STUDY OF TRACTION FORCE USING ECCENTRIC SCREW IN LARGE DYNAMIC COMPRESSION PLATE (DCP-L)

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ABSTRACT

Objective: To comparatively evaluate traction force (F) determined with the use of the eccentric screw in large compression dynamic plates (DCP-L). Methods: Three DCP-L plates were used, from four national manufacturers, all in austenitic stainless steel ASTM F 138, and instruments available in boxes of 4.5mm. The plates were attached to two specimens of synthetic polyethylene, and traction force was applied using a 4.5mm screw inserted into the eccentric hole, using instruments specific to each manufacturer. The results were obtained by a servo-hydraulic machine BME 2000 160/AT, Brasválvula. The implants were divided into groups. (Fab I, II, III, IV). The tests were stopped after reaching a pinch force of the load screw of 5 N. Results: Group I had a mean peak force (F Max) of 80.58 N; Group II: F Max 81.63 N; Group III: F Max 36.32N; and Group IV: F Max 37.52N. Using Krukal-Wallis Analysis of Variance (ANOVA non-parametric), where p = 0.05, there was a significant difference in maximum strength between the groups (p = 0.039). Conclusion: Plates DCP-L of group II showed greater strength (N) with plate fixation using the eccentric screw. Level of Evidence: Level III, analytical study.

Keywords: Fracture fixation, internal/methods. Bone plates. Bone screws. Biomechanics.

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INTRODUCTION

The main goal of internal fracture fixation is to achieve full limb function and fast patient rehabilitation as early as possible. For this purpose it is necessary to perform fracture stabilization using either an absolute or relative stability technique.[1]

In the treatment of fractures professionals aim to reduce mobility at the fracture focus, which may be compromised under functional load, and the only technique that will effectively abolish movement at the fracture focus is interfragmentary compression, which will create conditions for absolute stability.[2]

Perren *et al*., in 1967, in pursuit of rigid osteosyntheses and absolute stability, developed a new self-compressing plate: the Dynamic Compression Plate (DCP®).[3,4] This name stems from its ability to provide axial compression without the need for a tensor device, by exercising compression at the fracture focus through eccentric screw insertion.[5]

The hole of the DCP-L plate features a slope at one of the ends. When the spherical head of the screw is compressed against this surface, the plate comes away and compresses the fracture line. This occurs due to the use of the eccentric drill guide.[5] The interdigitation of fracture fragments and the compression reduce interfragmentary movement to almost zero and allow the direct bone remodeling of the fracture (primary bone consolidation).[6]

Because of the relevance of the use of the absolute stability principle, traction force analyses were conducted using the eccentric screw in 4.5mm DCP-L plates from different Brazilian manufacturers, aiming to comparatively analyze their results.

MATERIAL AND METHODS

Three DCP-L (Large Dynamic Compression Plates) were used, from four national manufacturers with significant commercial penetration in the Brazilian market, totaling 12 plates for study. They all had ten holes and were not pre-tensioned. According to each manufacturer, they were separated into groups designated Man. I, II, III and IV. All the models were made from ASTM F 138 austenitic stainless steel, as can be seen in Figure 1.

All the authors declare that there is no potential conflict of interest referring to this article.

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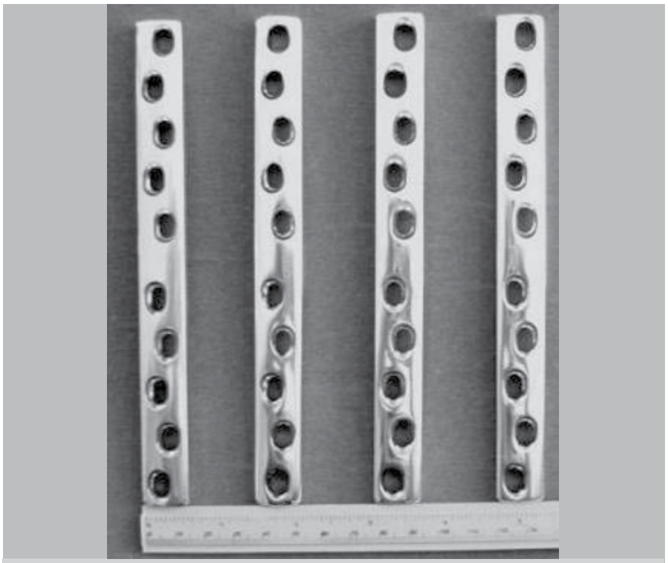

Figure 1. *Models of DCP-L plates used in the study. From left to right: Model– Man.I, Model - Man.II, Model - Man.III, Model – Man. IV.*

Polyethylene test samples in a diameter of 30mm were used to simulate bone diaphysis, separated from one another. The plates were attached, on each sample, using a 4.5mm cortical screw. The system was attached in a BME 2000 160/AT servo-hydraulic testing machine from the company Brasválvula and the test values were captured through a force transducer (F) in Newton (N), located at the top of the system. (Figures 2 and 3)

One of the segments remained fixed at the base of the testing machine and the other fixed to the force transducer. (Figure 3) The plate was attached with only one screw on each test sample, always using the third hole of the plate. The attachment holes of the test sample were drilled with these already mounted on the machine, and with the help of a guide and a drill bit, both from the manufacturer of the tested plate. The upper cylinder fixed to the transducer received a centered hole, while the cylinder fixed to the base was drilled eccentrically. After having fixed the centric screw up to the point of total stabilization of the plate on the test sample, the second screw was inserted in the eccentric hole, which was made with the help of temporary fixation using vice clamp pliers (Figure 4), applying tightening torque of 5 N. The Force X Time curve was captured during the tightening of the eccentric screw.

