STATIC LOAD TEST OF THE MODIFIED SLIDING HIP SCREW: THE DHS-AF ®

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ABSTRACT

Objective: To analyze the *in vitro* mechanical strength of the DHS-AF®. Methods: We evaluated the in vitro resistance of a sliding bolt modified by the addition of a connector system, DHS-AF®. Results: The changes performed by the authors allow the exchange by the surgeon of the sliding bolt without the need to remove the plate and disassemble the entire device to reposition it properly. We conducted a static bending test to evaluate maximum strength, stiffness and ductility of the system. DHS-AF® showed satisfactory mechanical properties when compared to other conventional devices which use the same principle. Conclusion: Based on these results, the authors propose the use of this new implant in further *in vivo* studies. ***Level of Evidence III, Analytical Study.***

Keywords: Hip fractures. Bone screws. Evaluation.

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INTRODUCTION

Fixation of intertrochanteric fractures of the femur has evolved over the past decades.[1] Currently, numerous studies have shown that the system of sliding hip screw is the method of choice for the treatment of these fraturas.[2-5] The principle of sliding screw placed in the femoral head is to provide stability and compression fracture through the controlled collapse of the main fragment over distal.[1, 6] Its use stands out mainly by the simplicity of the material, the relative technical ease of placement and the low rate of complications reported in the literature.[1,6-8]

The success of treatment depends, among other factors, on the proper positioning of the sliding screw head femoral.[1,6,9-15] However, characteristics of the implant design, as fixed angle and rotational stability of the intrinsic sliding pin, can lead to incorrect placement of the screw in the lap. The most common mistakes while applying the sliding screw are eccentric placement and incorrect choice of the size of the screw.

The idea of developing a new implant for stabilization of femoral intertrochanteric fractures is based on the proposal to allow the exchange of the sliding screw without necessarily the removal by the surgeon of the plate and dismantle the entire system to reposition it. Thus, we developed a board-sliding pin system with connector system DHS-AF®. The authors' goal with this study was to evaluate the in vitro mechanical strength of the DHS-AF®.

MATERIALS AND METHODS

The DHS-AF® system: The DHS-AF® board consists of five components: (1) main board, (2) tubular connection system, (3) sliding screw, (4) locking screw, and (5) cotter -pin. This model was manufactured by Baumer (Mogi Mirim, São Paulo, Brazil) with austenitic stainless steel ASTM F 138. The main board, which is set by 4.5 mm cortical screws to the proximal femur, has at its upper end a sliding tubular system, where adapts a piece of tubular connection. This part has a larger hole for the screw and another lower slider fixed to the main plate by a locking screw. With the union of these two parts, motherboard and tubular connecting piece, a slipping non-rotating system of the sliding bolt are set. The proposed amendment brings substantial advantage as the eventual replacement of the sliding bolt without dismantling the set of osteosynthesis in its entirety, by removing tubular connection piece. When removing the blocking screw, a guide wire through this hole can be inserted, in order to maintain fracture reduction, other wires may be introduced into the area that touches the main board with the same objective. (Figure 1)

The tubular connection piece has three main systems: two latches and one anchor. The anchor system, located in the proximal portion of that part, serves to enable the cotter pin to exert compression on the fracture. The first locking system is located on the inner tubular connecting piece and has the function of preventing the rotation of the sliding screw. The second lock system is located on the outer side of the tubular

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connecting part, having the function of preventing the rotation of this piece inside the tube of the main board.

Mechanical Tests: Static bending Assays were performed in five plates DHS-AF®with four holes with a fixed angle of 135°. The tests were conducted according to ASTM F384[16] and NBR 13762[17] guides. For such tests, the plate was previously attached to a stiff body of evidence using 4.5 mm diameter screws. This specimen was made especially for this type of test, in strict compliance with the parameters determined by those standards. They are: flexure - load required to promote a permanent 0.13 mm vertical deflection (vertical displacement); stiffness - the ratio of the bending strength, as defined above, and the total deflection produced by that load (LR); ductility - maximum vertical deflection at the time of load application that may support DHS immediately before a visible fracture in a minimum of eight times enhancement.[16,17]

In order to meet the specifications of the test, a pin extender was made, which allowed the application of the load in the vertical direction at a point distant 76 mm from the buckle for the model plate. The assembly of DHS-AF® attached to the test fixture with the respective extender pin is shown in Figure 2.

