UNIVERSITÀ DEGLI STUDI FIRENZE
DIEF DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

ADDITIVE 4 BIOMEDICAL

October 17th–18th, 2022

FIXTURE OSTEOINTEGRABILI REALIZZATE IN ADDITIVE MANUFACTURING IN TI6AL4V ELI: POTENZIALITÀ DELL'INTEGRAZIONE DI STRUTTURE LATTICE VORONOI

Chiara Bregoli, Jacopo Fiocchi, Carlo Albero Biffi, Ausonio Tuissi

Plesso Didattico Morgagni, Viale Morgagni, 44-48, 50134 Firenze

SC 09/A3 CoCo AM Additive Manufacturing
ASSOCIAZIONE NAZIONALE DISEGNO E METODI
COMET
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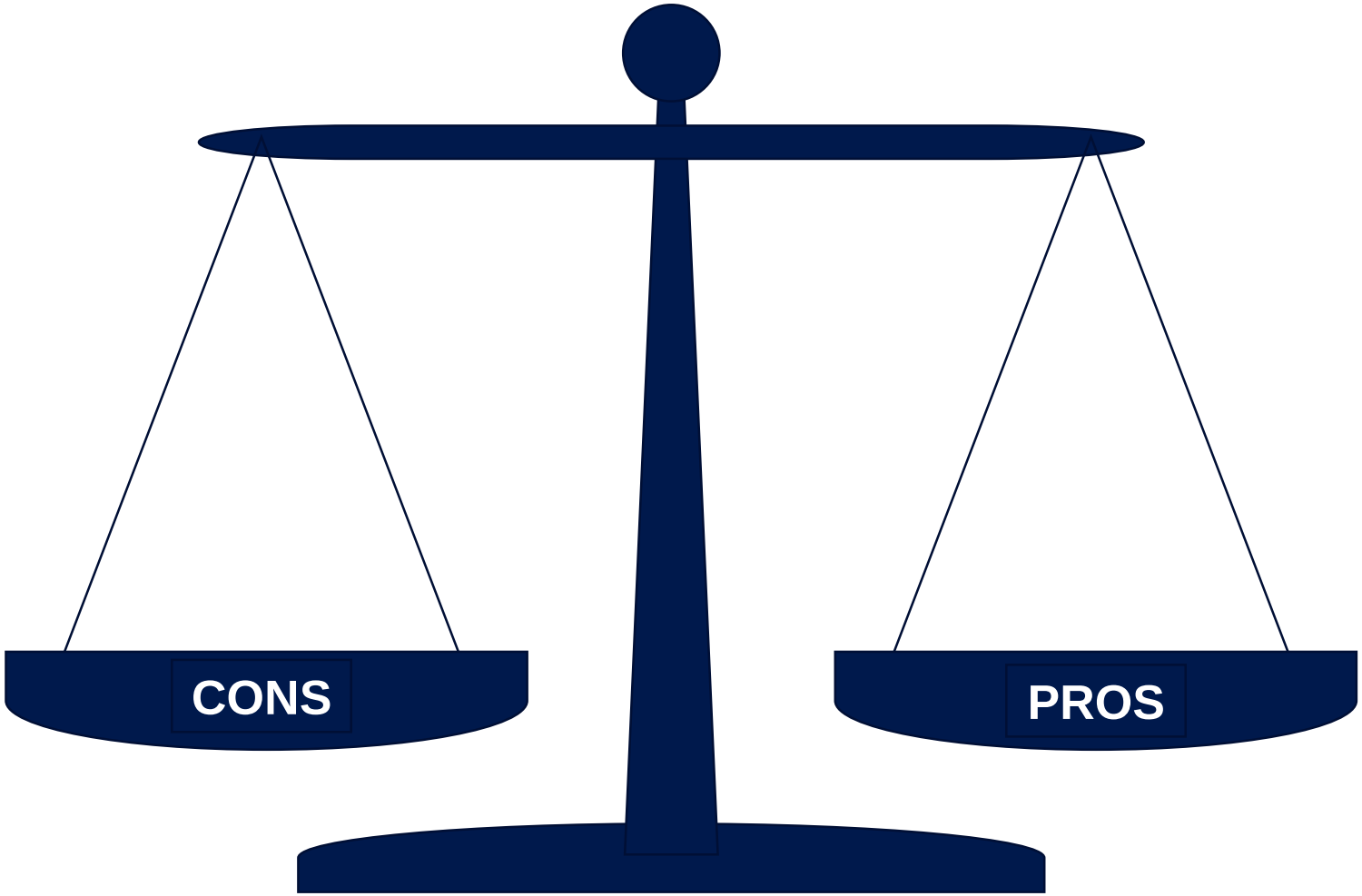
INTRODUCTION

Why use additive manufacturing in medical field?



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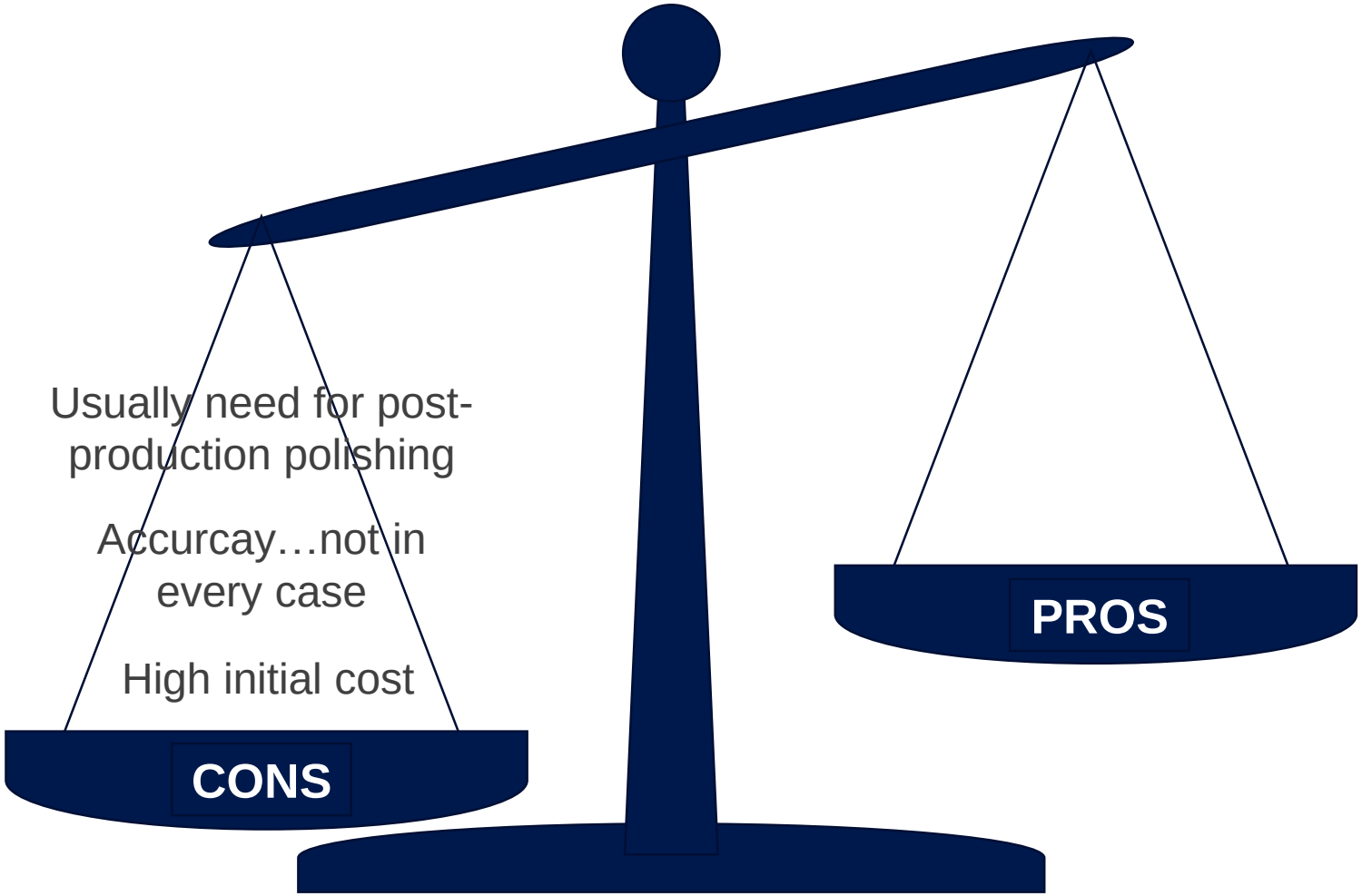

