

FIXATION OF SUPRACONDYLAR FEMORAL FRACTURES: A BIOMECHANICAL ANALYSIS COMPARING 95° BLADE PLATES AND DYNAMIC CONDYLAR SCREWS (DCS)

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ABSTRACT

Objective: To determine, by means of comparative biomechanical tests, whether greater compressive load resistance and flexion is presented by 95° angled blade plates or by dynamic condylar screws (DCS), and to correlate the failure type presented during the tests with each type of plate. *Methods:* Sixty-five porcine femurs were subjected to 1 cm medial wedge osteotomy, in the metaphysis, to simulate an unstable supracondylar femoral fracture. Osteosynthesis was performed on these pieces: 35 were fixed using 95° lateral blade plates and 30 with DCS plates. Another variable studied was

the failure type presented in each group, in an attempt to correlate this with the type of plate. Results: There were no statistically significant differences in biomechanical resistance between the two types of plates, or between the failure type and the plate type used for the osteosynthesis. *Conclusion:* The two types of plate behaved in a similar fashion. However, the angled blade plate proved to be superior to the DCS in the flexion test. No statistical difference in failure type or type of plate used was observed.

Keywords - Femoral fractures; Fracture fixation, internal; Biomechanics

INTRODUCTION

Fractures of the supracondylar region of the femur are complex lesions that are usually difficult to treat. They correspond to approximately 7% of all fracture of the femur and to 31% of them, if fractures of the proximal femur are excluded⁽¹⁾. The most frequent cause among the elderly population is falls from standing height with the knee flexed, while among young patients, it is high-energy trauma (traffic accidents and falls from a height), which generally lead to varus, valgus or rotational forces with axial loading. Ligament injuries may be associated with around 20% of these cases⁽¹⁾, along with fractures of the acetabulum, the femoral neck or diaphysis and the tibial plateau.

One peculiar characteristic of such fractures is the deformation caused by the different muscle groups that act on the knee (quadriceps, ischiotibial, gastrocnemius

and adductor muscles). This leads to deviation of the fragments, particularly in situations of hyperextension due to the action of the gastrocnemius, with the need for open reduction and internal fixation.

Controversy still exists concerning which method is best for supracondylar fractures of the femur. Several implantation methods are used for fixation of this type of fracture, but without any consensus regarding the method that would be most stable biomechanically. In addition to retrograde intramedullary fixation, plates with blades angled at 95° and dynamic condylar screws (DCS) have been highlighted.

Blade plates provide excellent fixation and are considered to be the method presenting greatest resistance to angulation and torsion forces, despite the greater technical difficulty⁽²⁻³⁾. On the other hand, because DCS are thicker than blade plates, they theoretically cause

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greater bone destruction⁽²⁾. Studies comparing DCS with retrograde and anterograde intramedullary rods have shown conflicting results⁽⁴⁻⁷⁾.

The aim of this study was to compare the biomechanical rigidity of internal fixation performed using 95° blade plates and DCS, in a simulation of unstable extra-articular supracondylar fractures in porcine femurs, and to correlate the types of plate with the type of failure, i.e. whether this was in the bone (fracture) or in the material used (loosening on breakage of the implant). These implants were chosen because they were the types most commonly used for treating the type of fracture that we study in our setting.

METHODS

Sixty-five femurs from pigs of the Landraz breed, of mean age 90 days, were selected for the experiment. The bones were stored at a temperature of -18°C and then were placed at room temperature 12 hours before the fixation procedure.

Sixty-five plates were used for fixation of the femurs. All of them had five orifices: 35 with a blade angled at 95°, of 55 millimeters (mm) in length, and 30 with DCS of 55 mm in length. The fixation at the most distal hole in both plates was performed using a spongy bone screw and three cortical bone screws were used in the proximal holes, while the hole corresponding to the region of the osteotomy was left without fixation. The osteotomy was performed around 4 cm from the joint surface. For osteosynthesis, the principles and techniques of the AO/ASIF group were used⁽⁸⁾, using plates and screws produced by the company I.O.L. Implantes Ltda.

After fixation of the femurs, wedge osteotomy was performed, with medial subtraction of 1 cm of material in the distal metaphysis region of the femur, using an oscillatory nitrogen saw, with the aim of creating an unstable supracondylar fracture (without medial support) (Figure 1).

