UNIVERSITY OF MEDICINE AND PHARMACY CRAIOVA

ABSTRACT OF PhD THESIS

DHS OSTEOSYNTHESIS IN TROCHANTERIC FRACTURES. BIOMECHANICAL STUDY AND PROSPECTS FOR TECHNICAL IMPROVEMENT

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CONTENT

Keywords: trochanteric fractures, osteosynthesis, elastic nails, DHS.

The general part contains four chapters. In the first two chapters, are presented the anatomy of the upper femoral end and trochanteric fractures with their etiopatogeny, classification, clinical study and imaging, general conduct of treatment (timing , choice of anesthesia, prophylaxis of thrombosis, prophylactic antibiotics, the choice of implant mechanical and fracture reduction).

Chapter 3 presents the intramedullary fixation with Ender rods and Chapter 4, dynamic hip screw fixation.

The **personal part** comprises two clinical and one experimental studies and will be presented below.

Chapter 1. CLINICAL AND STATISTICAL COMPARISON STUDY BETWEEN ENDER AND DHS METHOD

In the first part of the personal contribution, we conducted a clinical-statistical comparing study between two surgical techniques: Ender method and DHS method. We therefore examined a serie of 140 trochanteric fractures treated by the Ender method in a period of ten years (2002-2011) and a second set of 129 cases subjected to treatment by the technique of dynamic hip screw (DHS) in a period of only four years (2008-2011).

From the beginning, it can be seen that elastic intramedullary rod-Ender Weidner has narrower indications in recent years, particularly in stable fractures, and fractures that can be stabilized with simple "anatomical"reduction on orthopedic table. We also used this method in the elderly, comminuted fracture and more serious comorbidities, requiring faster, simpler and less bleeding intervention.

In the period 2002-2011 (10 years), we treated 140 cases with trochanteric fractures by flexible nails method (Table I). It is a selected series of patients aged over 65 years.

The distribution of these patients by age and sex showed a value of true axiom: clear predominance of trochanteric fractures in women (66.4%).

Table I. Trochanteric fractures operated by Ender technique during 2002-2011(10 years)

Age Group	M	F	Total
65-74 years	16	28	44
75-84 years	20	46	66
85 years and more	11	19	30
Total	47 (33,6%)	93 (66,4%)	140

In very few cases, we operated stable fractures. In 85% of cases, fractures were comminuted and unstable. Although the technique has been followed rigorously in terms of its requirements, we have also encountered some incidents and the number of complications was relatively high. It stressed, however, that throughout this series of cases, it was not practiced distal blockage. Mechanical complications recorded are shown in suggestive images.

The second series comprised 129 cases with trochanteric fractures operated by DHS technique in a period of only four years (2008-2011) (Table II).

In this series, the distribution of cases by age and gender, shows very high in patients of and over 65 years (118 cases, 91.5%) and especially in women (98 cases, 76%). Only 11 cases have been trochanteric fractures in the age group 25-64 years (3.9%).

Table II. Trochanteric fractures operated by DHS technique, 2008-2011

Age Group	M	F	Total	
25-34 years	1	1	2	
35-44 years	-	-	-	
45-54 years	4	1	5	
55-64 years	2	2	4	
65-74 years	6	21	27	118 cases (91,5%)
75-84 years	15	45	60	
85 years and more	3	28	31	
Total	31 (24%)	98 (76%)	129	

From this table also results that, in recent years, DHS fixation prevails, but this technique carries some mechanical intraoperative incidents. Complication rate, however, is much smaller than in Ender method, which is why a number of authors recommend waiving Ender method, although interesting and useful improvements have been made. In addition, the costs are much lower in Ender technique, and the results can be very good and good, if it is performed a distal solid block of elastic nails.

Overall, Ender method has yielded good results and very good in 119 cases (79%) and DHS method in 118 cases (91.5%).

Complication rate is significantly higher after Ender technique and possible complications, given the exposure of this method, are illustrated in full in radiological presentation of cases from the investigated cases.

It should be noted however that, in this series, it was never used the the distal lock.

Chapter 2. CLINICAL AND STATISTICAL PERSONAL STUDY ON DHS OSTEOSYNTHESIS

In a period of 7 years (2008-2014), we studied a series of 338 patients with pertrochanteric fractures treated by DHS technique. Is a wide series in which very rigorous preoperative planning helped us to adopt this modern technology with strict compliance during surgery, which yielded very good results, the vast majority of cases.

Table III presents the studied cases with complete data, the identity, sex and age of patients, the number of the plate screws fixing the femoral shaft.

In this series, we focused on mechanical and biomechanical aspects of osteosynthesis with DHS in fractures of trochanteric massive, always having attention to technical errors, incidents and complications of this surgical technique.