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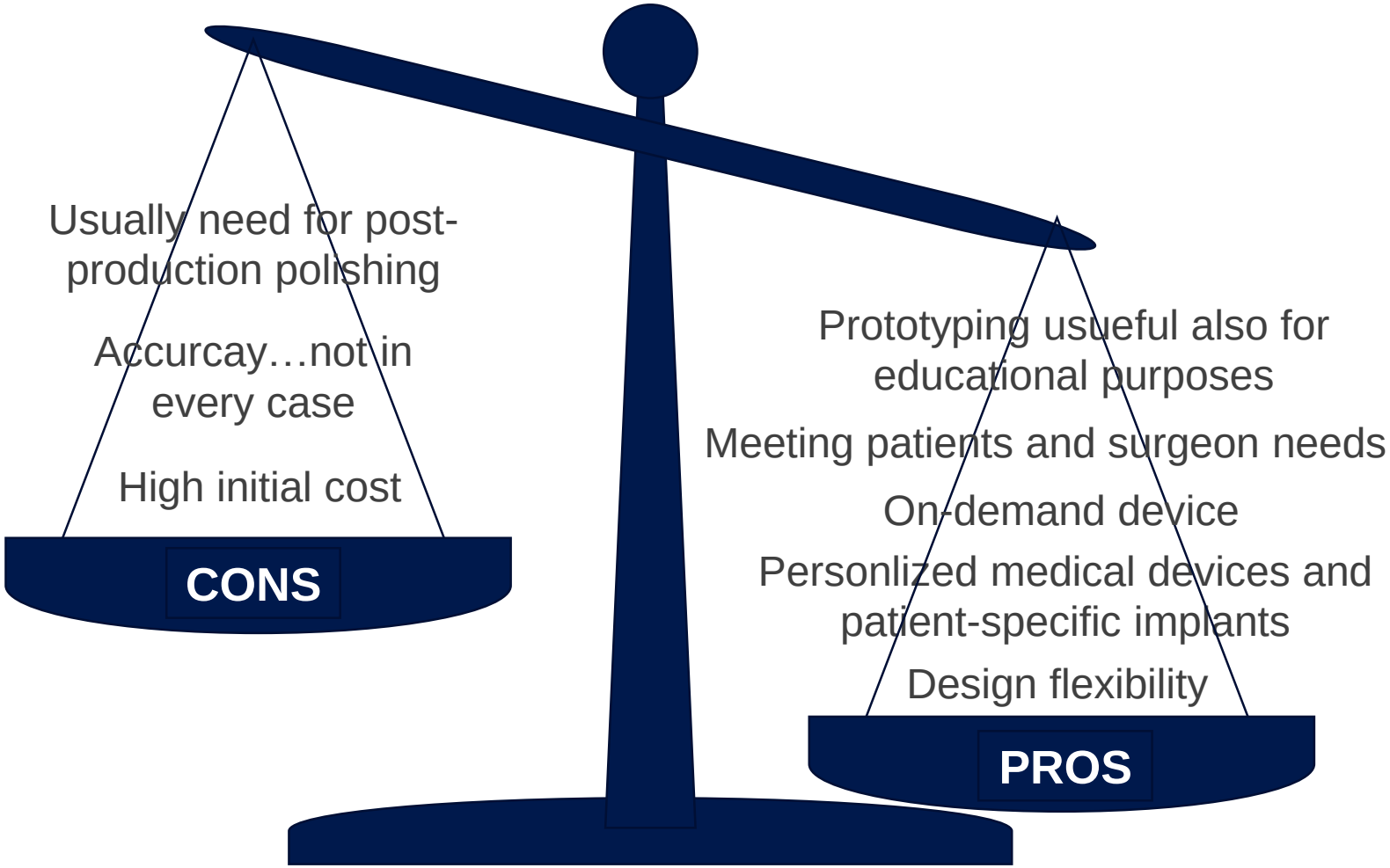
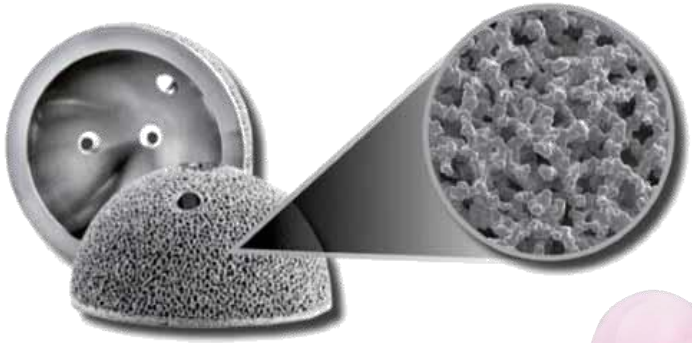


INTRODUCTION: WHICH 3D PROSTHESIS ALREADY AVAILABLE?

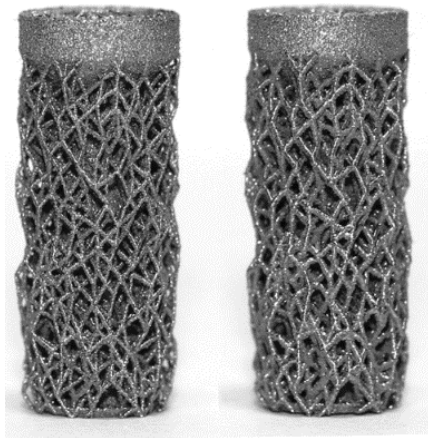
Porous surface for osseointegration

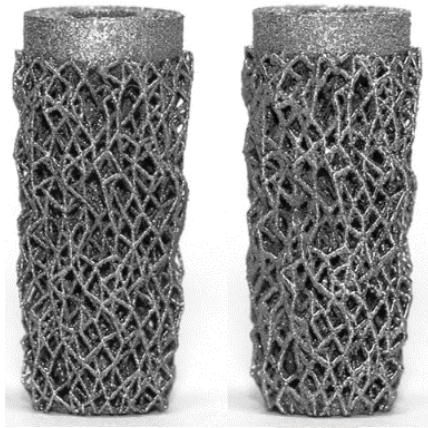


Customization

Design

Bone medical screw





INTRODUCTION: WHICH TRABECULAR STRUCTURE?

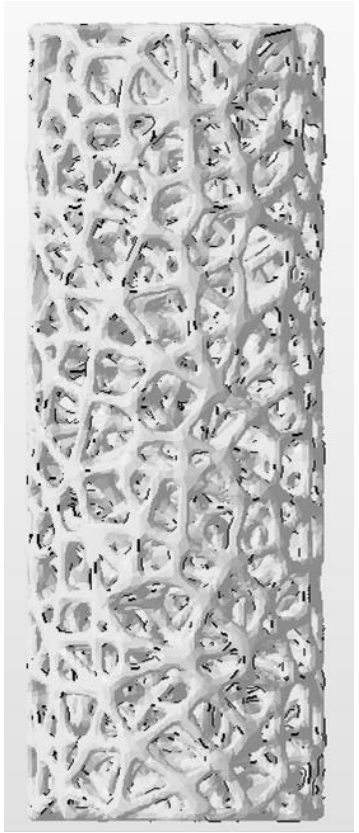
Arrangement of cancellous bone from micro CT

Trabecular structures:

- Unit Cells replicated in the 3D space
- **Stochastic 3D arrangement**

Settings:

Struts thickness
Porosity
Initial 3D volume to be fully or partially substitute by voronoi lattice structure

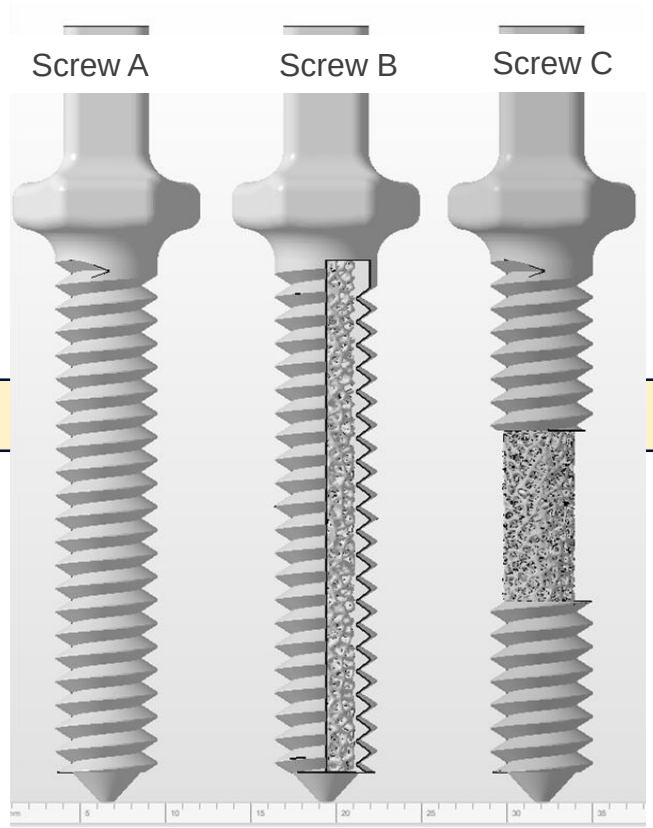


Materialise 3-matic

Voronoi Lattice Based Structure

WE AIM TO STUDY A NOVEL DESIGN OF BONE MEDICAL SCREW

Materialise 3-matic



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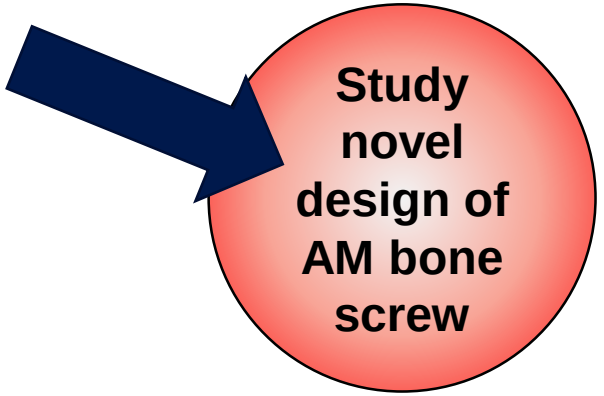
OBJECTIVES