The static bending tests were conducted in the Mechanical Engineering Laboratory, Universidade Estadual de Campinas (Unicamp) in July 2002 in a servo-hydraulic MTS model Test Star II®, with load capacity of 10 tons and displacement control. Data collection of the applied load (P) was made as a function of the vertical displacement of the piston (L). The vertical displacement speed of the piston was 5 mm/min. The static bending tests were interrupted after reaching the maximum vertical deflection (maximum vertical displacement) of 25.4 mm, in accordance with the standards specified for this type of test. The complete assembly of the Model DHS-AF® in the test machine immediately before the procedure is shown in Figure 3. The complete assembly of the test device, as well as the methodology used for determining the parameters of interest according to the test standards are illustrated in Figure 4, according to the same standards mentioned above (flexural strength, stiffness and ductility).

The assembly of the DHS-AF® stuck in fixture with extender pin attached before and after the tests is shown in Figure 5.

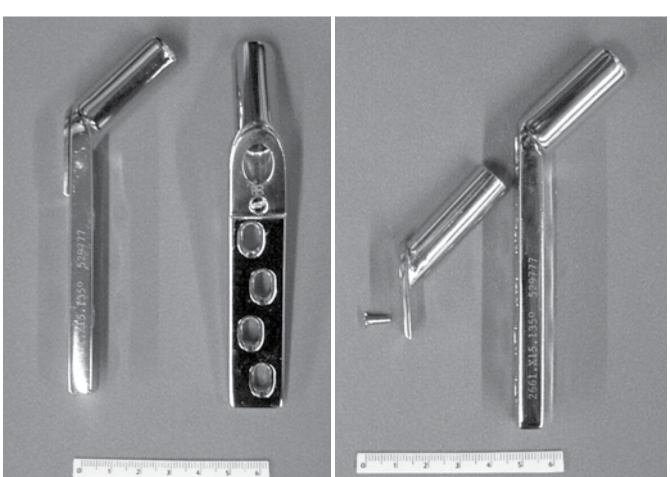

Figure 1. Four holes angled plate model DHS-AF® (135), made of austenitic stainless steel ASTM F-138 used for the static bending test.

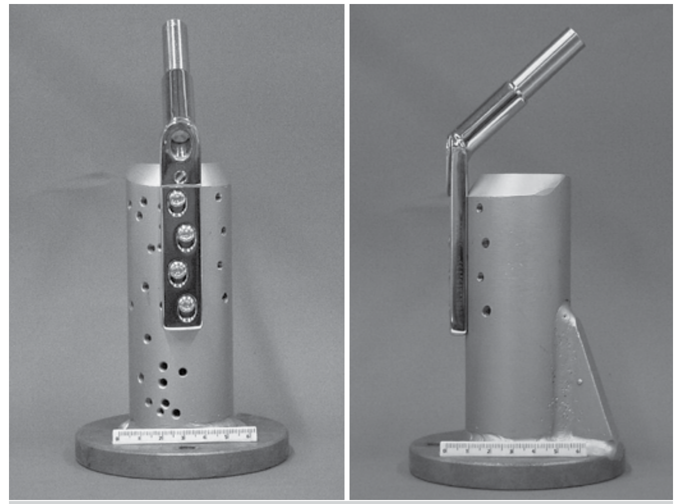

Figure 2. Assembly of angled plate model DHS-AF® with the respective extender pin on the fixation device for the static bending test.

Figure 3. Complete assembly of the device in the angled plate DHS-AF® test®.

RESULTS

The curves obtained in implant static flexion tests DHS-AF® present the values of the parameters determined from the tests. (Figure 6 and Table 1) The flexural strength ranged from -91.0 to -113.0 Kgf, with mean ± SD values of -101.0 ± 9.0 Kgf. The stiffness ranged from -45.3 to 53.2 Kgf / mm with mean ± SD values of -49.2 ± 3.3 Kgf/mm. The signs (-) are due to the fact that charging is in compression. All plates tested showed a ductility greater than 25.4 mm, no fractures were observed before the maximum vertical deflection established by the rules of static bending test for this type of implant. This finding shows a high flexibility of implant tested.