From Table IV, it appears a relatively high number of patients in the 90-100 years age group, with a mean of 91.5 years (22 cases) and a frequency of 4.5 times higher in women. Note, however, that the oldest patient was a man of 100 years.

Table IV. 90-100 years age group

Number of observation in the table	M	F	Age	Number of observation in the table	M	F	Age
Obs.31		F	91 years	Obs.226		F	93 years
Obs.34		F	90 years	Obs.230		F	91 years
Obs.41		F	92 years	Obs.256		F	90 years
Obs.56		F	90 years	Obs.264		F	90 years
Obs.60		F	93 years	Obs.286	M		94 years
Obs.86		F	93 years	Obs.290		F	92 years
Obs.90	M		92 years	Obs.291	M		90 years
Obs.124		F	91 years	Obs.297		F	90 years
Obs.139		F	90 years	Obs.299		F	90 years
Obs.198		F	91 years	Obs.322		F	90 years
Obs.211		F	90 years	Obs.327	M		100 years
Total Nr.of cases = 22 (4M/18F)							
Average age of the lot = 91.5 years							

Note: 4.5 times more common in women

Of course preoperative preparation and "planning" involves careful attention and rigor.

From Table V results apparent frequency 2.8 times more of these fractures in women (73.8%), particularly high frequency in 65-100 years age group (92.8%), with special mention for 90-100 years group (average age above 92 years), resulting in very high average age of 77.9 years for the entire series.

Table V. Distribution by age and sex of cases operated by DHS method in the 2008-2014 period (7 years)

Age group	M	F	Total
27-34 years	2	1	3
35-44 years	0	0	0
45-54 years	7	2	9
55-64 years	11	6	17
65-74 years	15	41	56
75-84 years	38	124	162
85-89 years	11	58	69
90-100 years	4	18	22
Total	88 (26,2%)	250 (73,8%)	338

Table VI contains the assignment of cases on other grounds: the affected part, age maximum, minimum and average, skin condition, fracture stability - basic criterion in assessing the gravity of trochanteric fractures and adopting the most appropriate treatment behaviors. Therefore, we referred this criterion throughout all our analysis.

Chapter 3. THE EXPERIMENTAL STUDY

In osteosynthesis with DHS system (Dynamic Hip Screw) in trochanteric fractures, complications may occur, mechanical in nature, if surgical technique is not rigorously followed.

Therefore it is important to know the states of stress and strain, occurring in metallic elements of DHS system and in femur cortical.

The experimental study was done by numerical simulation of osteosynthesis with DHS system (Dynamic Hip Screw) in simple pertrochanteric fracture, considering two DHS systems namely, two diaphyseal plates having different angle to cylinder, fixed with 3 cortical screws on diaphysis, subject to loads due to unipodal position (standing on one leg).

It was used the finite element method with the following steps:

– obtaining of geometrical configuration;
– element model generation;
– define and implement the boundary conditions;
– solving the finite element model;
– postprocessing results.

Followed the generation of geometrical modells:

– the geometry of the coxal bone;
– the geometry of the femur;
– geometric model of the coxal bone;
– geometric model of the femur;
– geometric model of diaphyseal plates;
– geometric model of the compression screw;

– geometric model of the compaction screw;
– geometric model of cortical screws.

It was then studied the finite element model in three cases.

Boundary conditions and solving finite element models:

– Conditions for support / fixing;
– Loads of stress.

Results in 3 cases.

Conclusions

1. Trochanteric fractures is an extensive chapter of trauma, and the options for a particular type of treatment, have well-defined indications and contraindications.
2. Surgical treatment methods have diversified significantly in recent years, so, increased surgery in trochanteric fractures is justified by the high quality of results, in most cases.
3. Of course, often, inadequate material supplies and high costs limit the use of most modern techniques. In this regard, comparative studies between different methods are of special importance to the specialist, who should harmonize quality results with size of the material costs.
4. The first benefit of surgical treatment in pertrochanteric fractures is early mobilization and hence considerable decline in mortality in elderly patients.
5. In a first clinical study I wanted to do a statistical and therapeutic comparison study between two surgical techniques, the Ender method and dynamic hip screw method (DHS).
6. Ender Method remains a valuable technique on vital and functional level and economically advantageous, especially in stable fractures. We believe that elastic rods are an acceptable solution even and in unstable fractures in elderly with some complications, requiring a simple intervention, and less bleeding.
7. In a series of 140 patients with pertrochanteric fractures, where I used Ender nails, we achieved very good results and good in 79% of cases, although this approach has limited indications.
8. The rate of incidents and complications in Ender method is relatively higher, but economic and social benefits should be considered, not uncommon in sight.
9. Osteosynthesis with DHS is now widely used worldwide, although the high cost limits often access to this method.
10. Biomechanically, DHS method has the advantage of allowing the fracture impaction and proximal fragment sliding whith the screw bolt after diaphyseal plate guide. Being a dynamic fixation allows early loading, whereas the risk of degradation is very low and provides anatomical healing of the highest quality.

