

IN VITRO APPLICABILITY TEST OF THE AF DYNAMIC HIP SYSTEM (DHS-AF)

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ABSTRACT

Objective: This report considers the results of the applicability test of a modified dynamic hip system developed by the authors, which allows either the manipulation or the exchange of the sliding screw, without the need to remove the plate and take all the system apart in order to change its size or position. **Methods:** Five modified plates – DHS-AF – manufactured with austenitic stainless steel ASTM F 138, with 4 holes and a 135° angle were inserted in five segments of synthetic bone of proximal femur (Synbone).

All implants were fixed to the femur following the surgical techniques described by AO foundation (Arbeitsgemeinschaft für Osteosynthesefragen). **Results:** The modified dynamic hip system (DHS-AF) allowed ease in handling and exchange of sliding screw without the need for plate removal. **Conclusion:** In vitro test of the applicability of DHS-AF afforded promising results and led us to believe that after biomechanical evaluation to confirm its safety it may be reproduced in vivo.

Keywords: Hip fractures. Orthopedic nails; Bone screws.

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INTRODUCTION

The fixation of intertrochanteric femoral fractures has been evolved over recent decades.¹ Countless studies have shown that the sliding hip screw system is the method of choice for the treatment of these fractures.²⁻⁵ The principle of the sliding screw, inserted in the femoral head, is to provide stability and compression to the fracture by means of the controlled collapse of the proximal fragment on the distal fragment.^{1,6} Its use stands out mainly because of the simplicity of the material, the relative technical ease of its placement and the low rate of complications reported in literature.^{1,6-8}

The good positioning of the synthesis during hip surgery, when using the conventional dynamic hip system (DHS), is always centralized both in the anterior posterior direction, and in the latero-lateral direction of the femoral neck, respecting the pin-apex distance (PAD).⁹ However, specific features of the implant design, such as its fixed angle and the intrinsic rotational stability of the sliding pin, can carry to the incorrect placement of the screw in the neck. The most common mis-

takes during application of the sliding screw are its eccentric placement and incorrect choice of screw size.⁶

The idea of developing a new implant for stabilization of intertrochanteric femoral fractures is based on the proposal of allowing the replacement of the sliding screw without the surgeon having to remove the plate and dismantle the entire system to reposition it. This facilitates the quest for the ideal PAD, without the need for manipulations of the system or of the fracture. A dynamic hip system type plate was developed to this effect, with a sliding tubular connector system, known as DHS-AF. The purpose of this study is to demonstrate the results of the in vitro applicability tests of the DHS-AF.

MATERIAL AND METHODS

Five DHS-AF plates produced by a national company, all in austenitic stainless steel ASTM F 138, with a 135° angle and four holes were used in the study. The DHS-AF system is formed by five components: (1) main plate, (2) sliding tubular connection system, (3) locking screw, (4) sliding screw and (5) cotter pin (Figures 1a, 1b, 1c), which were applied to five Syn-

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bone synthetic proximal femur segments. The DHS-AF plates were fixed to the synthetic bones, using the surgical techniques described by the AO Foundation for use of the conventional DHS.⁶ After the application of the implants, the connection part was removed and the sliding pin manipulated and replaced. The DHS-AF plates were fixed to the synthetic bones with 4.5 mm cortical screws in the proximal third of the femur. There is a tubular structure at the upper end of the main plate, which is the site of adaptation of a sliding tubular connection part (Figure 1c) with two holes: a larger one, with anti-rotating locking system for the introduction of the sliding screw and another smaller one, which fixes it to the main plate through a locking screw. (Figure 1c) The reproduction seen in the conventional DHS system (Figure 1a) occurs with the union of these parts, the main plate and the sliding tubular connection part. The proposed modification is evidenced upon the removal of the sliding tubular connection part, at which time the anti-rotating mechanism of the sliding screw is released, allowing temporary stabilization of the fracture with guide wires (Figures 2a, 2b) and creating space for the introduction of the screwdriver that manipulates the sliding screw (Figures 3a, 3b), enabling the modification of the PAD or possible replacement of the sliding system. (Figure 4a, b, c).