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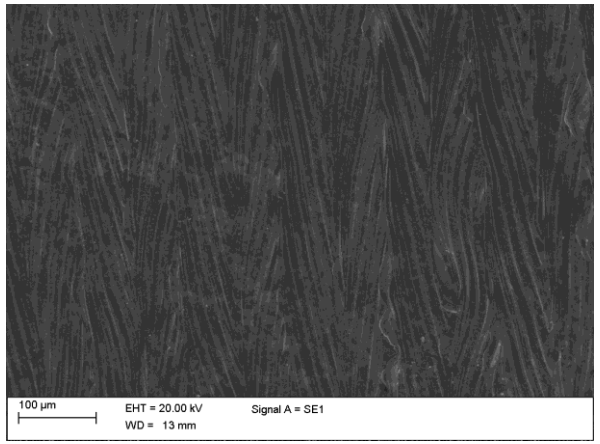

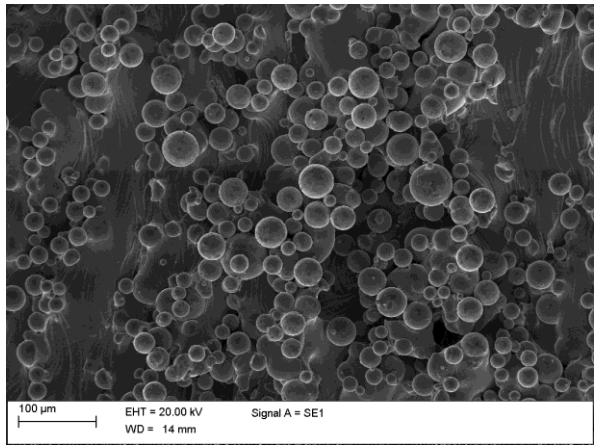

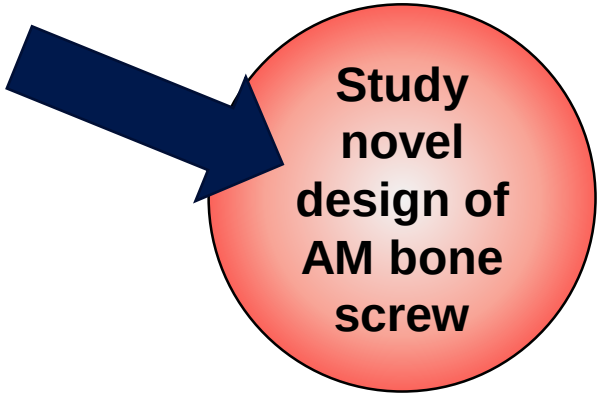

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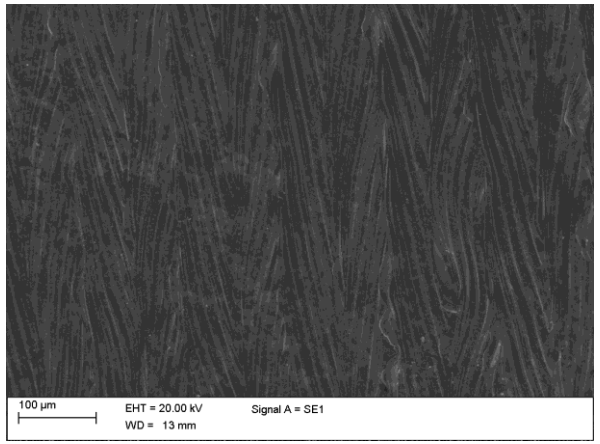
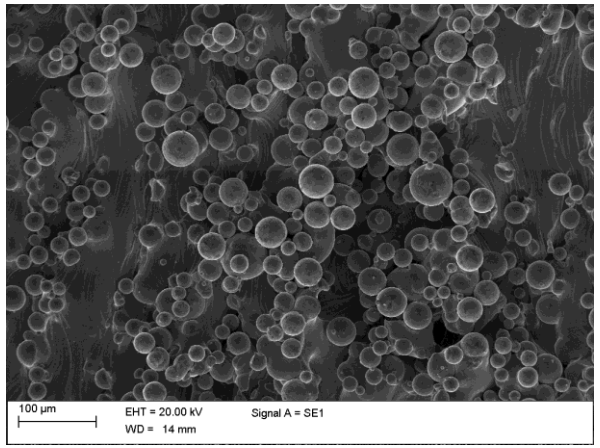


