A2 fracture, the screw and proximal fragment slide laterally and there is no structure to block this movement. Further stress on the femoral head will cause screw penetration or loosening. This suggests that the intact posteromedial femoral section imparts important support in the event of lateral wall fracture in DHS treatment. However, if the femur does not have a stable posteromedial section, the quality of the lateral wall plays a decisive role in the DHS outcome. This hypothesis could explain why A2 fracture patients with trochanter buttress plate-mounted DHS had better outcomes in than those with DHS-alone.5,11

A previous study revealed that lateral wall fracture occurs more frequently in AO/OTA 31-A2.2 and 31-A2.3 than in 31-A1 and 31-A2.1 fractures.4 In our study, AO/OTA subgroup classification was not used because large inter-observer and intra-observer biases between A2.1 and A2.2 fractures were reported in a previous study.8 Our result showed that the lateral wall fracture occurred more frequently in A2 fractures where the bone was generally thinner, than that in A1 fractures. We postulate that the thinner lateral wall was created by the lower fracture line that simultaneously caused comminution of the posteromedial section (Fig. 3).

A number of previous studies used rate of re-operation to evaluate the effect of lateral wall on treatment outcome.3,4 The rate of re-operation can be readily influenced by a patient’s medical condition and his/her willingness to receive an operation. In the present study, we used implant failure as a criterion for treatment failure rather than rates of re-operation, which for DHS, increased defined failures almost two-fold.

There were several limitations in this study. First, the operations were not performed by a single surgeon. The operative skills of surgeons may have been different and this could have affected the treatment outcome. Second, the lateral wall fractures were only evaluated by radiography, so linear fractures of lateral wall could have been missed. Third, the sample size was relatively small. Factors that may confound the effects of treatment method on outcomes, such as bone density and bone quality, BMI and mental status, were not included in our statistical analysis.

We conclude that: 1) lateral wall thickness is a reliable predictor of post-operative lateral wall fracture; 2) applying a > 20.5 mm threshold value for the use of a DHS can be expected to minimise the risk of post-operative lateral wall fracture; and 3) ITF with a lateral wall thickness < 20.5 mm should not be treated with a DHS alone.
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