The sliding tubular connection part has three main systems: two with locks and one of the prop type. The prop system, located in the proximal portion of this part, is designed to allow the cotter pin to perform the fracture compression. The first lock system is located on the inside and is designed to avoid the rotation of the sliding screw. The second lock system is located on the outside, to prevent the sliding tubular connection part from starting to rotate inside the tube of the main plate. (Figure 5)

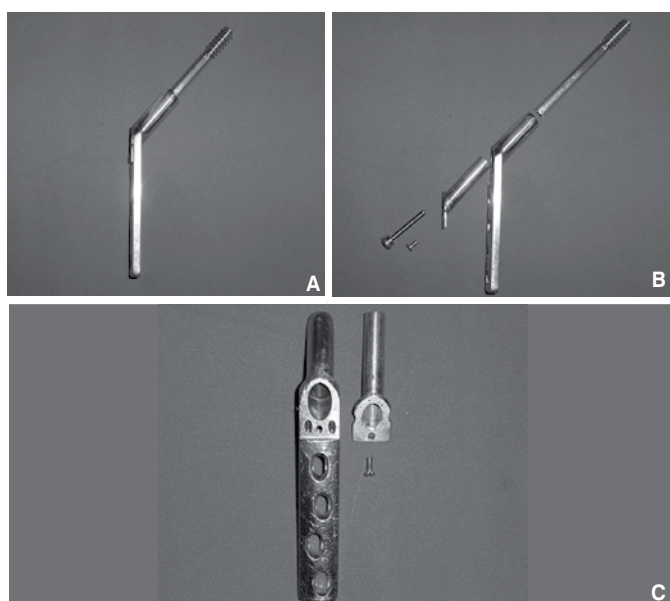


Figure 1. Photograph of the Angulated Plate model DHS-AF 135^o with four holes, of austenitic stainless steel ASTM F 138. A- Lateral view of the assembled system B- Exploded lateral view of the system. C-Front view of the main plate and sliding tubular connection part.

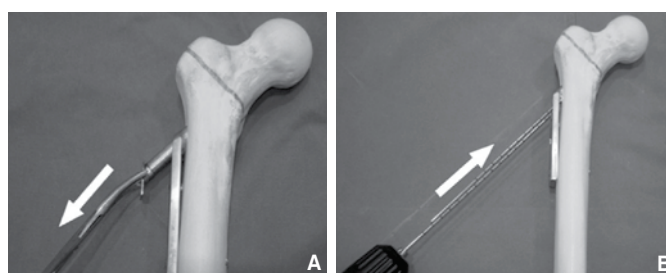


Figure 2. A - Removal of the sliding tubular connection part B- Temporary fixation of the fracture with guide wires introduced through the holes of the main plate.

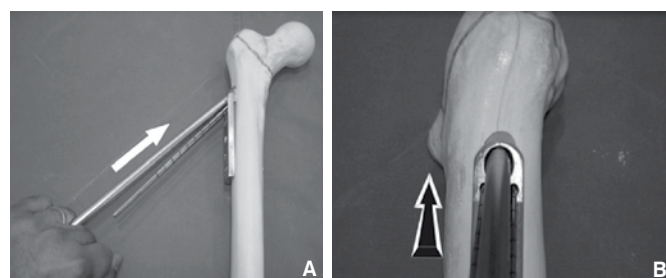


Figure 3. A - Lateral view of introduction of the -manipulation key of the sliding screw, inside the main plate. B - Front view of introduction of the manipulation key of the sliding screw, inside the main plate.