The test samples were kept a certain distance apart, to allow the sliding of the screw on the plate slope from start to finish without them colliding, thus optimizing the force produced by full use of the slope.

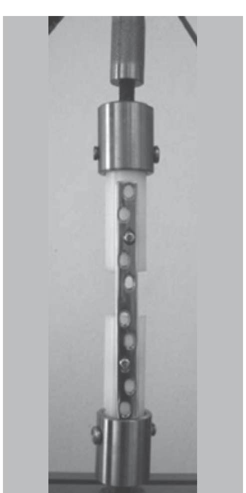

Figure 2. *Complete assembly of the system in the testing machine.*

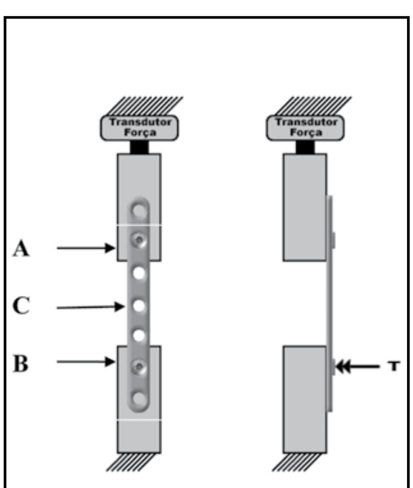

Figure 3. *Diagram representing the test system. A – centric hole, B – eccentric hole, C –DCP-L plate, T – torque 5 N.*

Figure 4. *Assembly for execution of eccentric hole, with guide and drill bit, both from the same manufacturer as the tested plate.*

RESULT

Group I presented mean peak force (Max. F) of 80.58 N, Group II: Max. F 81.63 N, Group III: Max. F 36.32N, Group IV: Max. F 37.52N, as represented in Tables 1, 2, 3 and 4. The curves obtained in the test are presented in Figures 5, 6, 7 and 8.

Conducting a statistical analysis according to Krukal-Wallis ANOVA,[7] there is significant difference in the peak force among the plants ($p = 0.039$). Based on the multiple comparison test, where $p=0.05$, it was identified that Plants I and II presented significantly higher Peak Force than Plants III and IV, as illustrated by Tables 5 and 6, with no significant difference between Plants I and II or between Plants III and IV.

Table 1. *Results of Man-I; Mean Peak F. = 80.58; SD 16.70.*

MANUFACTURER I	PEAK FORCE (N)
UNIT I	70.20
UNIT II	71.70
UNIT III	99.84

Table 2. *Results of Man-II; Mean Peak F. = 81.63; SD 25.20.*

MANUFACTURER II	PEAK FORCE (N)
UNIT I	86.97
UNIT II	54.19
UNIT III	103.73

Table 3. *Results of Man-III; Mean Peak F. = 36.32; SD 6.40.*

MANUFACTURER III	PEAK FORCE (N)
UNIT I	35.48
UNIT II	43.11
UNIT III	30.39

Table 4. *Results of Man-IV; Mean Peak F. = 37.52; SD 4.44.*

MANUFACTURER IV	PEAK FORCE (N)
UNIT I	39.22
UNIT II	32.48
UNIT III	40.87

Table 5. *Peak Force (N) of each sample according to the plant.*

Sample	Plant I	Plant II	Plant III	Plant IV
1	70.20	86.97	35.48	39.22
2	71.70	54.19	43.11	32.48
3	99.84	103.73	30.39	40.87

Table 6. *Statistical analysis of Peak Force (N) according to the plant.*

Plant	Mean	SD	Median	Minimum	Maximum	p value [a]	significant differences [b]
I	80.6	16.7	71.7	70.2	99.8	0.039	
II	81.6	25.2	87.0	54.2	103.7		I ≠ III and IV
III	36.3	6.4	35.5	30.4	43.1		II ≠ III and IV
IV	37.5	4.4	39.2	32.5	40.9		

SD: Standard Deviation;
a - Kruskal-Wallis non-parametric ANOVA.
b – multiple comparisons based on the statistics of Kruskal-Wallis, at the level of 5%

