The Mechanical Properties Of Fixing Greater Trochanter Or Lesser Trochanter In Complex Four Part Intertrochanteric Fractures

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Introduction: Dynamic hip screw (DHS) is a popular fixation device for treating femoral intertrochanteric fractures (ITF). However, in complex four-part ITF, the reported failure rate is high. For these cases, fixation of greater/lesser trochanter should be a reasonable solution to provide additional stability of proximal femur. Previous studies have investigated on the effect of lesser trochanter fixation and there are general agreement that fixation of the lesser trochanteric fragment in unstable ITF could prevent varus collapse of femoral head. There are few studies have discussed about the biomechanical influence of greater trochanter fixation, as well as abductor muscle force reconstruction. The simulation of abductor force is also difficult in mechanical test. Using an in-vitro biomechanical test, this study is designed to analysis when a four-part ITF treated with DHS, the mechanical properties of the fixing the greater trochanter with abductor muscle reconstruction and/or fixation of lesser trochanter. We hypothesis that fixing greater trochanter or lesser trochanter will improved the mechanical property of unstable ITF treated with DHS.

Methods: 22 left femur sawbones (3403, Composite femur, Pacific Research Labs, Vashon Island, WA, USA) were harvested the proximal part 27 cm from tip of femoral head. 20 specimens were pre-fractured as a four-part ITF, another 2 for intact performance. The pre-fractured specimen were divided into four treatment method groups, including DHS only (D), DHS+fixed greater trochanter (DG), DHS+fixed lesser trochanter (DL), DHS+fixed greater and lesser trochanters (DGL). The loading condition of biomechanical test was to simulate single-leg stance (with the femur fixed at 25 degree adduction and 15 degree anteversion). The material testing system is 370 Bionix (MTS system corp. Eden Prairie, MN, USA). There was 100N preload and using displacement control under the rate of 10 mm/min until failure. We defined failure as a new fracture line found in the specimen. The sampling rate of the MTS machine is 10 Hz. For simulating abductor forces (DG and DGL groups), a pushing device using the lever theory (20 times magnify ratio) was applied 588.6 N with 30 degree to vertical through the screw on the greater trochanter. Failure loading, stiffness and failure mode of the specimens in 4 groups were evaluated. All the 20 specimens were fixed with dynamic hip screws (DHS Screw, Synthes, PA, U.S.A.). For the groups fixing the lesser trochanter (DL and DGL groups), one 3.5 mm cortical screw was applied from anterior-lateral to posterior-medial, and the screw tip was penetrated to ensure the stability. For the groups fixing the greater trochanteric fragment (DG and DGL groups), a tension band wire was used. There was additional 3.5 mm cortical screw put in 2cm below greater trochanteric tip for application of abductor force in group DG and DGL.

There are two intact bone was test under the same condition of the fractured groups. One is intact bare bone (N-1), the other is intact bone with abductor force (N-2). The average failure load and stiffness of group D and group GL was compared to N-1. The average data of group DG and DGL was compared to N-2. The study use SPSS (Chicago, IL, USA, V 17) for statistic analysis. This is a small sample study, the data should not be normal distribution. Then we use Kruskal-Wallis test to find the statistically significant differences among the four groups. Then use Mann-Whitney U test to compare each other. The significance of difference is defined as P< 0.05.

Results: Stiffness and Failure loading
The average failure loading of the 4 groups is shown in Fig 1. There existed statistically significant differences between group D and DL (P=0.034) as well as Group DL and DGL (P=0.043). The average stiffness is shown in Fig 2. There exited statistically significant differences between Group D and Group DL (P=0.034) as well as Group D and Group DGL (P=0.034).
Fig 1. The average Failure loading
Fig 2. The average stiffness

**Failure mode analysis (Fig 3)**

Group D: After over sliding, the barrel of the side plate incarcerated into femoral neck, then there was a small piece of fracture found in anterior-medial cortex of femoral neck.

Group DL: There was a large triangular shielding fragment at anterior-medial cortex of femoral neck.

Group DG: The femoral head rotated (got more ante-version) while loading then the fracture site got displaced. The anterior-medial cortex began to crack and a non-displaced fracture line extended into femoral head.

Group DGL: Similar fracture pattern as Group DL.
Fig 3. Failure mode; D: failure mode in group D, incarcerated of barrel, crack of medial cortex; DL: large shielding fragment; DG: rotation of femoral head, medial cortex crack with non-displaced fragment

**Normalization (Fig 4)**

Fig 4 The stiffness and failure loading restored in 4 groups in comparison with normal bone N-1 and N-2.

**Discussion:** Fixation of lesser trochanter combined with DHS is the strongest construct in treating four-part ITF. Fixing greater trochanter or lesser trochanter could limit the sliding of the femoral head then improved the stiffness of the construct. This supports our hypothesis that fixing greater trochanter or lesser trochanter will improve the mechanical properties of unstable ITF treated with DHS. Reconstruction of greater trochanter could limit the lag screw not to have excessive sliding, but the abductor tension will rotate the femoral head, displace the fracture site and increase loading on the medial cortex. Carefully post-operative planning is necessary if the abductors were reconstructed.

**Significance:** The clinical relevance of the study is that when treating a four-part intertrochanteric fracture with DHS, lesser trochanter must fix to enhance the strength and stiffness of the construct. Reconstruction of greater trochanter is also advised to enhance total stiffness. Weight bearing should be limited until evidence of bone healing if the greater trochanter was fixed. Because weight bearing would increase abductor tension leading to fragment rotation, displacement and eventually nonunion.

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**References:**

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