

# COMPARISON OF VOLUMES OCCUPIED BY DIFFERENT INTERNAL FIXATION DEVICES FOR FEMORAL NECK FRACTURES

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## ABSTRACT

**Objective:** The objective of this paper is to measure the volume occupied by the most widely used internal fixation devices for treating femoral neck fractures, using the first 30, 40 and 50 mm of insertion of each screw as an approximation. The study aimed to observe which of these implants caused least bone aggression. **Methods:** Five types of cannulated screws and four types of dynamic hip screws (DHS) available on the Brazilian market were evaluated in terms of volume differences through water displacement. **Results:** Fixation with two cannulated screws presented significantly less volume than shown by DHS, for insertions of 30, 40 and 50 mm ( $p=0.01$ , 0.012 and 0.013,

respectively), fixation with three screws did not show any statistically significant difference ( $p= 0.123$ , 0.08 and 0.381, respectively) and fixation with four cannulated screws presented larger volumes than shown by DHS ( $p=0.072$ , 0.161 and 0.033). **Conclusions:** Fixation of the femoral neck with two cannulated screws occupied less volume than DHS, with a statistically significant difference. The majority of screw combinations did not reach statistical significance, although fixation with four cannulated screws presented larger volumes on average than those occupied by DHS.

**Keywords** – Femoral Neck Fractures; Fractures Fixation, Internal; Hip/surgery

## INTRODUCTION

Intracapsular fractures of the femoral neck correspond to approximately 50% of all hip fractures. Surgical treatment options for dislocated fractures include arthroplasty and internal fixation (the latter being the treatment of choice in younger patients). The majority of existing works do not demonstrate any great superiority between the more widely used internal fixation methods (dynamic hip screw, DHS; or multiple cannulated screws, MCS). Various meta-analyses and biomechanical works have failed to show any difference between the two methods<sup>(1-4)</sup>. It is known that one of the main complications of surgical

treatment with these devices is avascular necrosis of the femoral head<sup>(5)</sup>.

Studies on animal models demonstrate increased blood flow in the head of the femur with the use of internal fixation, and perhaps an additional increase in this flow when the fixation device applied compression on the fracture<sup>(6)</sup>. One possible means of reducing this complication is to reduce the volume occupied by the implants within the femoral head, facilitating vascularization and the process of bone consolidation. The aim of this study is to measure the volume occupied by different implants used for fixation of the fractured femoral head, using as approximation the first 30, 40 and 50 mm of each of these implants.

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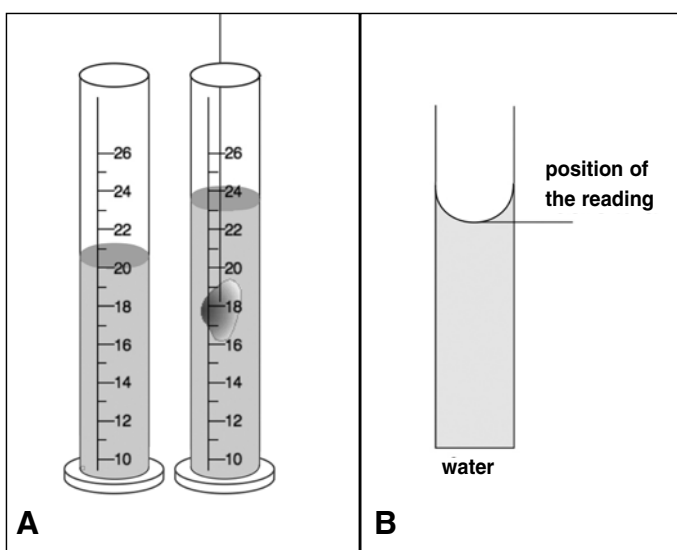
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## MATERIALS AND METHODS

Different brands of cannulated screw (MCS) and sliding screw (DHS), manufactured by three different national orthopedic materials manufacturers, were compared. The different brands were identified as A, B and C.

Given that there are different fracture lines (subcapital, mediocervical and basocervical) and that the femoral head can vary in size, the first 30, 40 and 50 mm of each screw were arbitrarily considered, to simulate different penetration lengths of the screws inside the femoral heads. The volume occupied by the DHS was compared with that occupied by the MCS, considering two, three and four cannulated screws.

The method used to determine the volumes of the screws was difference in volume. Three measurements were performed for each volume considered, using the mean value for the purpose of the calculations. The procedure was carried out according to the following sequence: marking of the screws, considering insertion of 30, 40 and 50 mm with a GECOR-Paq-01 digital caliper, addition of water to a graduated cylinder up to a determined volume, immersion of the irregular solid to the predefined height, then determining the new volume of water in the cylinder. The volume of the solid is the difference between the final and initial volumes. Figure 1A shows the system used for the volume measurements. In this system, the volume reading should be taken from the bottom of the meniscus, as shown in Figure 1B.



**Figure 1** – (A) Representation of the system of graduated tube used to determine the volumes occupied; (B) reading position of the meniscus.