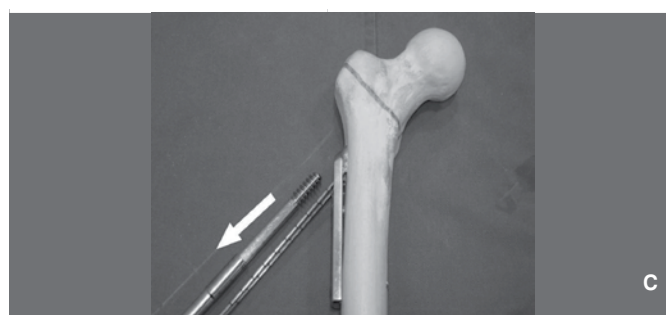
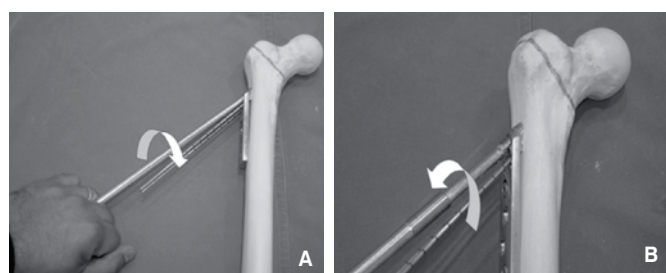


Figure 4 A - Manipulation of the sliding screw increasing its introduction without the removal of the main plate. B- Manipulation of the sliding screw reducing its introduction without the removal of the main plate. C- Removal of the sliding screw for replacement without removal of the main plate.

RESULTS

All the applicability tests were conducted successfully and without technical difficulties. They allowed the replacement and the manipulation of the sliding screws, both in the direction of their introduction and in distancing from the femoral head apex, in the synthetic bone models.

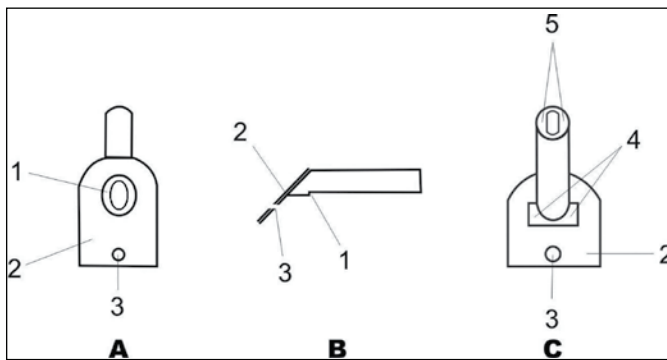


Figure 5. Illustration of the sliding tubular connection part. A - Front view B- Lateral view C - Rear view. 1- cotter pin strut system, 2- Lateral fin of the tubular connection part, 3- hole of the locking screw of the tubular connection part, 4- Anti-rotating lock system of the sliding tubular connection part, 5- Anti-rotating lock system of the sliding screw.

DISCUSSION

The treatment of intertrochanteric fractures has evolved over the last 50 years, particularly in relation to the choice of implant.^{1,7} Since Smith-Petersen¹⁰ published his preliminary results with the three-flanged nail in 1931, several authors have focused their attention on the development of synthesis materials intended for intertrochanteric fractures. Thus there was the consecutive advent of the implants of Thornton,¹¹ of Jewett and Eugene¹² and of McLaughlin¹³, all based on the Smith-Petersen nail. However, deficiencies common to all these systems, such as considerable aggression to the femoral neck promoted by the three-flanged nail and the constant need for association of other synthesis materials, generally in more unstable fractures, produced a high rate of complications and their subsequent abandonment.

It was only at the end of the 50s, with the appearance of the AO Foundation, that major progress was made in the field of internal fixation devices.⁶ High performance angulated plates or blade plates were developed specifically for intertrochanteric fractures. Initially, it was believed that the "U" profile of the blade and the presence of the fixed angle were associated with greater implant resistance. However, difficulties in the insertion of the laminar part and early fatigue of these materials gave rise to doubts with regard to their use.¹⁴ As was the case of the Smith-Petersen nail, the first AO implants became obsolete after a while. Due to these technical difficulties, various implants have appeared since then, almost always presenting the same evolution as their predecessors.