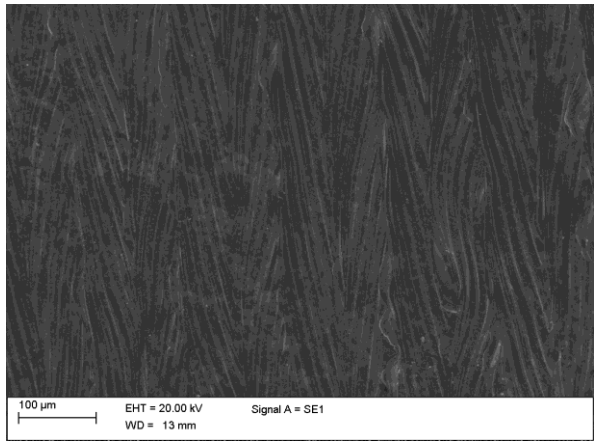


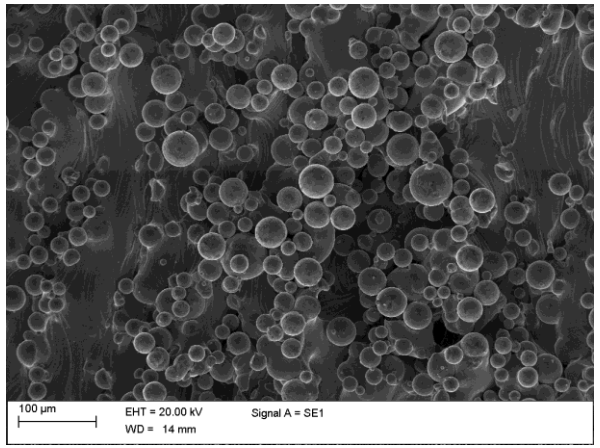
Surface morphology

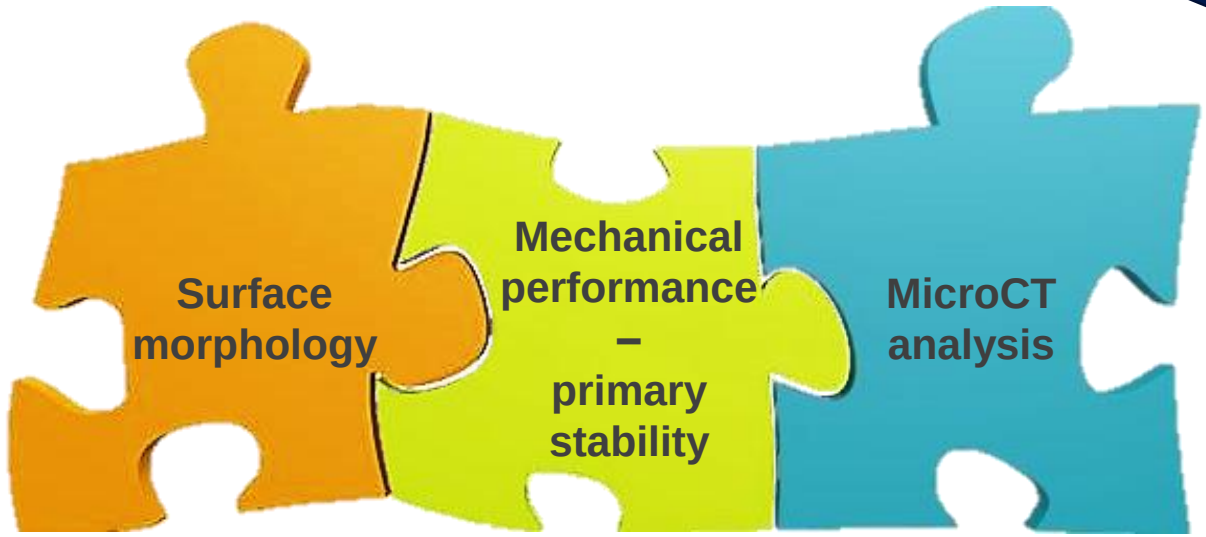
MicroCT analysis

Study novel design of AM bone screw

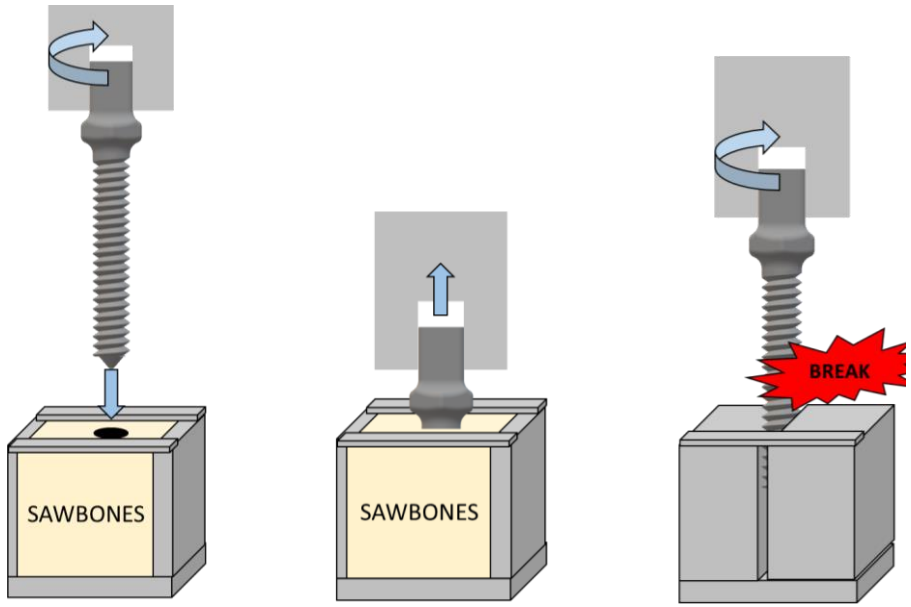
OBJECTIVES







Study novel design of AM bone screw



Insertion Test Pull out Test Torsion Test

MATERIALS AND METHODS

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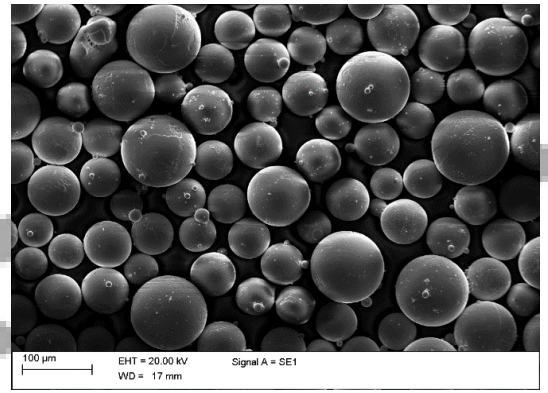
Ti6Al4V ELI powder

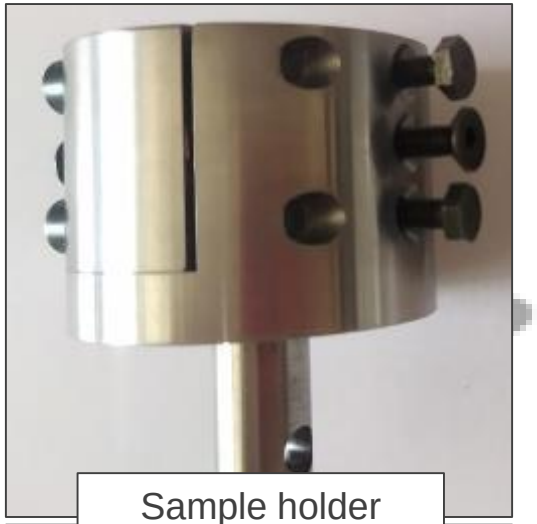


Laser Powder Bed Fusion (LPBF) technology

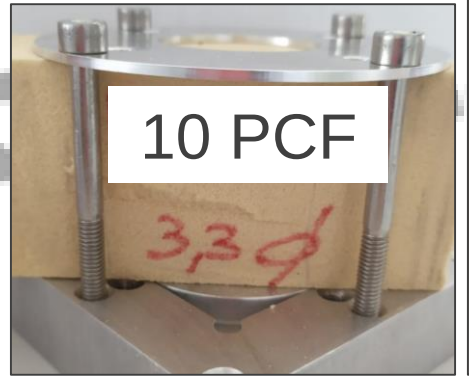
Parameters	Values
Scanning strategy	Meander
Laser spot size [µm]	65
Hatch distance [µm]	65
Point distance [µm]	75
Thickness layer [µm]	30
Power [W]	200
Exposure time [µs]	50

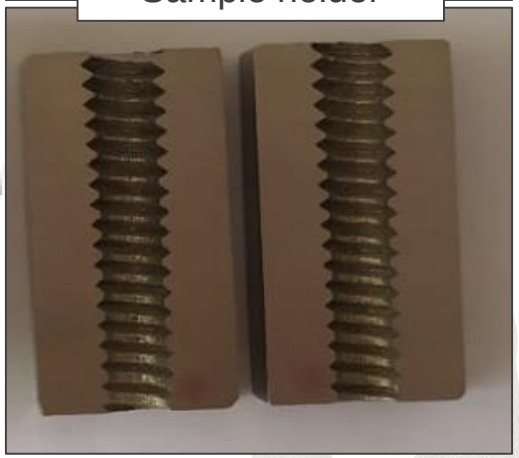
Microscope investigation and microCT analysis