The bones were again stored at a temperature of approximately -18°C after fixation. Twenty hours before starting the experiment, they were transferred to a refrigerator at a temperature of around 4°C, and then, one hour before the tests, they were left at room temperature.

To carry out the biomechanical test, the installations of the mechanical test laboratory of the Nuclear Technology Development Center of the National Nuclear

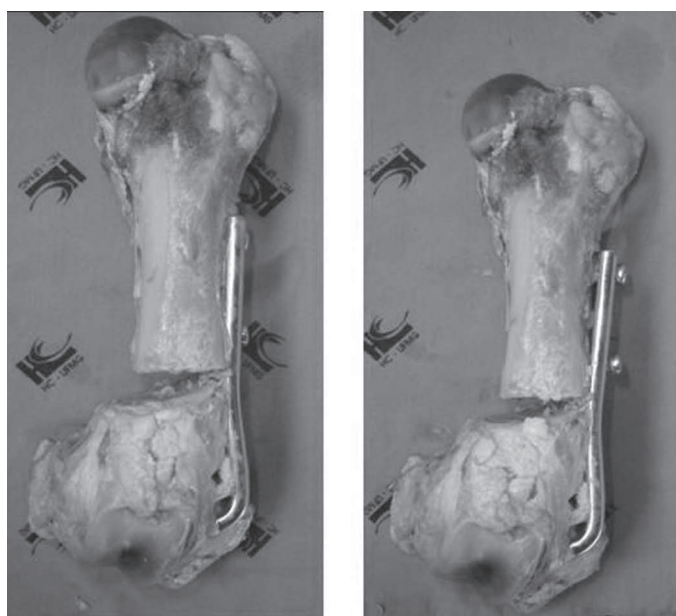


Figure 1 – Fixed specimen subjected to wedge osteotomy with medial subtraction, before and after the flexion test

Energy Commission (CDTN/CNEN) were used. The specimens were subjected to axial compression loads and flexion loads in the *Instron TTDML*[®] universal test machine (Canton, MA, USA), with a maximum capacity of 10 tons (Figure 2).

Metal supports were constructed to ensure a perfect fit for the specimens in the test machine while applying the loads, with the aim of avoiding any type of movement that could falsify the point of mechanical failure. In the compression test, no contact between the supports and the synthesis material was allowed, in order to avoid inappropriate transmission of the loads that were applied to the combined plate and bone. In the flexion test, it was sought to apply the load to the middle third of the diaphysis, on the cortex diametrically opposite the synthesis material (Figure 3).

The specimens were randomized into four groups according to the type of fixation and the type of test used. Thus, 20 specimens with fixation using blade plates and 15 using DCS were subjected to flexion loads, while 15 with fixation using blade plates and 15 using DCS were subjected to axial compression loads.

After correctly positioning the specimens, they were subjected to loads that were progressively increased at a rate of one centimeter per minute (cm/min). The loads, which were measured in kilogram-force (kgf), were plotted on analogue graphs as far as the point of mechanical failure. This was defined as a change in the



Figure 2 – Instron TTDML® universal test machine (Canton, MA, USA). Mechanical test laboratory of the Nuclear Technology Development Center of the National Nuclear Energy Commission (CDTN/CNEN)

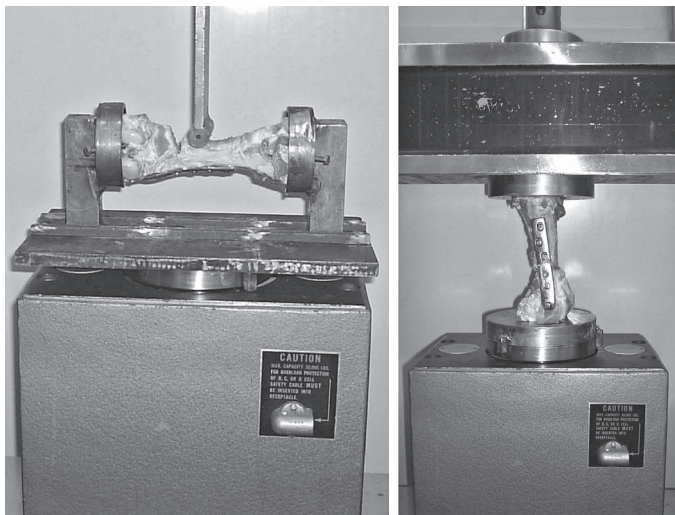


Figure 3 – Flexion test (left) and compression test (right)

shape of the graph of force versus mechanical failure. The failures observed during the tests occurred either in the bone (fracture) or in the proximal screws of the plates (loosening), and were duly noted and statistically analyzed.

