DOI: 10.20396/revpibic.

Biomechanical substrate models for testing osteosynthesis screw

Amanda F. Araujo*, Andrés Humberto Cáceres Barreno, Luciana Asprino

Abstract

Experimental analyzes on bio-models can investigate biomechanical parameters, mainly, when models are able to simulate the facial skeleton. The aim of this study was to compare and correlate the density by micro-computerized tomography and drilling resistance of three differents bio-models or substrates (polyurethane foam block, femur bovine and swine ribs) when insert osteosynthesis screw. The substrate blocks density were analyzed using X-ray microtomography (microCT) and the final insertion torque was analyzed using a surgical motor. Results: Group 1 (femur bovine) obtained the highest values of density and Group 3 (Polyurethane foam 40 pcf) that showed the lowest value of density. Regarding the final Torque insertion values, Group 1 (femur bovine) and Group 3 (Polyurethane foam 40 pcf) showed higher results than Group 2 (swine ribs), with a statistical difference. Conclusion: The polyurethane blocks with a density of 40 PCF showed final insertion torque similar to the bovine femur blocks, demonstrating that they are bone substitutes suitable for screw insertion tests.

Key words:

Surgical fixation devices, Bone density, X-ray microtomography.

Introduction

Surgical fixation devices (SFD) have been used in Oral and Maxillofacial surgery over the years. SFD were developed based on biomechanical studies. One important factor is choosing the correct substrate material, analyze their properties and responds to the specific biomechanical tests. However, even with several types of substrates is difficult to reproduce the same biomechanical behavior.

The aim of this study was to compare and correlate the substrates density and final insertion torque using three different substrates when installing osteosynthesis screw.

Results and Discussion

The study groups were divided according their type: femur bovine (Group 1), swine ribs (Group 2) and Polyurethane foam (40 pcf) (Group 3). They were cutted in blocks with the same dimensions (2,5 cm x 1,5 cm x 1,5 cm). Plastic dispositive were glued on specific regions in order to analyze the bone density using microCT. After that, each block was drilled in the spot previously set by the plastic dispositive using Contra-angle reductor velocity (20:1) (IchiroPro®) which was linked to the universal testing machine Instron 4411 (Instron Corp, Norwood, MA). The fixation system used was 1.5 mm. Self-tapping screws 1,5 x 12 mm were installed by one operator with the Contra-angle and the final insertion torque values were registered. The statistical analysis included ANOVA with $P < 0,05$.

The density results from the Micro CT analyzes showed that had statistically differences between the 3 groups. Group 1 (femur bovine) obtained the highest values of density, these values were statistically significant when compared to Group 2 (swine ribs) and Group 3 (Polyurethane foam 40 pcf) that showed the lowest value of density. (Table 1).

Regarding the final Torque insertion values, Group 1 (femur bovine) and Group 3 (Polyurethane foam 40 pcf) showed higher results than Group 2 (swine ribs), with a statistical difference. (Table 1).

Table 1. Averages of density and Final Torque Insertion (FTI) for the tested groups.

	Density		FTI	
	Average	SD	Average	SD
G1	0,479a	0,135	15,76a	3,72
G2	-0,106b	0,117	9,21b	2,37
G3	-0,523c	0,021	14,09a	1,73

Different letters indicate significant statistically differences between the groups according to the test ANOVA-one way with post-hoc of Tukey ($p<0,05$).

The performance of biomechanical tests of fixation materials in different test specimens contributes to the improvement of the macrogeometry characteristics of the material, as well as to understand its behavior in a specific clinical situation. Depending on the nature of the fastening materials, these may be classified as synthetic, animal or human. Each presents its advantages and disadvantages, and the comparison between them is necessary to know which one is most similar to the clinical part.

This research demonstrated different substrates may have similar mechanical behavior depending on the type of test being applied, being this behavior due to inherent characteristics of each test body. However, for greater comparability in specimens that resemble the clinical situation, further studies on the behavior of substrates commonly used in biomechanical studies in Maxillofacial Surgery are necessary.

Conclusions

The polyurethane blocks with a density of 40 PCF showed final insertion torque similar to the bovine femur blocks, demonstrating that they are bone substitutes suitable for screw insertion tests, such as for dental implants, for example, or for biomechanical comparisons of bone fixation methods.

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