MECHANICAL PROPERTIES OF TITANIUM ALLOY MESHES USED IN INTERBODY FUSION CAGE

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Introduction

Interbody fusion cages fill the interbody space while ensuring a stable connection at the implant-bone interface. Cages made of titanium alloy (Ti6Al4V) are commonly used in spine surgery due to their mechanical strength and much better osseointegration than PEEK cages [2,3]. Early bone fusion is favoured by adjusting the stiffness and eliminating the stress shielding effect, mainly by introducing to the cage surface porosity or scaffolding in the shape of mesh structures.

In the technology of producing implants, 3D printing is prevalent, allowing the suspension of the contact surface between the material and the bone by adjusting the design and filling density. In this way, it is possible to produce implants with a relatively small filling, characterized by favourable mechanical properties favouring cell adhesion and osseointegration of the implant-bone tissue [1,4].

The research aimed to determine the mechanical parameters based on the indentation test of titanium alloy meshes used in interbody fusion cage.

Materials and Methods

The research was carried out on meshes obtained by 3D printing, the structure of which was based on the connection of two six-armed pyramids described by the dimensions: width of the shoulder spacing (W), the height of the arms connection between pyramids (h), the height of the elements corresponding to the distance between the two vertices of the pyramids (H) - TABLE 1.

Meshes were made of titanium alloy Ti6Al4V (ELI) powder with a particle diameter of ± 50 µm. The printing was carried out on an EOS M280 printer with a laser beam diameter of 90 µm and a power of 200W. To improve the mechanical properties, printed titanium meshes were treated at 800°C (1470°F) for 4 hours in argon inert atmosphere.

The indentation test (spherical indenter with a diameter of 5 mm) was carried out at a speed of 2 mm/min to damage the mesh using the MTS 858 Mini Bionix testing machine. Then, performed a microscopic analysis of the damage resulting from the indentation test using a light microscope.

TABLE 1. Geometric dimensions of the tested meshes.

Samples	Geometric dimensions		
	W	h	H
	[mm]		
S3	0,20	1,8	1,8
S4	0,24	1,8	1,8
S5	0,20	2,0	1,8
S6	0,24	2,0	1,8
S7	0,20	1,8	1,6
S8	0,24	1,8	1,6
S9	0,20	2,0	1,6
S10	0,24	2,0	1,6

Results and Discussion

The mechanical parameters for each group of meshes were determined based on the indentation studies, as shown in FIG. 1. The analysis of the maximum force value and the stiffness coefficient showed that higher values are found in the groups in which the height of the arms connection between pyramids (h) is 0.24 mm than in the groups in which this value was 0.20 mm.

The highest values were found in the S8 group, for which the value of the maximum force was 473±32 N and the value of the stiffness coefficient was 231±6 N/mm.

On the other hand, the lowest values were found in group S9 where for which the value of the maximum force was 276±16 N the value of the stiffness coefficient was 61±3 N.

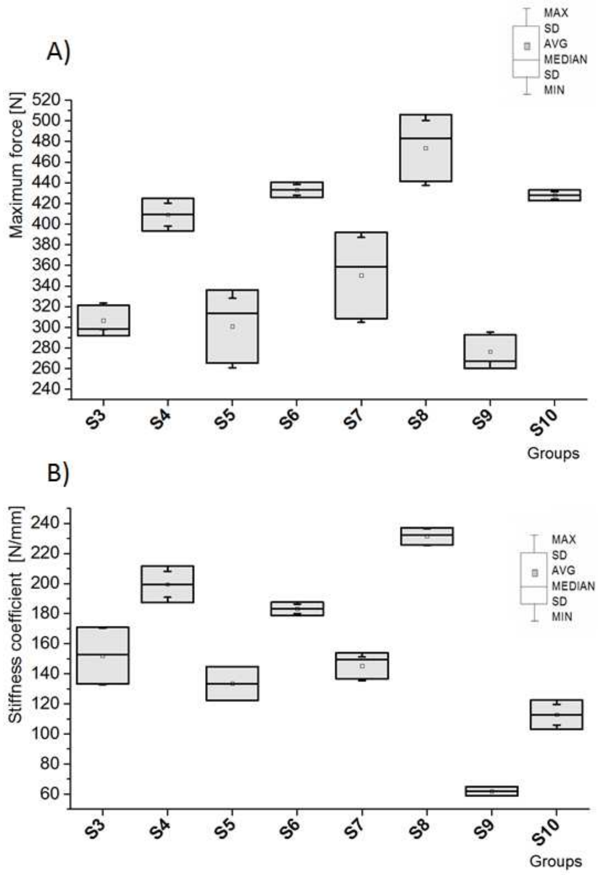

FIG. 1. The average value of a) the maximum force; b) the stiffness coefficient (k) of the tested groups of meshes.

Conclusions

The most significant impact showed the dimension of the height of the arms connection between pyramids (h). After the indentation test, the microscopic analysis of the meshes showed no discrepancies in the mechanism of damage arising from geometric differences.

References

[1] A. Arjunan, M. Demetriou et al., J Mech Behav Biomed Mater. 2020.
[2] C. Chen, Y. Hao et al., Mater. Des. Des. 175 (2019), 107824.
[3] E. Provaggi, C. Capelli et al., Mater. Design. 163 (2019), 107540.
[4] Q. Ran, W. Yang et al., J. Mech. Behav. Biomed. Mater. 84 (2018), 1–11.