Statistical methodology

All the variables were subjected to descriptive analysis.

Student's t test for independent samples was used to compare the mean forces to which the plates were subjected. The Anderson-Darling test was used to investigate whether the data presented normal distribution and the Levene test was used to investigate the supposition of equality of variance. Pearson's chi-square test was used to compare the proportions of bone failure and screw failure for each type of plate. The significance level was taken to be 5%.

RESULTS

The mean flexion force for the DCS plate was 89 kgf (SD = 22), with a minimum of 40 kgf and a maximum of 125 kgf. For the blade plate, the mean for this force was 109 kgf (SD = 41), with a minimum of 55 kgf and a maximum of 185 kgf (Table 1).

Table 1 – Distribution of the flexion and compression forces according to type of plate

	N	Mean (kgf)	Standard deviation	Min. (kgf)	Median (kgf)	Max. (kgf)
Flexion						
DCS	15	89	22	40	95	125
Blade	20	109	41	55	103	185
Compression						
DCS	15	301	220	75	250	700
Blade	15	276	97	165	250	505

The boxplots (Figure 4) present the distributions of the flexion and compression forces according to the type of plate. The distribution of the flexion force was much more homogenous in specimens with DCS than

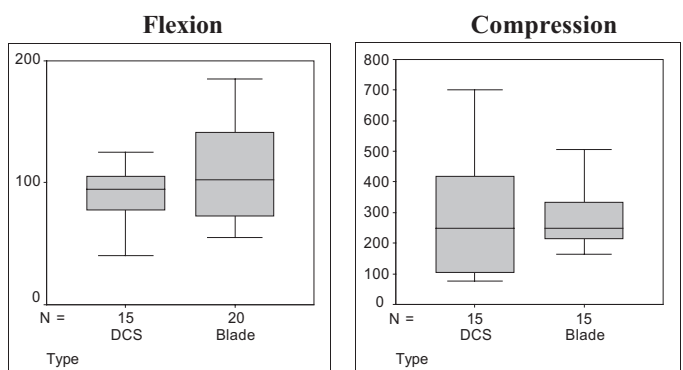


Figure 4 – Boxplots for flexion and compression forces as a function of the plates

in those with blade plates (smaller box, thereby indicating data of greater homogeneity in the sample). On the other hand, for the compression force, it was seen that the blade plates presented distribution of greater homogeneity than did the DCS.

The variables of flexion and compression forces as a function of type of plate did not violate the supposition of normality, according to the Anderson-Darling test. The supposition of equality of variances was not assumed, according to the Levene test.

Table 2 presents the test to compare the means of the flexion and compression forces as a function of the type of plate. No statistically significant difference in the mean flexion force ($t = -1.904$; $p = 0.066$) and mean compression force ($t = 0.398$; $p = 0.694$) according to type of plate was detected, i.e. the two plates were the same with regard to the flexion and compression forces.

Table 2 – Student’s t test (independent samples) for comparing means

	Student’s t test for equality of means*	
	T	p value
Flexion	-1.904	0.066
Compression	0.398	0.694

*Equality of variance not assumed

To investigate whether the proportions of types of failure were different according to type of plate, Pearson’s chi-square test was performed. In the tests using flexion force, it was observed that the assemblages with DCS failed visually more often in the bone, at the location of the osteotomy, while the assemblages with blade plates failed more often in the metadiaphysis region, at the location of screw fixation. This difference was not statistically significant ($\chi^2 = 2.37$; $p = 0.123$), and it was concluded that the two plates behaved similarly with regard to types of failure (Table 3).

In the tests using compression force, it could be seen that the assemblages with DCS failed more often in the metadiaphysis region at the location of screw fixation, while the assemblages with blade plates failed more often in the bone, in the region of the osteotomy. This difference was not statistically significant ($\chi^2 = 0.52$; $p = 0.472$) (Table 3).

