



Biomechanical comparison of antirotator compression hip screw and cannulated screw fixations in the femoral neck fractures

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Objective: The aim of this study was to compare the biomechanical properties of minimal invasive sliding antirotator compressive hip screw (MIS–A–CHS), and multiple cannulated screws (CS) on a Pauwels type 3 femoral neck fracture model.

Methods: A Pauwels type 3 vertical femoral neck fractures was created on 12 third-generation proximal femur models which were divided into two equal groups. The fracture was fixed with three CS in the first group, and MIS–A–CHS in the second group. The axial and rotational stiffness and maximum compression effect were compared between the groups.

Results: The axial and rotational stiffness and maximum compression were significantly higher in MIS–A–CHS group (912.5 N, 540 N and 10.2 N/m, respectively) than the CS group (627.5N, 380 N, and 3.9 N/m, respectively).

Conclusion: MIS–A–CHS appears to be a more secure fixation method in Pauwels type 3 femoral neck fractures than the CS.

Key words: Femoral neck fracture; cannulated screw; compressive hip screw; biomechanics.

Vertical shear fractures of the femoral neck are challenging injuries especially in young adults. An anatomical reduction with stable fixation will improve the results and numerous devices have been developed for this purpose. Although the devices of osteosynthesis for femoral neck fractures have been greatly improved recently, their use is still limited due their weakness against bending and torsional forces.^[1-5] Dynamic hip screw (DHS) has bio-

mechanical advantages compared to cannulated screws (CS), while their main disadvantage is the extensive soft tissue exposure.^[6-10]

To provide a more stable fixation method without extensive surgical exposure in femoral neck fractures, we developed a new internal fixation device [Minimally invasive sliding antirotator compressive hip screw (MIS–A–CHS)] (FA, patent no: 2009/02053).

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Fig. 1. The drilling and tapping of the bone **(a)**, the insertion of cannulated 12 mm lag screw **(b)** the 5 mm interlocking screw is sent to a dynamic interlocking hole which is oblong in shape with the help of an external guide. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

The aim of this study was to compare the biomechanical properties MIS–A–CHS, and multiple cannulated screws (CS) on a Pauwels type 3 femoral neck fracture model.

Materials and methods

A Pauwels type 3 vertical femoral neck fractures was created with a saw with an angle of 85° with the horizontal plane on twelve third-generation proximal femur models (Synbone AG, Malans, and Switzerland). The specimens were then divided into two groups of 6 each. In the first group the fracture was fixed with 3 CS (TST Tibbi Aletler Ltd., Istanbul, Turkey), while a MIS–A–CHS

(TST Tibbi Aletler Ltd., Istanbul, Turkey) was used in the second group.

In group A, the fixation was achieved with 3 parallel CS of 85 mm length and 6.5 mm width. The first CS was driven up to the subchondral bone just beneath articular side of the femoral head; second screw was placed near to the posterior cortex and the third near to inferior cortex. In group B, the fracture was fixed with a MIS–A–CHS. After drilling and tapping on the guide wire the cannulated 12 mm width lag screw of the MIS–A–CHS was inserted. Then, an interlocking screw of 5 mm width was locked to the dynamic interlocking hole with the help of an external guide (Figure 1a, b, c). Then an antirotator blade was



Fig. 2. The placement of antirotator blade on the groove of lag screw is seen from the AP **(a)** and lateral **(b)** aspects. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

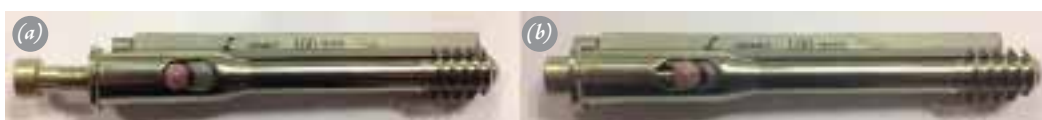


Fig. 3. The position of the interlocking screw within the oblong hole is seen before **(a)** and after **(b)** screwing down the compression screw. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