Finally, in 1980, Regazzone *et al.*¹⁵ of the AO Foundation, developed the dynamic hip system (DHS).⁶ Unlike the old-fashioned rigid implants, in this new development, the introduction of a sliding screw through the plate, made it possible, for the first time, to promote continuous compression through the fracture focus. Moreover, other problems common to the devices previously developed were corrected with the DHS, such as loss of reduction in the postoperative stage and perforation of the femoral head by the pin.¹⁵ Today the sliding screw is the method of choice for most intertrochanteric fractures.^{4,16} The incidence of complications when this system is used correctly is around 5%.¹⁴ Nevertheless, poor preoperative planning, te-

chnical errors and degenerative changes occurring in older patients are frequently related to poor results.¹⁷

Dittel and Rapp¹⁴ performed a new modification in the dynamic hip system, creating a system that allows the variation of the tube-plate angle, calling it MARTIN, with the purpose of correcting errors that arise when it is necessary to use the dynamic hip system. It has a fixed tube-plate angle, in morphologically deviated necks, whether in varus or in valgus. In 1998¹⁸, Watson *et al.* presented a modification of the dynamic hip system called MEDOFF, which makes it possible to have double sliding, creating a rail system on the lateral side of the plate, which enables not only the controlled sliding of the sliding screw, but also that of the metaphysis on the diaphysis. This modification determines better control and greater biomechanical resistance in unstable fractures, aiming to resolve the fault-related problems of the conventional DHS, when used in unstable proximal femoral fractures. Such problems were resolved later on with the development of the intramedullary implant.¹⁹

In 2004, the AO Foundation developed a new system similar to the dynamic hip system, focusing on preserving the bone stock of the femoral head, called dynamic helical hip system (DHHS), which has the same fixation principle as the DHS system, yet instead of having a screw that points towards the center of the head, it has a helical blade, designed to preserve bone tissue from the femoral head. The improvement of the instruments developed together for use of this implant served to reduce errors in relation to the choice of size of the sliding helical pin. However, difficulties relating to its fixed tube-plate angle and its handling or replacement still remain in consolidated fractures with a high level of impaction. For this purpose, it is necessary to dismantle the entire system.²⁰ In this context, little is said about the possible errors and complications directly related to the design of the dynamic hip system. So much so that due to its fixed angle, and to the impossibility of handling or replacing the sliding screw without dismantling the entire system, disastrous consequences can occur, mainly related to the quality of the reduction obtained, and to the longer time of surgical exposure. In an attempt to resolve these difficulties, a modification was developed in the sliding screw system of the hip, with the purpose of allowing the replacement of the sliding pin, without the surgeon necessarily having to remove the plate and dismantle the entire system to reposition it, called DHS-AF. The DHS-AF system does not exempt the surgeon from using and respecting the implantation technique of the extramedullary system of the sliding plate-tube type for proximal femur already described by the AO. It is believed that this technical is irreplaceable.

The DHS-AF system was developed for the performance of minor corrections and/or replacement of the sliding pin, ensuring safety and convenience for the surgeon and the patient, in potential measurement errors and/or in major impaction of proximal femoral fractures.

The advantage described with the DHS-AF system can benefit everyone that uses the sliding plate-tube system, parti-

cularly those executing this procedure without a radiology apparatus, and those that perform it with the aid of radiology, who may be subject to the parallax effect,²¹ a phenomenon that causes distortion of the image that depends on the distance between patient and image capturing device.

Another advantage of the DHS-AF system is the possibility of replacing the sliding screw, in consolidated fractures of elderly patients with significant impaction of the proximal femur, in which there is considerable sliding of the pin that produces friction on the lateral side of the thigh, causing pain. The solution indicated for this problem is the replacement of the syn-

thesis material, as its simple removal can cause weakness of the femoral neck and consequently fracture. With the DHS-AF system it is possible to replace the sliding pin in a fast and non-invasive manner, which is a major benefit for the patient. The changes proposed in this study were developed with a basis on this difficulty and on the design problems of current sliding screws.

CONCLUSION

Based on these assays, the authors conclude that the application of this new implant is technically comparable to existing methods.

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