Instron E3000 - Mechanical characterization

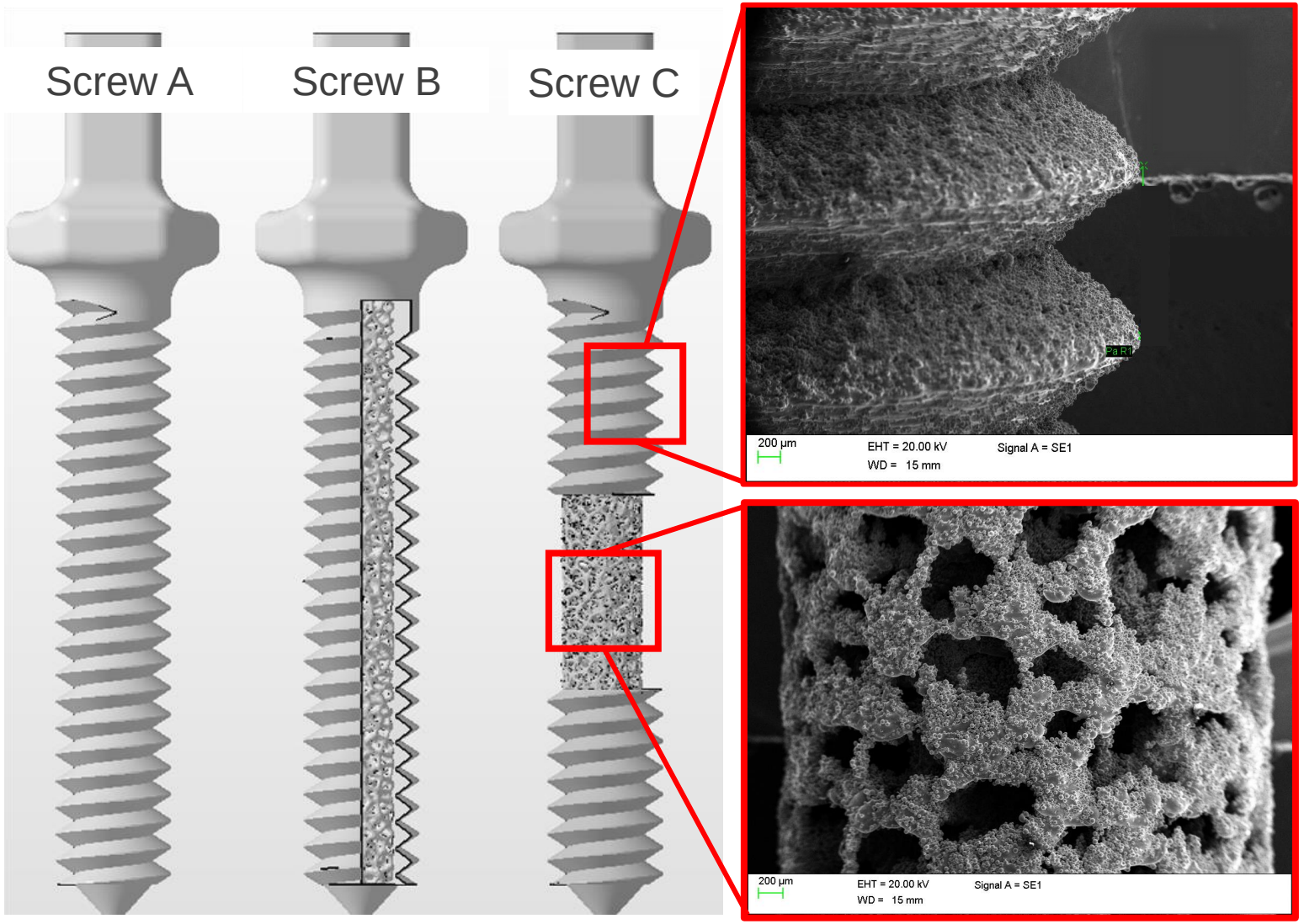


Sample holder





RESULTS: MORPHOLIGAL ANALYSIS



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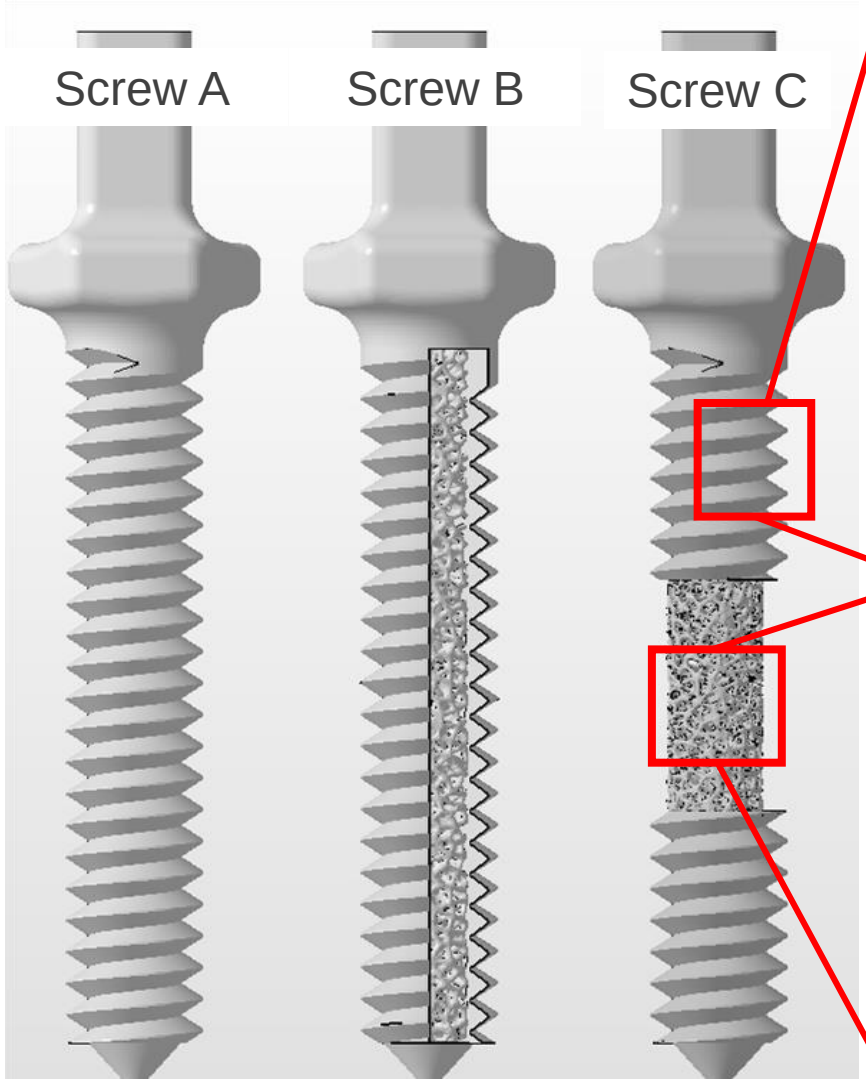
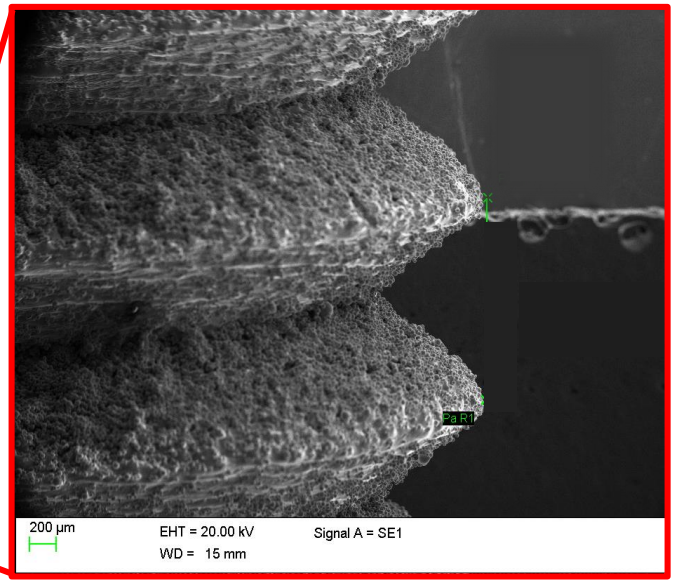
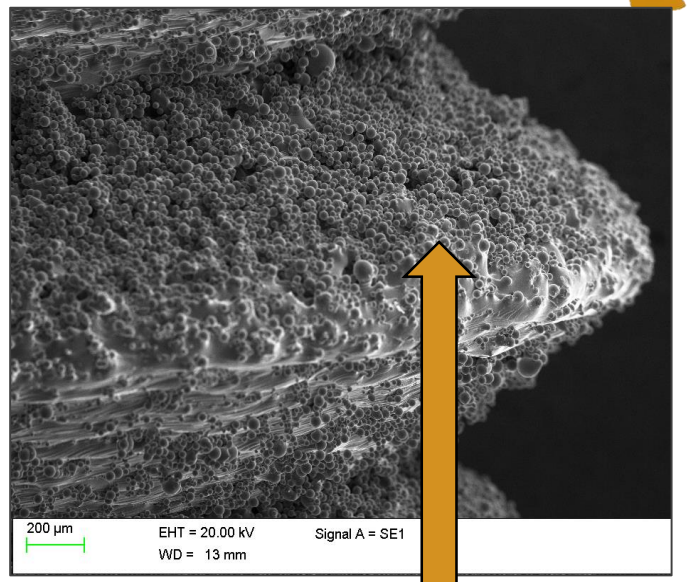
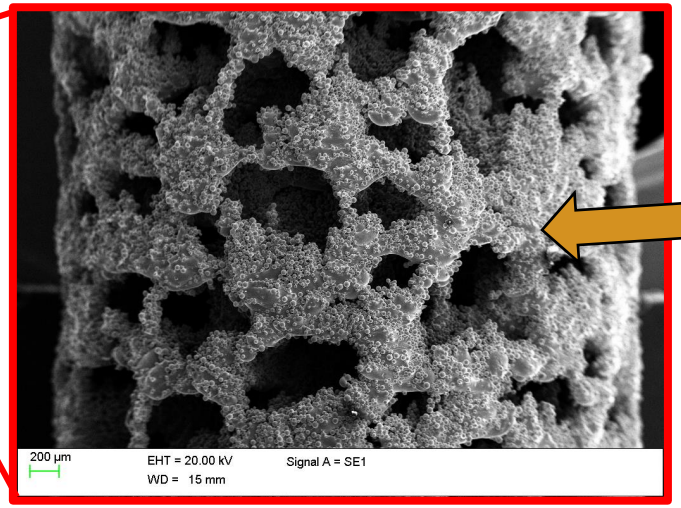






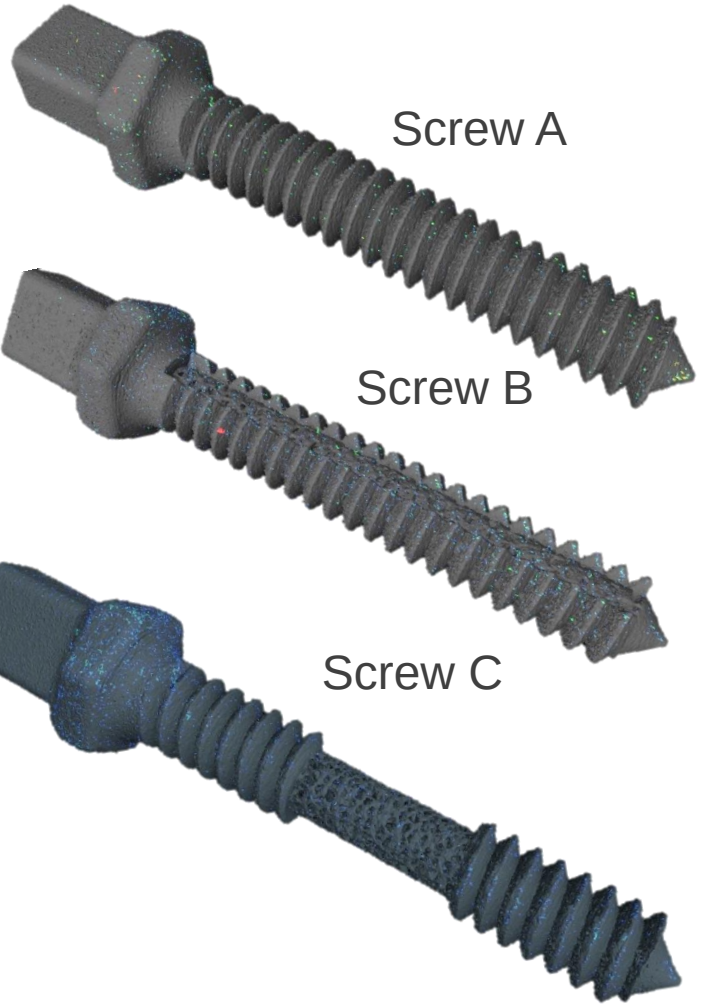


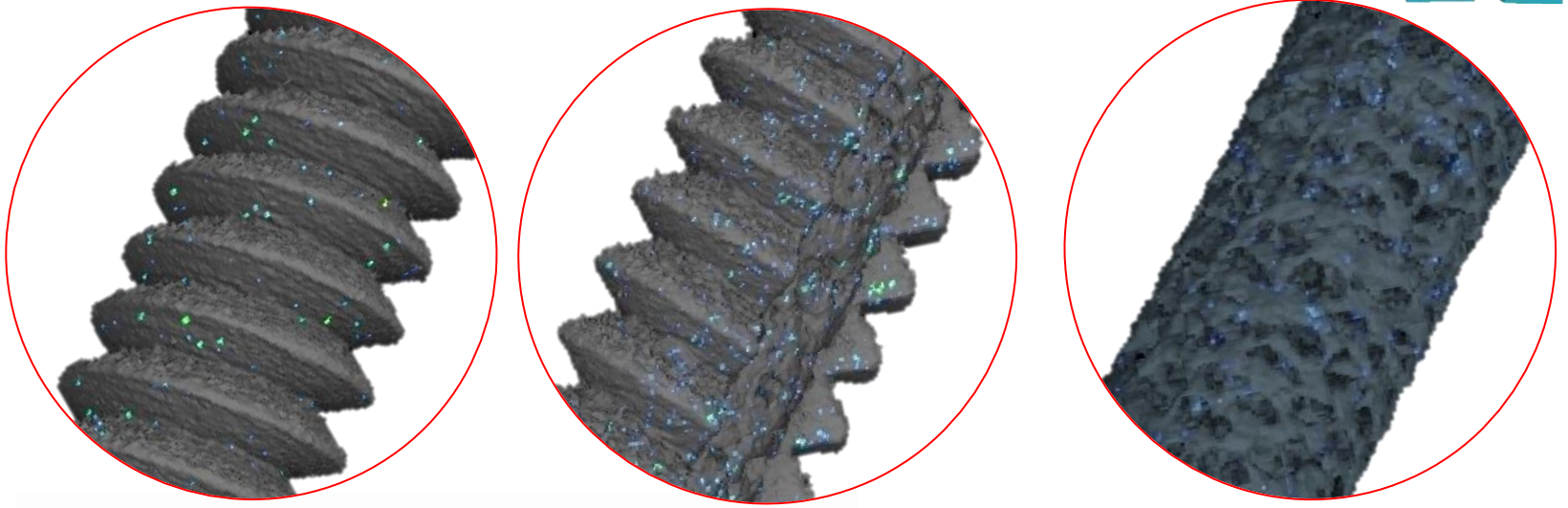
Ti64 particles partially adhered on the surface of the threads and on the structs