DISCUSSION

Treatment of intertrochanteric fractures have evolved greatly over the last 50 years, particularly with respect to the choice of implante.[1,7] Since Smith-Pettersen in 1931 published its preliminary results with the trilaminar nail, several authors turned

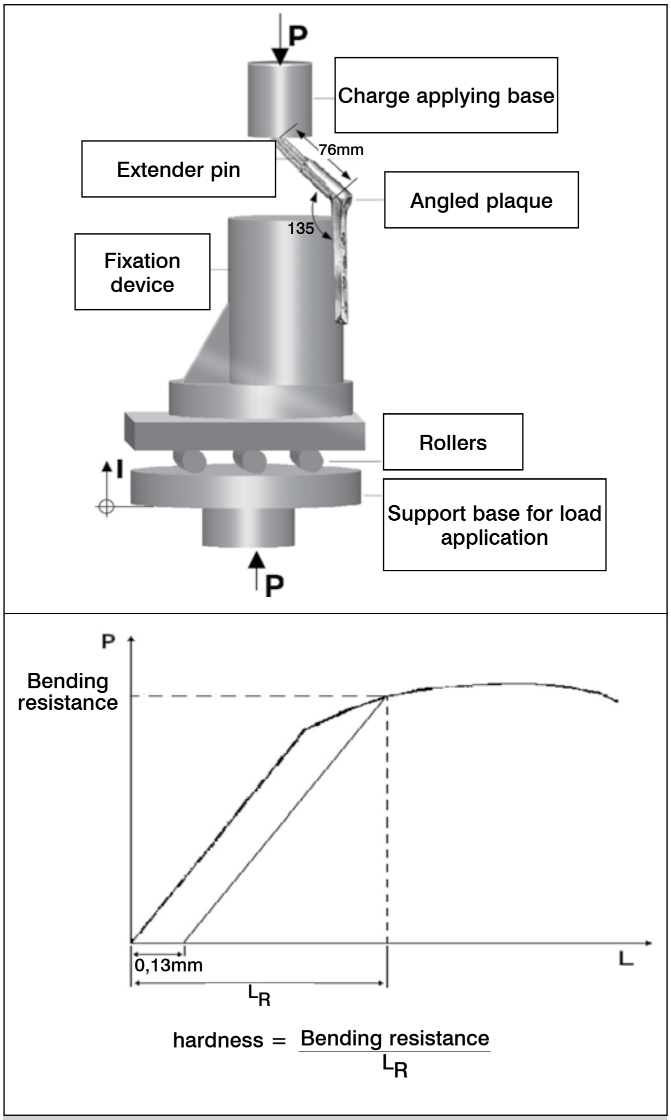

Figure 4. Scheme assembly of the device and methodology used for determining the parameters of the static bending test angled plate.

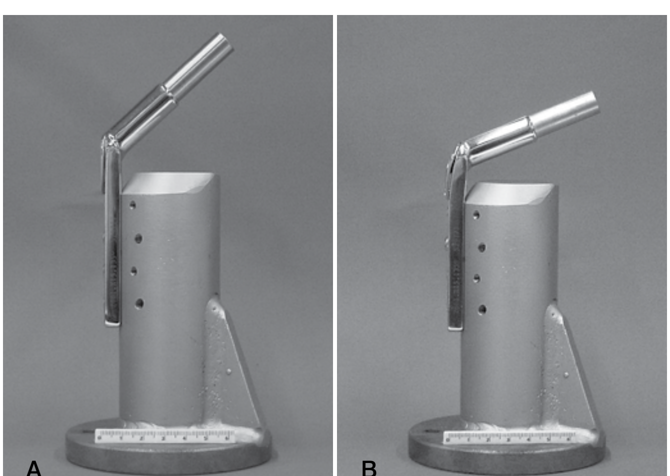

Figure 5. Assembling the model angled plate DHS–AF® with extender pin in fixture before (A) and after (B) the flexion static tests.