The premises of variance and distributions were evaluated for the application of the mean comparison tests. The Mann-Whitney non-parametric test was also applied, for comparison of the distributions. A level of significance of 5% was adopted for all the comparisons. The statistical calculations were carried out using the software SPSS 16.0.

## RESULTS

Table 1 shows the different brands and screw sizes for the different insertion lengths (30, 40 and 50 mm) in relation to the volumes occupied. Table 2 shows the comparison between the DHS and the different screw configurations, considering the maximum and minimum volumes obtained for the screws of each manufacturer. Table 1 also shows the results of the statistical analysis of the data.

Figures 2, 3 and 4 show, in visual form, the mean values for the screw volumes, comparing DHS for two, three and four cannulated screws, respectively, observing the different insertion lengths (30, 40 and 50mm). In each case, a linear trend is observed.

In relation to the volume in  $\text{cm}^3$ , it is demonstrated that comparison of the DHS with the volume of three cannulated screws was the only configuration in which there are no statistically significant differences; two screws occupied a smaller volume, and four screws occupied a larger volume than the DHS.

**Table 1** – Mean screw volume measurements.

Identification of the screws	Volume ( $\text{cm}^3$ )		
	30 mm	40 mm	50 mm
<b>DHS</b>			
Brand A thread 19	1.9	2.4	2.8
Brand A thread 28	1.9	2.4	3.0
Brand B thread 25	1.7	2.2	2.6
Brand C thread 20	1.5	2.0	2.4
<b>Cannulated screws</b>			
Brand A thread 19	0.5	0.7	0.9
Brand A thread 32	0.5	0.7	0.9
Brand B thread 32	0.5	0.7	0.9
Brand C thread 16	0.4	0.5	0.7
Brand C thread 32	0.5	0.6	0.8

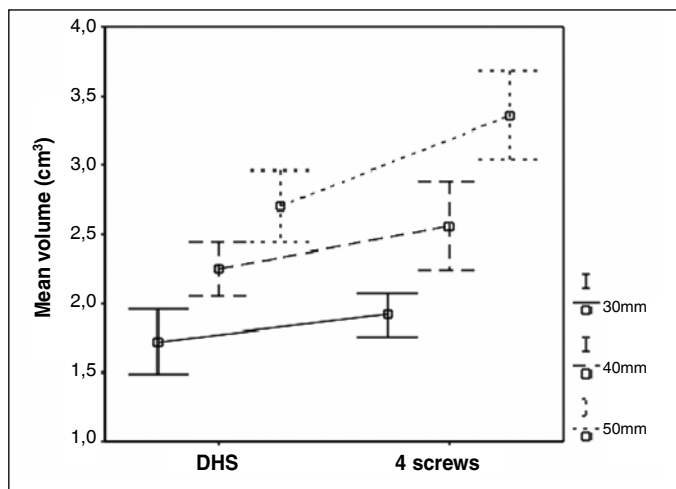
## DISCUSSION

In the treatment of fractures of the femoral neck, three surgical conducts are traditionally used: internal fixation, hemiarthroplasty, and total hip arthroplasty. Osteosynthesis has the potential to offer the patient a normal hip after consolidation of the fracture.

**Table 2** – Comparison of the results for DHS and cannulated screws.

Size	Type	Minimum	Maximum	Mean ± SD.	SEM.	p
30 mm	DHS	1.40	1.90	1.72 ± 0.24	0.12	0.010
	2 Cannulated screws	0.80	1.00	0.96 ± 0.09	0.04	
	DHS	1.40	1.90	1.72 ± 0.24	0.12	
	3 Cannulated screws	1.20	1.50	1.44 ± 0.13	0.06	0.123
	DHS	1.40	1.90	1.72 ± 0.24	0.12	
	4 Cannulated screws	1.60	2.00	1.92 ± 0.18	0.08	
40 mm	DHS	2.00	2.40	2.25 ± 0.19	0.09	0.012
	2 Cannulated screws	1.00	1.40	1.28 ± 0.18	0.08	
	DHS	2.00	2.40	2.25 ± 0.19	0.09	
	3 Cannulated screws	1.50	2.10	1.92 ± 0.27	0.12	0.080
	DHS	2.00	2.40	2.25 ± 0.19	0.09	
	4 Cannulated screws	2.00	2.80	2.56 ± 0.36	0.16	
50 mm	DHS	2.40	3.00	2.70 ± 0.26	0.13	0.013
	2 Cannulated screws	1.40	1.80	1.68 ± 0.18	0.08	
	DHS	2.40	3.00	2.70 ± 0.26	0.13	
	3 Cannulated screws	2.10	2.70	2.52 ± 0.27	0.12	0.381
	DHS	2.40	3.00	2.70 ± 0.26	0.13	
	4 Cannulated screws	2.80	3.60	3.36 ± 0.36	0.16	

SD = Standard deviation and SEM = Standard error of the mean.