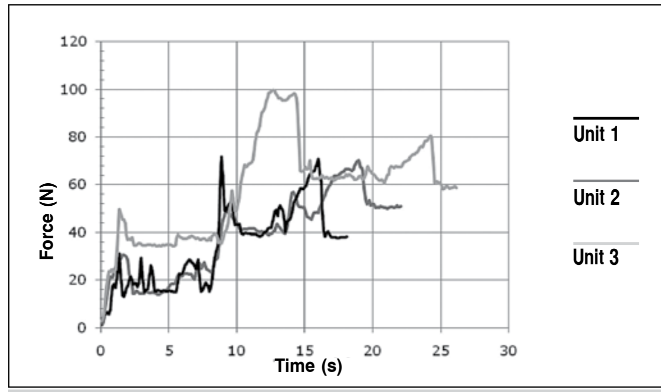

Figure 5. *Representation force x time curve MAN. I.*

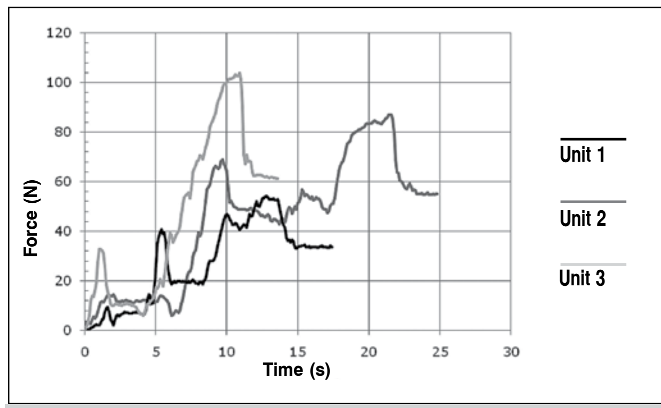

Figure 6. *Representation force x time curve MAN. II.*

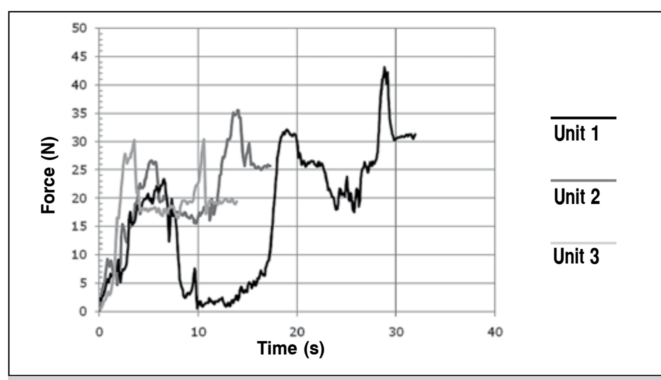

Figure 7. *Representation force x time curve MAN. III.*

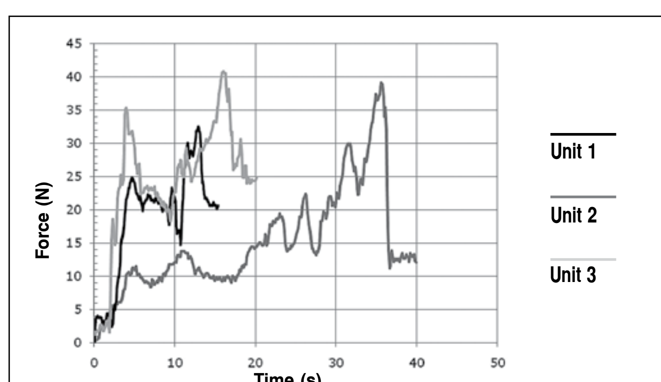

Figure 8. *Representation force x time curve MAN. IV.*

Force (N)- – Unit

DISCUSSION

Fixation with conventional compression plate using absolute stability techniques has had room for the surgical treatment of fractures since the pioneer work of Danis and the AO group in the middle of the 20th century.[8]

Fracture fixation with absolute stability decreases tension at the fracture focus to the extent of allowing direct consolidation, without visible bone callus. However, this technique further compromises bone vascularization, when compared to other fixation methods. Consequently, the surgeon's expertise in performing it can be of vital importance in the good evolution of treatment.[5]

Through scientific studies it was verified that compression at the fracture focus determines bone necrosis, yet there is no specification in absolute values when this phenomenon compromises the treatment.[9]

Under the principle of fracture fixation with the use of DCP plates, designed by the AO Foundation, each eccentric screw causes displacement of 1mm in the fragment fixed to it, thus determining a compression value,[6] which will decrease over five to nine weeks.[5,10,11]

During macroscopic analysis of the implants and instruments used in this study, we did not observe alterations in the morphology (size, thickness, hole diameter and slope gradient) of the plates, but the eccentric guides appeared with many differences in this aspect. Thus the holes were drilled (depending on the manufacturer) in varying degrees of eccentricity, a fact that is directly related to the traction force obtained in the results, demonstrating the lack of standardization in the production of orthopedic implants and instruments by Brazilian manufacturers,[12] which may compromise the good evolution of treatment.

CONCLUSION

The MAN.II group determined greater traction force with the use of the eccentric screw.

In our literature there is a shortage of clinical studies for determination of ideal compression force in the absolute stability technique with use of DCP plate.

The absence of standardization among Brazilian manufacturers in the production of instruments used in 4.5mm boxes, determines a difference in compression values at the fracture focus.

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