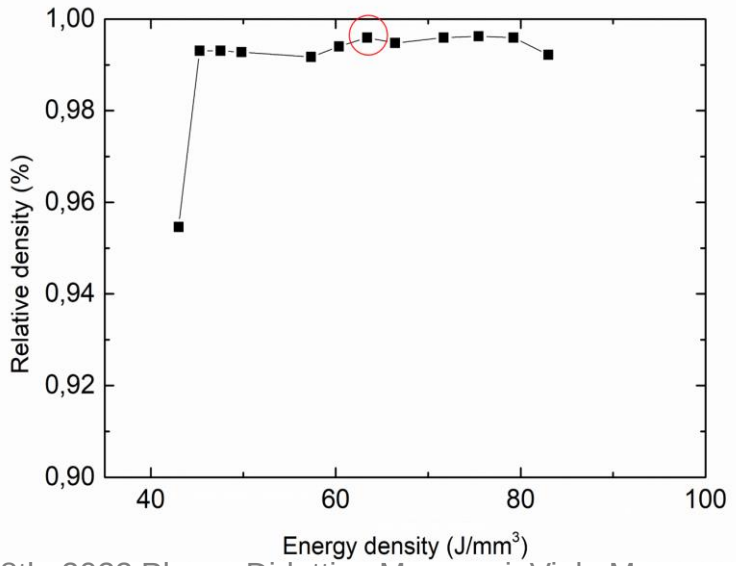
Good accuracy and reproducibility

RESULTS: DEFECTS ANALYSIS

Micro CT 22 µm







Verified printing parameters were used in order to avoid lack of fusion and gas porosities

RESULTS: DEFECTS ANALYSIS

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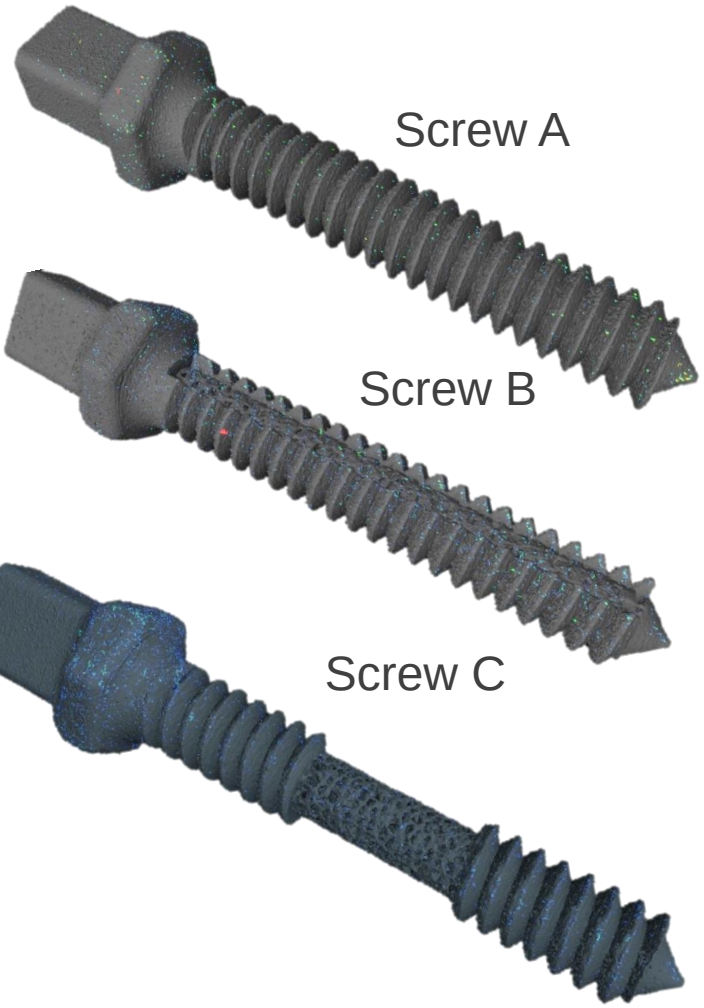
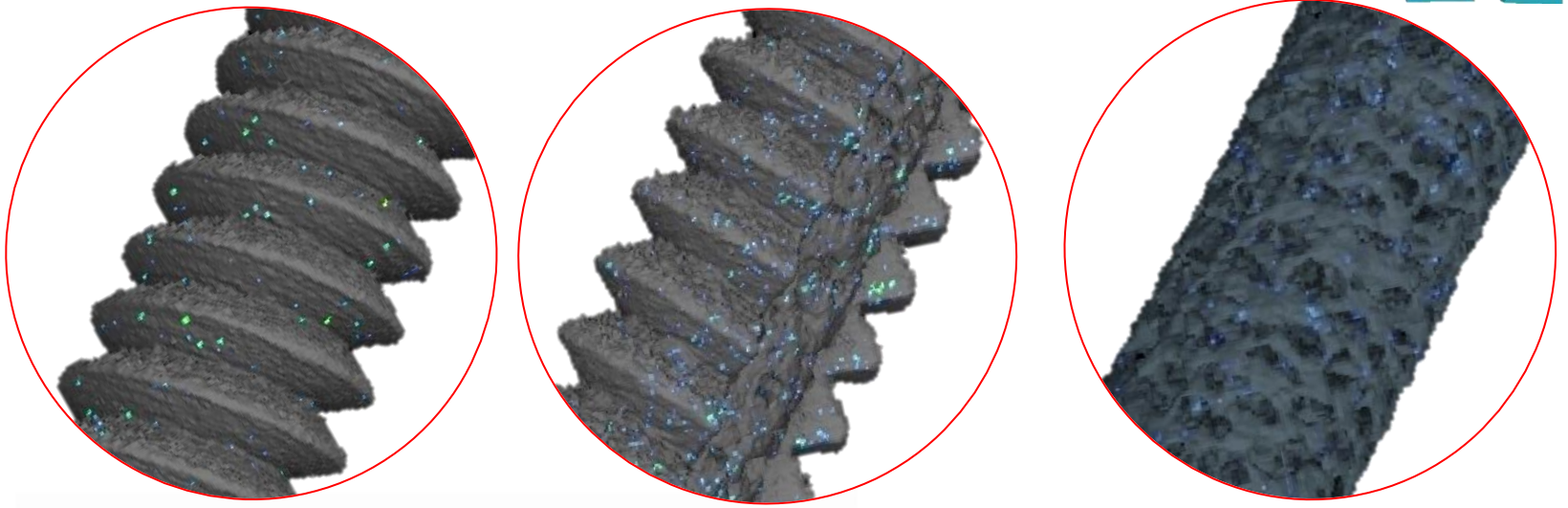
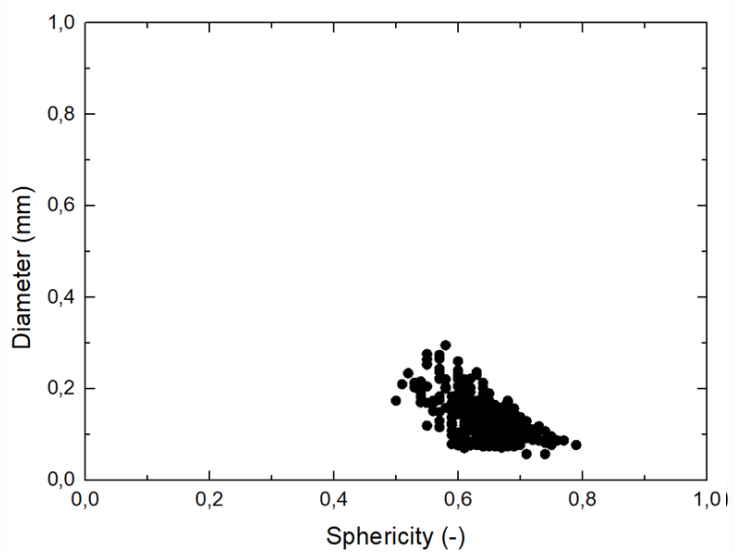
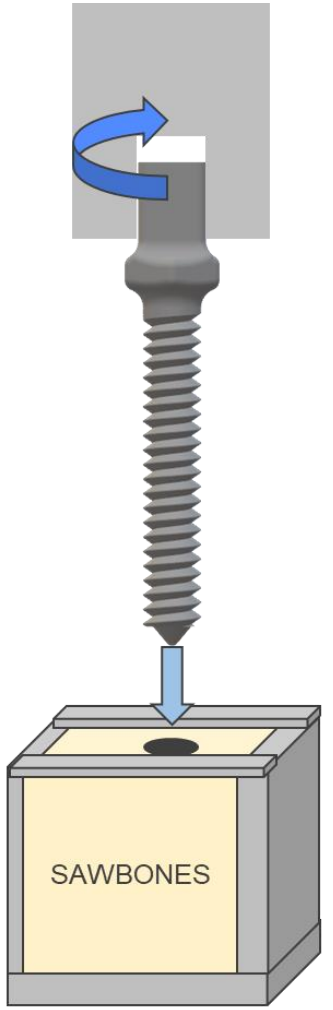