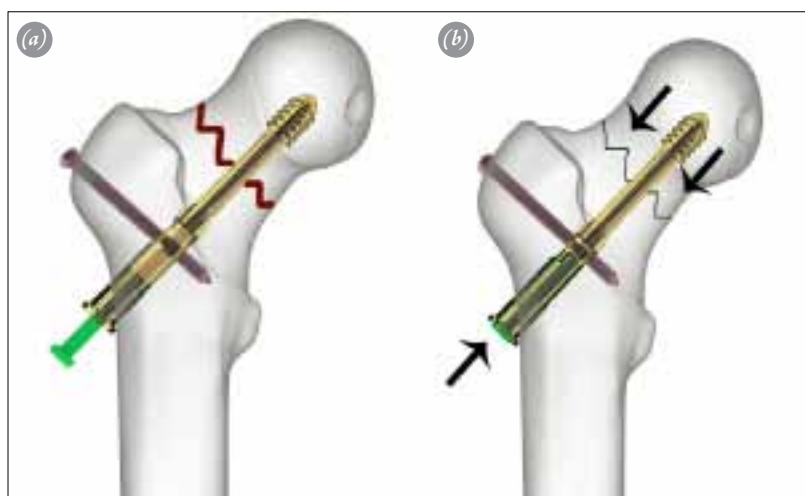


Fig. 4. (a, b) Once screwed, the compression screw push the interlocking screw in the oblong hole which result in compression at the fracture site. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

inserted through its groove (Figure 2). Finally a compression screw was driven from the distal tip of the lag screw to push the interlocking screw in the oblong hole (Figure 3 a, b) for additional compression and lock the antirrotator blade (Figure 4). The maximum compression forces yielded was measured with a torquemeter (Torqueleader, Guildford, and Surrey, UK) during the implementation.

Biomechanical testing was done with a Shimadzu AGS-X test machine (Shimadzu, Kyoto, Japan). All groups were tested in an axial loading with a 7° valgus offset from the vertical mechanical axis to simulate normal weight bearing axis. Proximally, the femoral head was inserted into an acetabulum-type cup and distally the femur shaft was potted in cement (Figure 5). A vertical force was applied at the apex of the femoral head using displacement control. The axial load was applied in a 10 mm/min and the failure was assumed as 10 mm displacement. Displacement is measured by the test machine itself automatically.

Assuming a 95% confidence interval and a minimum acceptable power of 80% combined with a calculated 150 N standard deviation and significant difference of 300 N, it was determined that a total sample size of 6 specimens was needed for each group.

Statistical comparisons were carried out using Statistical Package for Social Sciences (SPSS) 16.0. Descriptive statistics were calculated for the entire population and two screw types. Statistical analysis was performed using Mann–Whitney U-test with significance set at $p < 0.05$ to evenly distribute the 6 intact femur models into 2 statistically equivalent test groups with respect to their mechanical stiffness. Using the same statistical approach, the 2 treatment groups were subsequently com-

pared with one another for axial and torsional stiffness and maximal compression. The mean, standard deviation and median values of axial and torsional loading and maximal compression were calculated.

Results

The failure was occurred at mean 627.5 N for the group A and 912.5 N for the group B in axial loading ($p < 0.05$)



Fig. 5. The biomechanical test setting. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. A and B axial, torsional and maximum compression yielded by torquemeter.

	Axial loading (N)	Torsional loading (N)	Maximum compression yielded by torquemeter (N/m)
Group A			
Mean	627.50	380.00	3.90
SD	13.20	5.88	0.29
Median	626.60	380.00	3.90
Minimum	601	370	3.5
Maximum	654.3	389.3	4.4
Group B			
Mean	912.50	540.00	10.22
SD	8.49	6.60	0.30
Median	912.00	540.00	10.25
Minimum	900	530	9.8
Maximum	924.2	550.2	10.6
p	0.001**	0.001**	0.001**

Mann-Whitey U-test: **: $p < 0.01$.

and 380 N for group A and 540 N for the group B in torsional loading ($p < 0.005$) (Table 1). No implant failure or catastrophic bony failure was happened. The maximum compression yielded by torquemeter just before the failure was 3.9 N/m for the group A and 10.2 N/m for the group B ($p < 0.005$).

