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Biomaterials, Material Sciences, Implants

Superficial properties of Ti6Al4V discs obtained by the additive and subtractive manufacturing method

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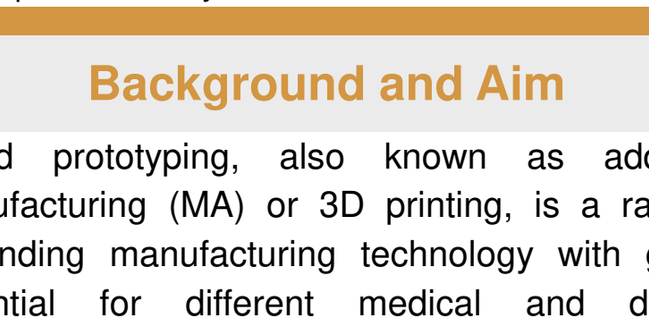
Abstract

Selective Laser Melting (SLM) is a recent additive manufacturing (MA) technique that can be employed in custom implant making. The aim of this study was to evaluate and compare the physico-chemical and mechanical properties of Ti-6Al-4V discs obtained by the additive manufacturing (SLM), and subtractive manufacturing by conventional machining. Were used 30 discs (n=10), divided into 3 groups: additive manufacture by SLM (DSLM); conventionally machined with surface treatment H_3PO_4 + NaOH (DCMST), and conventionally machined without surface treatment (DCM). In order to characterize the surfaces, Scanning Electron Microscopy (SEM), X-ray Dispersive Energy Spectroscopy (EDS), surface roughness by confocal laser microscopy and wettability by a goniometer were performed. ANOVA and Tukey's test (α=0.05) were used for the quantitative analysis. MEV images showed a rougher surface of the DSLM, with unfused spherical particles, the DCMST topography similar to a sponge or coral, characteristic of applied nanometric treatment and DCM, polished surface. EDS demonstrated the presence of the essential elements of the alloy (Ti, Al and V) in the DCM and DSLM, in the DCMST also showed the presence of Na. For the roughness parameters (Ra and Sa), DCMST (0.17 and 0.18 μm) and DCM (0.06 and 0.07 μm) were similar (p=0.974), the highest mean was observed for DSLM (9.09 and 11.03 μm) (p<0.001). For wettability, the DCMST had the less contact angle (18.55º) and the DSLM had the highest (103.23º) (p<0.001). In the present study, the MA promoting greater roughness and less hydrophilicity in DSLM discs. Thus, further studies should be performed to ensure the effectiveness of this technique in dentistry.

Background and Aim

Rapid prototyping, also known as additive manufacturing (MA) or 3D printing, is a rapidly expanding manufacturing technology with great potential for different medical and dental applications. The technique of selective laser melting (SLM) is the most recent method of MA that can be used in the manufacture of customized dental implants, being the main difference of 3D implants compared to 2D models, the surface. The objective of this study was to evaluate and compare the physico-chemical and mechanical properties of Ti-6Al-4V discs obtained by the additive manufacturing, Selective Laser Melting (SLM), and subtractive manufacturing by conventional machining.



Methods and Materials

30 discs, divided into 3 groups (n=10) were used: additive manufacture by SLM (DSLM); conventionally machined with surface treatment (DCMST), and conventionally machined without surface treatment (DCM) (Table 1).

Table 1. Characteristics of Ti-6Al-4V discs

	DSLM	DCMST	DCM
Type of manufacturing	Selective laser melting	Conventional milling	Conventional milling
Surface treatment	Without surface treatment	Surface treatment (H_3PO_4 + NaOH)	Without surface treatment
Discs dimensions	Ø 5mm x 1mm	Ø 8mm x 3mm	Ø 8mm x 3mm
Alloy	Ti-6Al-4V (particle size <63 μm)	Ti-6Al-4V	Ti-6Al-4V

The equipment used for SLM was the REALIZER GmbH SLM 50® (IFW Dresden Institute, Dresden, Germany) with continuous wave fiber laser (λ = 1070 nm, F position: 9.55 mm, spot size ≈ 60 μm) using gas-atomized Ti-6Al-4V powder with particle size <63 μm.