Low defects presence
No relevant present of porosities due to lasck of fusion.
Mainly more spherical porosities

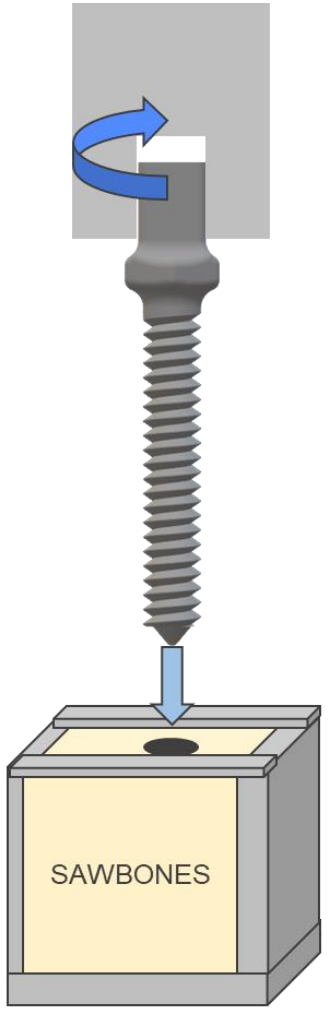
RESULTS: MECHANICAL CHARACTERIZATION



Insertion-torque test

Polyurethane foam cubes with density of 10 PCF

RESULTS: MECHANICAL CHARACTERIZATION



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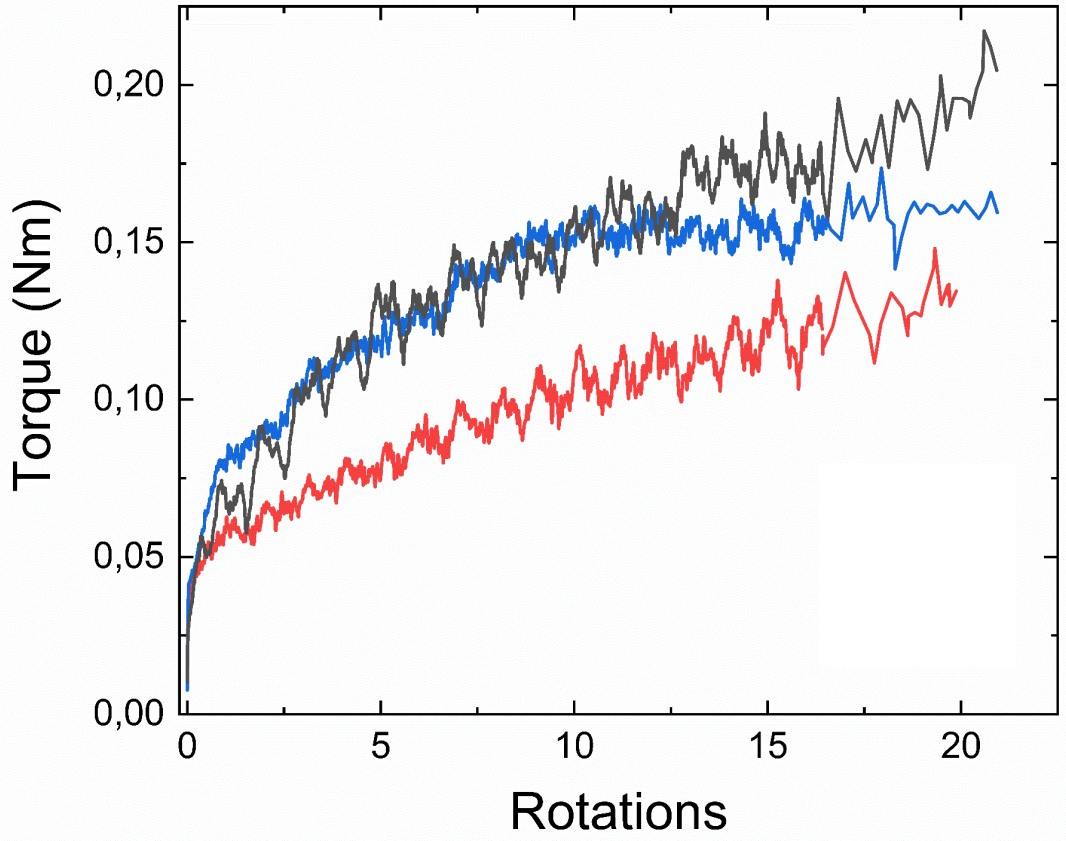