11. In our series of 129 cases with pertrochanteric fractures (operated by the DHS method), good results and good percentage amounted to 90.1%.
12. Both methods of fixation have quite precise indications, in well-chosen cases, considering the state of the patient, type of fracture, possible associated diseases, surgical team's experience and material supplies.
13. Early mobilization, rather low rate of complications and mortality appreciable declined in the elderly, is the first and greatest benefit of surgical treatment in pertrochanteric fractures.
14. Rigid internal fixation and early mobilization allows physiotherapy and immediate loading.
15. Although the costs are relatively high, osteosynthesis with DHS has many advantages, so it is used widely throughout the world. It is a dynamic system of osteosynthesis, which gives the assembly a great rigidity and stability, with very little risk of degradation.
16. Although the complication rate is lower compared to other implants, DHS osteosynthesis may involve some major mechanical complications.
17. Main mechanical complications are: compression screw penetration in the joint, diaphyseal detachment of the plate, compression screw detachement from sleeve, rupture of compression screw under the threaded part, excessive external sliding of compression screw, plate rupture under the sleeve tube, expulsion of compaction screw.
18. Each mechanical complication has precise technically causes that have to be known perfectly, to avoid their production.
19. Also knowledge of technical causes solves impeccable these mechanical complications, based on an accurate and comprehensive planning.
20. In a personal series of 129 cases with pertrochanteric fractures operated by DSH, we recorded 8.6% mechanical complications, all being resumed, with very good results and good.
21. The final conclusion is that strict compliance with the initial preoperative planning, is the main guarantee of mechanical complication rate decrease and that if they appear, a new planning can ensure resumption of fixation with great results.

    From the experimental study were the following conclusions:
22. The use of a small-size for the generation of three-dimensional mathematical models and use of orthotropic characteristics to define the material of the bone made possible to determine, with accuracy, the local stress (the holes, the areas of contact between components, etc.).
23. The 3 mathematical models generated for this study can be completed with several anatomical elements (ligaments, cartilage, the material failure criteria, etc.) and can be used for future research of the hip joint, normal and with fractured femur, such as the continued application of the load to failure / breakage of components;

24. Following loadings through the coxal bone and muscle of the buttock, for all cases of study, we determined the components of the forces that have strained the femur in the femoral head area (hip joint center): Fx = 37.524 N; FY = -481.8 -1,174.1 N = N and FZ, obtaining resultant force Fr = 1276.54 N, acting on the femoral head which is 2.55 times the weight (in the present study G = 500N). With these components were determined and the resultant angles: in the XY plane angle is 16.35 ° and the YZ plane was calculated an angle of 23.5 °, thus verifying his Pauwels theory. Therefore, it is important that the load is not applied directly to the femoral head, but through the entire bony configuration of the hip joint;
25. The results obtained for case 1 indicate that the tension on the cortical of the femur, is evenly distributed on the major part of the shaft. In the case of using the DHS system, diaphysial plate causes the tension developed in the cortical area of the plate to be smaller, stressing more the diaphyseal area located at the third screw down;
26. In both cases the study,on the simulated DHS system , there is a high tension on the external cortex of the femur, in the hole of the third cortical screw, the worst being the case 2. Thus, the study shows the possibility looseness or rupture of screw 3.
27. Values of tensions that develop the DHS system elements in case 3 are lower than those calculated for case 2.
28. Use of DHS in case 2 stiffens the upper end of the femur, more than using DHS system in case 3.
29. The state of stress and strain at the cancellous bone, is auspicious for osteosynthesis (tensions under value of 5-8 MPa).
30. In case 3, the DHS system makes the two bone segments, to achieve a contact in the transversal cortical (in the plane of the fracture) resulting in a local area (the base of the femoral neck) with a high tension (121 MPa). Over time, this contact area (which takes the initial load) can break, the entire load being taken over by the DHS system components, and, through diaphyseal plate, force arrives and gives additional cortical screws stress (and the corresponding regions of the femur) with the risk of breaking the screw (shearing) or taking out the femoral cortical screw.
31. In case 2, the stress distribution occurring on the diaphyseal plate and holes cortical area shows an approximately symmetrical system load, ie femur plan bending coincides with the bending of the plate. Instead, in the case 3, it appears that tension is asymmetrically distributed on the diaphyseal plate, creating the possibility of moving of the plate in relation to femur diaphysis.