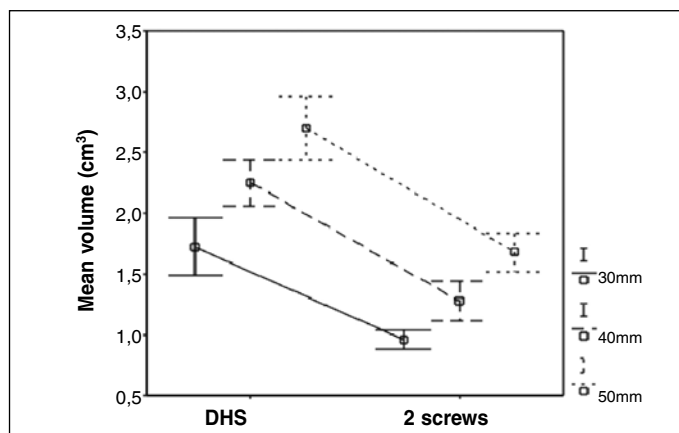
**Figure 4** – Comparison between the DHS and four cannulated screws.

However, it presents risks of failure and complications: pseudarthrosis, necrosis of the femoral head, etc. Lu-Yao et al<sup>(7)</sup>, in a review of 106 published studies, concluded that the level of loss of fixation of the osteosynthesis is 16% (ranging from nine to 27%). Tronzo<sup>(8)</sup>, in a literature review, found more than 100 different implants. Currently however, for internal fixation, the choice of the majority of orthopedists is divided between the dynamic hip screw (DHS) and multiple cannulated screw (MCS).

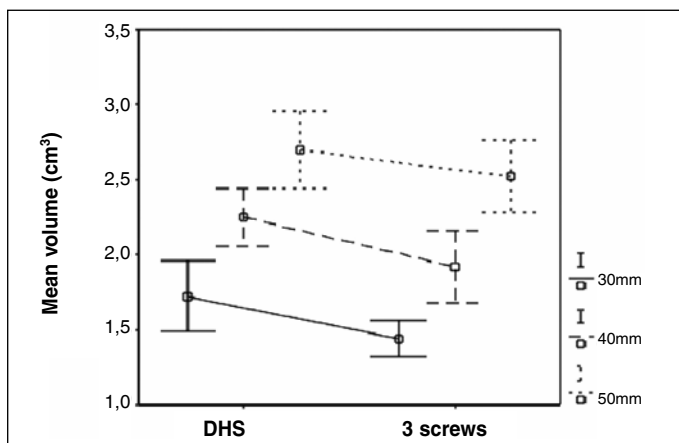
Surprisingly, there is no randomized prospective work that compares these two methods. Neither is there a consensus on whether to use two screws, or more than two.

Krastman et al<sup>(9)</sup> concluded that for non-dislocated fractures (Garden I and II), only two cannulated screws are sufficient to obtain consolidation. In the normal technique using three screws, it is recommended that the screws be placed perpendicular to each other. Lagerby et al<sup>(10)</sup>, analyzing 268 osteosyntheses, concluded that the screws were correctly placed in just 151 cases (56.3%).

Parker and Blundell<sup>(3)</sup>, in a meta-analysis on the choice of synthesis material, analyzed 25 randomized studies, concluding that the majority had an insufficient number of patients to enable a firm comparison between the implants. Deneka et al<sup>(11)</sup> carried out a biomechanical study of unstable fractures of the femoral neck, and reported that from a mechanical point of view, the DHS is statistically superior to three cannulated screws in all the aspects analyzed. Meanwhile, Clark et al<sup>(4)</sup> did not find differences between the treatments. From a clinical point of view, there is a



**Figure 2** – Comparison between the DHS and two cannulated screws.



**Figure 3** – Comparison between the DHS and three cannulated screws.

consensus that osteosynthesis with MCS is a less invasive technique, with less tissue aggression, less bleeding, and shorter hospitalization time<sup>(12-15)</sup>. Bhandari et al<sup>(16)</sup>, in a study carried out among orthopedists, concluded that North American surgeons tend to use cannulated screws, while European surgeons prefer DHS.

However, neither of these two methods is able to prevent the main complication associated with this fracture, which is avascular necrosis of the femoral head. This can occur in between four and 86% of cases<sup>(7,15,17-19)</sup>. Therefore, all the factors that potentially reduce the chance of osteonecrosis should be used: early surgery, anatomical reduction, stable osteosynthesis, etc. If the use of synthesis material is necessary, its use is likely to damage the debilitated circulation of the post-fracture femoral head, to a greater or lesser extent. Therefore, theoretically, a

smaller volume of intra-head synthesis material will be desirable. It was for this reason that we evaluated the volumes occupied by the DHS and the MCS in the femoral head.

## CONCLUSION

There are different profiles of cannulated screws and DHS, with larger and smaller threads available on the national market. In a global comparison of all the brands and models evaluated, and in different simulations of penetration lengths of the osteosynthesis in the femoral head, it is observed that fixation with two cannulated screws occupies less space in the proximal fragment than the DHS, while fixation with four screws occupies more space than the DHS in the femoral head, and fixation with three screws occupies a similar volume, without statistical difference.

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