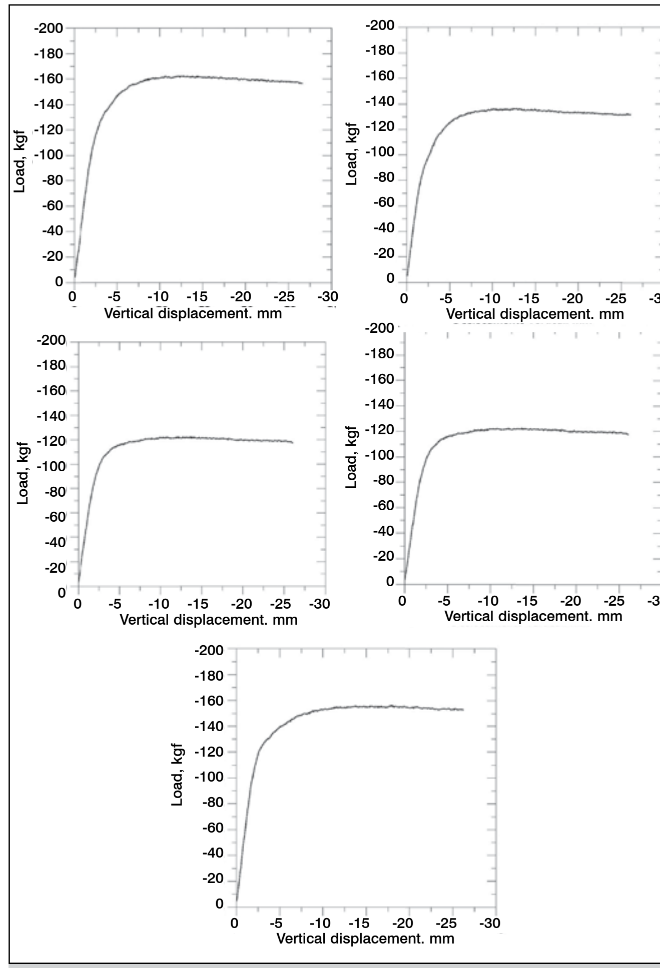

Figure 6. Static flexion tests of DHS AF® Angled Plate implants.

Table 1. Parameter values obtained in static flexion tests of angled plate type implants model DHS-AF®.

Plaque	Resistance to Flexion	Stiffness, kgf/mm	Ductility, mm
1	-113,0	50,2	> 25,4
2	-91,0	52,0	> 25,4
3	-101,0	45,5	> 25,4
4	-91,0	45,3	> 25,4
5	-109,0	53,2	> 25,4
Mean ± Standard Deviation	-101,0 ± 9,0	49,2 ± 3,3	-

Source: SOT, 2002. N.B.: negative signal (-) due to the fact that the loading is in compression.

their attention to the issue of development of synthetic materials for intertrochanteric fractures.[6] Thus, consecutively appeared the Thornton, Jewett and McLaughlin implants, all based on the Smith-Pettersen nail. However, deficiencies common to all these systems, as the great aggression to the femoral neck by the trilaminar nail and the constant need of association with other synthetic materials, usually in the most unstable fractures, produced a high incidence of complications and later its abandonment. Only in the late 1950s, with the creation of the AO group - Association for the Study of Internal Fixation

(Arbeitsgemeinschaft für Osteosynthesefragen), new advances could be made in the field of fastening internal devices.[6] Specifically for intertrochanteric fractures high performance angular plates or placards blade have been developed. Initially it was thought that the "U" shaped profile of the blade and the presence of fixed angle were associated with increased strength of the implant. However, difficulties in the insertion of the laminar part and early fatigue of these materials led to doubts regarding its uso.[18] Like what had happened to the Smith-Pettersen nail, the first AO implants have become obsolete after a period of time. Because of these technical difficulties, many implants have emerged since then, almost always presenting the same evolution of its predecessors. Finally, in the 1980s, Regazzone et al.,[19] of the AO Group, developed the dynamic hip screw (DHS®). Unlike the rigid implants, in this new system the introduction of a screw through the sliding plate has made possible to promote continuous compression through the fracture focus, which was never made possible before. In addition, other common devices previously developed were fixed with DHS® as loss of reduction in the post-operative phase and perforation of the femoral head by the pin.[19] Currently, the sliding bolt is the method of choice for most intertrochanteric fractures.[4,20] The incidence of complications when the system is used correctly is about 5%.[18] Despite that, poor preoperative planning, technical mistakes and degenerative changes occurring in older patients are often related to poor results.[12] In addition, we must consider the lack of standardization among manufacturers of the DHS® systems in our country as a possible cause of treatment failure, according to a previous study.[21]

In this context, little has been discussed about possible errors and complications directly related to the design of the dynamic hip screw. Due to its fixed angle and the impossibility of changing the sliding screw without disassembling the whole osteosynthesis, disastrous consequences can occur, mainly related to the reduction quality and longer surgical exposure. Recently in our service a modification was performed in a sliding hip screw in order to permit the exchange of the sliding pin without the need for the surgeon to remove the plate and disassemble the entire system to reposition the implant.[22] This implant was called DHS-AF®.

This theoretical advantage may not be important in developed countries or even in services in our country that rely on a fluoroscopy unit. However, we believe that the national reality does not allow the easy insertion of the image intensifier in most orthopedics services. Based on this logistical difficulty and on design issues of currently existing sliding screws, we developed the changes proposed in this study.

Thus, the goal of the authors of this study was to evaluate the *in vitro* resistance of the DHS-AF® through static bending test, since the implant structural changes may alter the mechanical properties thereof. We evaluated the flexural strength, stiffness and ductility, as recommended for material testing.[16,17,23] The results obtained were similar to those found in the literature on experiments with underlineament.[18,24,25]

CONCLUSION

Based on these data, the authors conclude that this new implant is safe to be used in future studies *in vivo,* proving its practicality and benefits.

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