Table 3 – Pearson’s chi-square test for comparing proportions of failures according to the type of failure (bone or screw) in the flexion strength test

Flexion	DCS	Blade	Total	DCS	Blade		
BONE	10	8	18	67%	40%	χ^2	2.37
SCREW	5	12	17	33%	60%	p value	0.123
Total	15	20	35			OR	3.00 (0.61; 15.61)
Compression	DCS	Blade	Total	DCS	Blade		
BONE	7	9	16	47%	60%	χ^2	0.52
SCREW	8	6	14	53%	40%	p value	0.472
Total	15	15	30			OR	0.58 (0.11; 3.13)

DISCUSSION

Although the evolution of the treatment of supracondylar fractures of the femur follows the principles of rigid internal fixation, thereby enabling early rehabilitation⁽⁹⁾, there is no consensus regarding the ideal fixation material⁽¹⁰⁻¹²⁾.

In 1995, Firoozbakhsh *et al*⁽⁶⁾ published a study comparing intramedullary rods with plates angled at 95°. They used synthetic femurs in which a medial defect had been produced (osteotomy), which were fixed using an intramedullary rod or a 95° degree blade plate. The results showed that the plate presented greater rigidity in relation to forces in the valgus direction, torsion and lateral flexion. On the other hand, the difference in compressive forces relating to the varus direction and medial flexion was not statistically significant.

In 1996, Koval *et al*⁽⁷⁾ published a study that was similar to that of Firoozbakhsh *et al*⁽⁶⁾. They concluded that the 95° plates presented greater rigidity than did the intramedullary rods, both in transverse fractures and in osteotomy of the distal femur with a medial defect.

In a study in 1997, David *et al*⁽⁵⁾ compared intramedullary rods and DCS in several patterns of fracture of the distal femur. For this, they used femurs from human cadavers with different patterns of osteotomy. Through this, they produced different fractures that, based on the AO/ASIF group classification⁽⁸⁾, ranged progressively in degree of severity from type 33^a to type 33C. The results showed that there was no difference between intramedullary rods and DCS according to the type of fracture and, consequently, they concluded that the choice of osteosynthesis material should not be based

on the fracture pattern. They also recommended from this study that, if DCS were chosen, it should have 12 holes in a configuration with greater dispersion of the screws because this would have greater rigidity. On the other hand, if intramedullary rods were chosen, a configuration with closer grouping of the locking screws would be chosen.

One of the disadvantages of using DCS is the loss of bone material while preparing the hole for the dynamic screw⁽²⁾. This finding was not confirmed by the present study, since no difference was observed between the two types of implant with regard to the type of failure, i.e. whether there was bone or implant failure ($p = 0.123$ in the flexion test and $p = 0.472$ in the compression test).

In a biomechanical test on DCS and 95° blade plates, Jaakkola *et al*⁽¹³⁾ concluded that DCS presented greater rigidity in axial compression and a greater mean for the maximum load than observed with blade plates, which is in line with the results from the present study, although without statistical significance ($p = 0.694$). On the other hand, the results from the flexion test were similar, although in our study the blade plates presented a greater mean load than seen with DCS, albeit without statistical significance ($p = 0.066$). This trend might be proved statistically by increasing the sample size.

Harder *et al*⁽¹⁴⁾ did not observe any difference in a biomechanical comparison between blade plates and DCS, with regard to treating unstable supracondylar fractures of the femur. However, these authors suggested that DCS should be used as the implant method

of choice because of its technical ease, particularly if the distal fragment were at least 4 cm in size and in situations with less experienced surgeons. This result resembles the findings from the present study regarding the biomechanical equivalence of the plates, although no implant method that could be considered to be the one of choice was seen in the present study, despite the greater technical difficulty observed in introducing blade plates.

CONCLUSION

There was no statistically significant difference in relation to load resistance under flexion and compression, or in relation to the type of failure, i.e. whether it occurred in the bone (fracture) or in the material (loosening or breakage of the implant) between blade plates and DCS. However, there was an indication ($p = 0.066$) that blade plates might present greater rigidity in flexion than seen with DCS. We might be able to confirm this tendency if we were to increase the sample size of the blade plate group in the flexion test. In this study, we tested the rigidity of the plate-bone combination (measured in kgf) and not the fatigue of the osteosynthesis material. It needs to be emphasized that studies comparing these types of plate are scarce. Nonetheless, our findings are compatible with studies in the existing literature, in terms of equivalence between DCS and blade plates for treating extra-articular supracondylar fractures of the femur in experimental models.

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