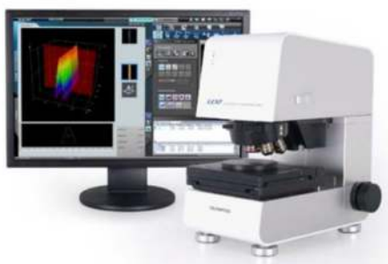
Surface Characterization

(Carl Zeiss mod. EVO 50/EDS/ IXRF Systems mod. 500 Digital Processing)

SEM/EDS

- 20 kV acceleration
- Objective aperture of 20 μm
- Distance 5 mm (SEM) and 8.5 mm (EDS)

Surface Roughness



(LEXT 4000; Olympus, Hamburgo, Alemanha)

Confocal Microscopy

- Ra/Sa parameters
- Magnification of 20×
- Resolution of 1024 × 1024 pixels

Wettability

(KSV CAM200)

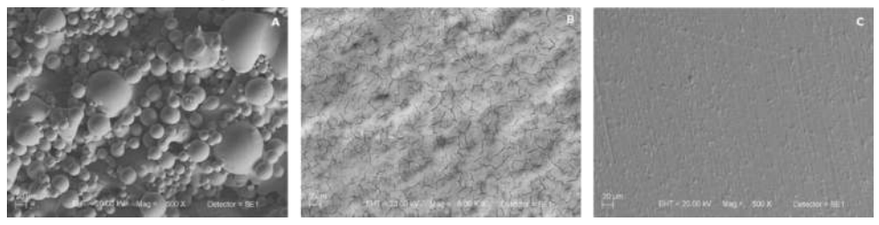
Goniometer

- Drop of 4-μL distilled water
- 60 seconds for stabilization
- Dried with a 1-min nitrogen flow

ANOVA and Tukey's test (α=0.05) were used.

Results

MEV images showed a rougher surface of the DSLM, a topography similar to a sponge or coral of the DCMST, and polished surface for DCM.

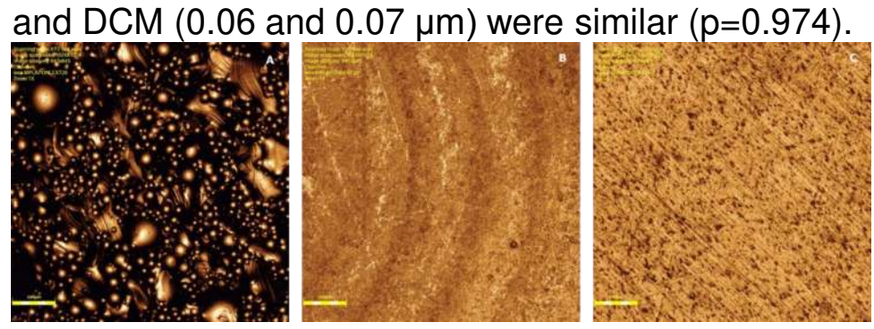


EDS demonstrated the presence of the essential elements of the alloy (Ti, Al and V) in all discs, in the DCMST also showed the presence of Na (Table 2).

Table 2. Chemical composition of Ti-6Al-4V discs

	Weight percent (wt.%)			
Samples	Ti	Al	V	Na
DSLM	88.24	8.82	2.93	-
DCMST	86.33	6.51	2.52	4.62
DCM	89.65	7.02	3.31	-

For the roughness parameters (Ra and Sa), the highest mean was observed for DSLM (9.09 and 11.03 μm) (p<0.001); DCMST (0.17 and 0.18 μm) and DCM (0.06 and 0.07 μm) were similar (p=0.974).



For wettability, DSLM had the highest (103.23º) (p<0.001) contact angle, and the DCMST had the less (18.55º).

Conclusion

Although MA presents innumerable advantages inherent in the technique, such as the possibility of product customization, waste reduction, energy consumption and duration of surgeries. In the present study, the MA promoting greater roughness and less hydrophilicity in DSLM discs. Thus, further studies should be performed to ensure the effectiveness of this technique in dentistry.

References

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FAPESP

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