The results of this experiment demonstrated statistically significant increase in axial stiffness for the MIS-A-CHS compared with traditional fixation with CS in Pauwels type 3 femoral neck fractures. Rotational stiffness was also significantly greater for the MIS-A-CHS group over the CS group.

Discussion

Vertically oriented femoral neck fractures are difficult to treat. Screw loosening, fracture displacement and some other complications may often occur with regards to the internal fixation of femoral neck fractures, which in turn increases the rates of reoperation due to the nonunion and femoral head necrosis.^[3,4,11,12]

An ideal implant for femoral neck fracture fixation should meet the following criteria: (1) provide excellent patient outcomes in simple and complex femoral neck fractures; (2) provide instrumentation that improves the surgeon's ability to obtain a fracture reduction; (3) allow compression (lag screw effect) across the fracture site; (4) provide angular stability and prevent or at least minimize shortening of the femoral neck; (5) allow a minimally invasive surgical insertion; and (6) provide excellent outcomes even when the fracture is not anatomical (7) preventing cut-out of implant.^[13-15]

There were two weak points of the study: the use of 3rd generation artificial bone, which is not equivalent to the real biological bone and the lack of optical devices to measure the displacement. We did not have these facilities in our biomechanical laboratory.

The MIS-A-CHS is developed in order to address these requirements. The advantages of MIS-A-CHS include the ability to make compression, percutaneous application and interlocking with a screw from its oblong hole. In order to prevent the occurrence of "Z" effect it is designed to behave as a monobloc implant with one lag screw.

In this study, we demonstrated the substantial biomechanical advantages of the MIS-A-CHS in simulated Pauwels 3 femoral neck fractures. The MIS-A-CHS constructs had significantly less femoral head displacement compared with specimens stabilized with CS either in axial and in torsional loading and provided more compression at the fracture line.

Theoretically, a device that allows fracture impaction significantly reduces the rate of delayed union or nonunion. The MIS-A-CHS has the compressive effect on the fracture site not only provided by conventional screwing maneuver but also an additional compression effect can be provided by compression screw (Figure 2). It still has sliding effect remaining after compression. We measured the maximum compression effect indirectly provided by the MIS-A-CHS and CS separately. The results demonstrated the improved compression effect of MIS-A-CHS. The results were in consentient with the previous studies which clearly showed the superiority of conventional dynamic hip screws over CS.^[16-18] However, the cannulated screw is still a widely used fixa-

tion device in femoral neck fractures.^[5,19-21]

The difference between conventional dynamic hip screws (CDHS) and MIS-A-CHS in producing compression effect is the use of the plate on the lateral cortex for compression in CDHS. On the other hand MIS-A-CHS uses the interlocking screw for the same purpose which is implanted percutaneously (Figure 3). The interlocking screw of MIS-A-CHS also prevents the lag screw to come out.

The standard procedure for CS fixation is technically demanding. A study reported that the adequate CS position was only 56.3% (151 of 268).^[22] However, placement of one lag screw properly is technically easier than placement of three parallel separate screws. In clinical practice it might be easier to insert one lag screw of MIS-A-CHS percutaneous.

Poor fixation and loss of reduction may occur because of lack of control on the proximal fragment, which may rotate during insertion of the lag screw. Rau et al. reported this complication in 20% of their cases.^[23] In the original technique of inserting MIS-A-CHS a temporary use of a Kirchner wire prevents the rotation. In the design of MIS-A-CHS, there is an anti-rotational wedge slides on the groove at the side of the lag screw and locked by compression screw after placement of it which prevents to come out. This anti-rotational wedge provided additional stability in the control of proximal fragment.

One of the advantages of the CS method is the less invasive surgery associated with a small incision, less blood loss, and a shorter hospital stay.^[23] In addition, the DHS method had more disadvantages related to more soft tissue stripping than CS method.^[9] However the MIS-A-CHS can be applied percutaneous.

Besides the aforementioned biomechanical advantages of MIS-A-CHS, the preliminary results of our new system provide the clinical advantages of easy implantation, percutaneous application and lack of any implant failure.^[24]

Conflicts of Interest: No conflicts declared.

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