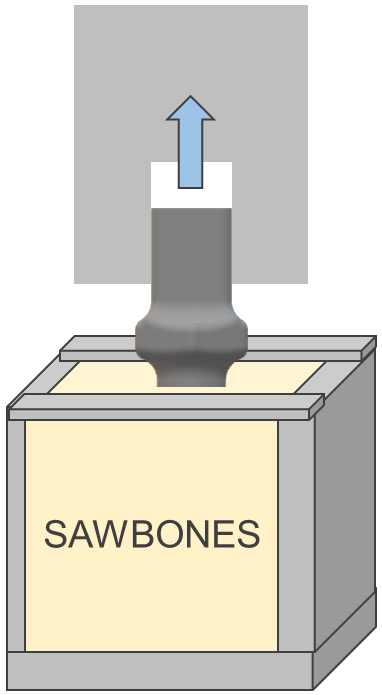
Screw A

Screw C

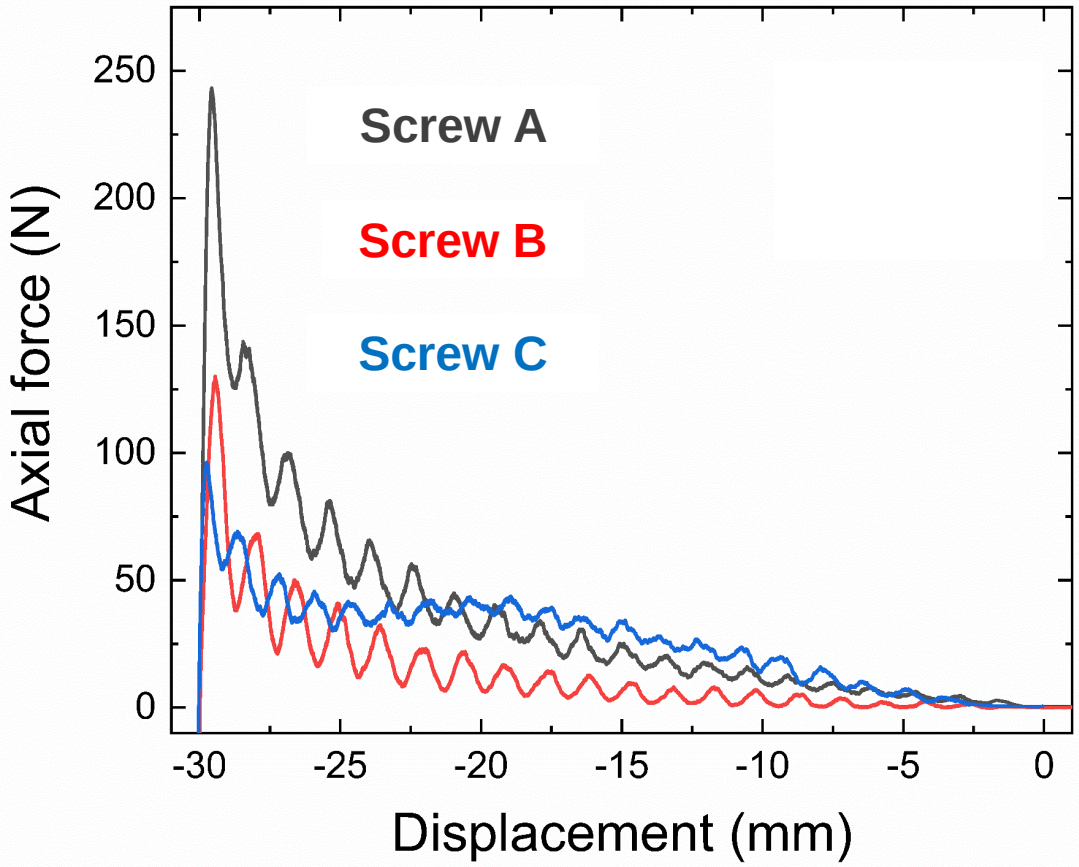
Screw B

Screw B presents the lowest torque so it damages less the sawbone

RESULTS: MECHANICAL CHARACTERIZATION



Axial pull out from Sawbones

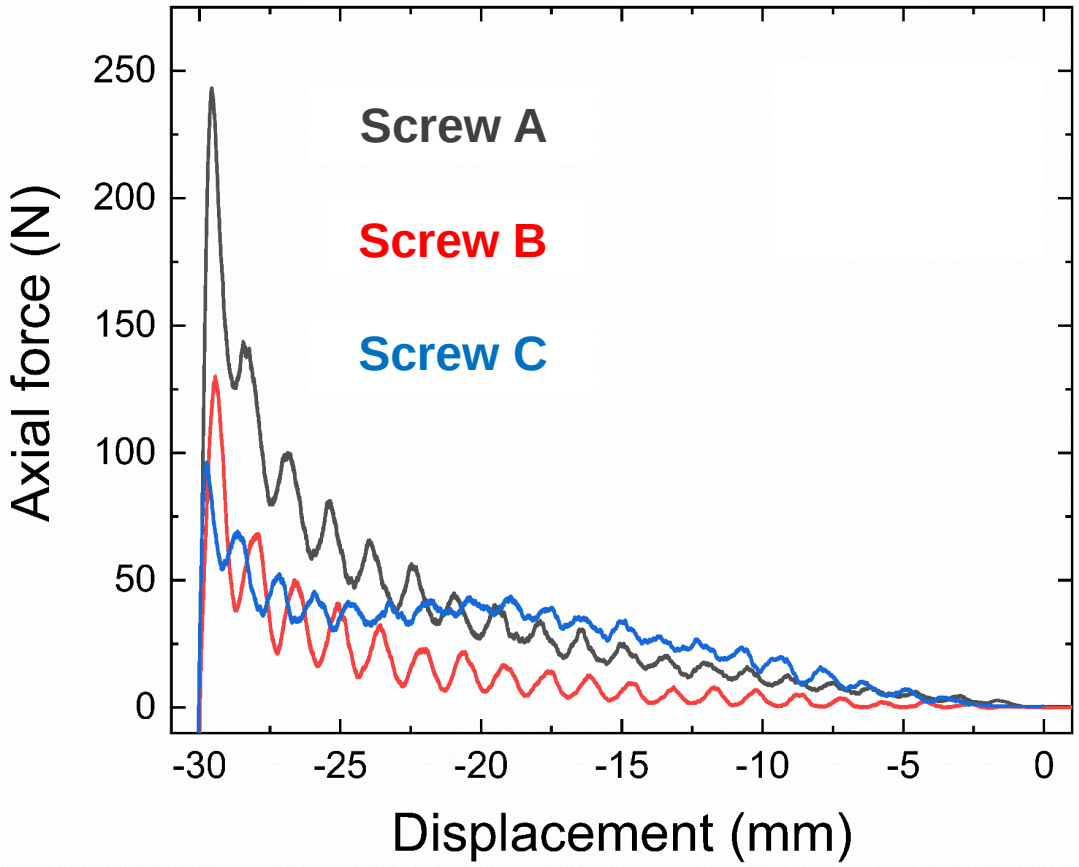


Screw A presents the greatest axial pull-out thanks to the fully threaded features

Screw C presents the lowest axial pull-out due to the transversal lattice sector

RESULTS: MECHANICAL CHARACTERIZATION

Axial pull out from Sawbones



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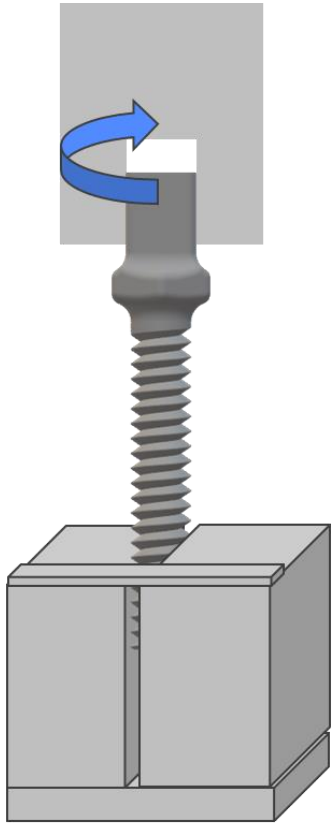
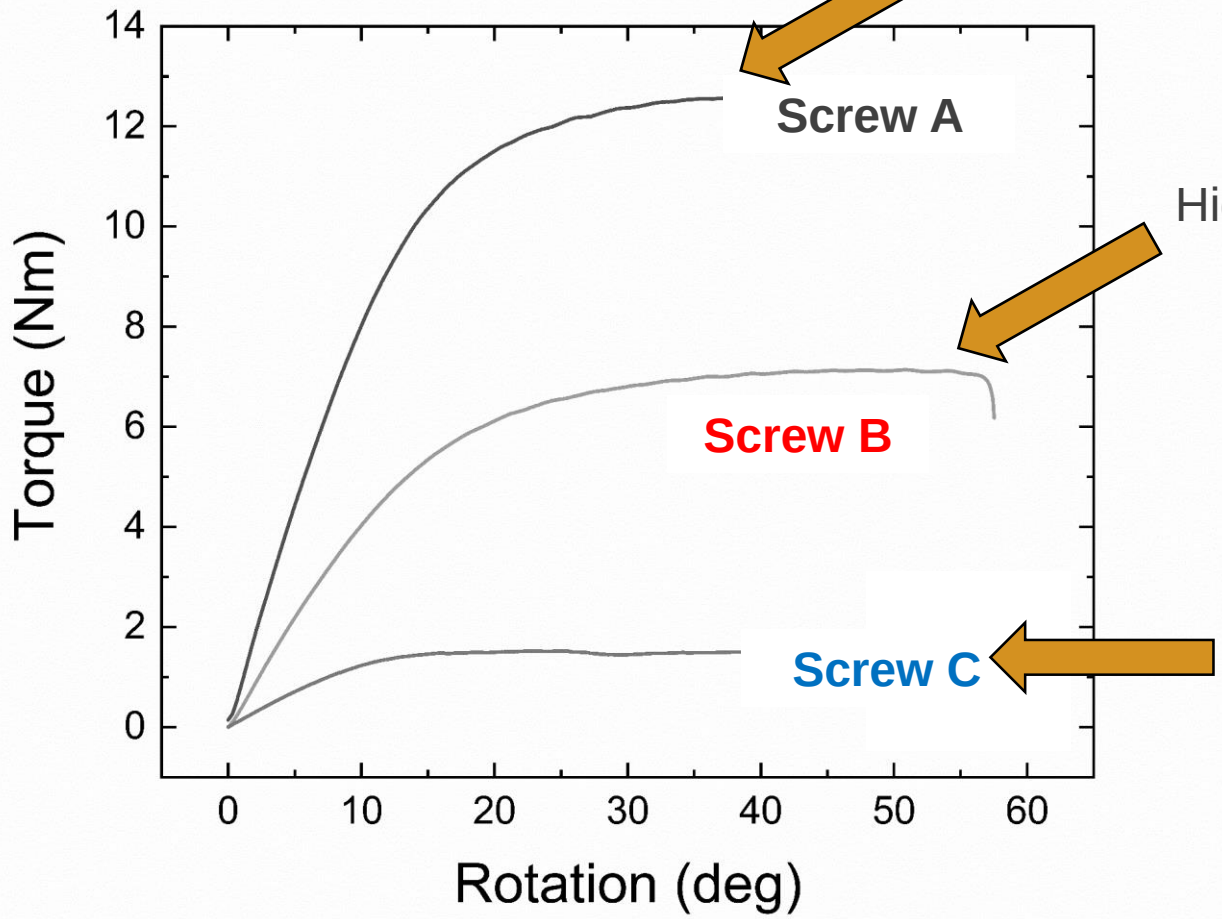


Torsional strenght

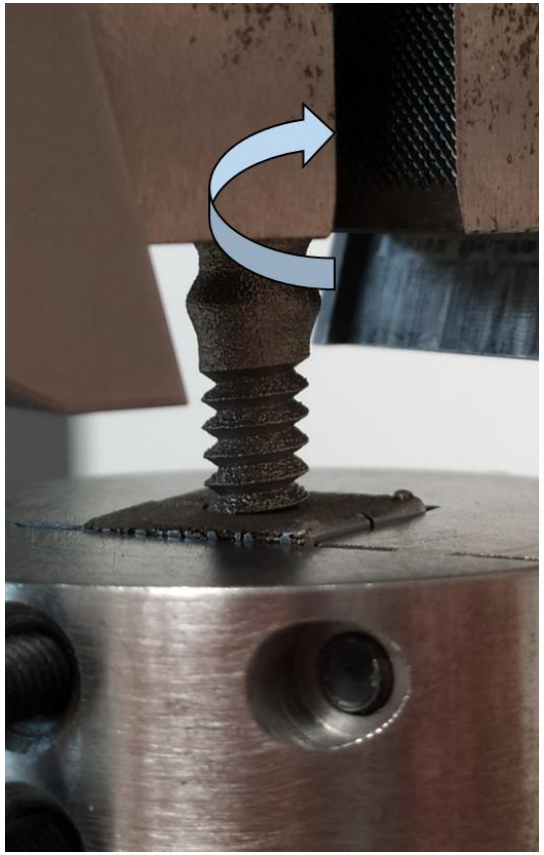


Greatest UTS

Highest elongation for screw B

Lowest torsional mechanical performance

RESULTS: MECHANICAL CHARACTERIZATION



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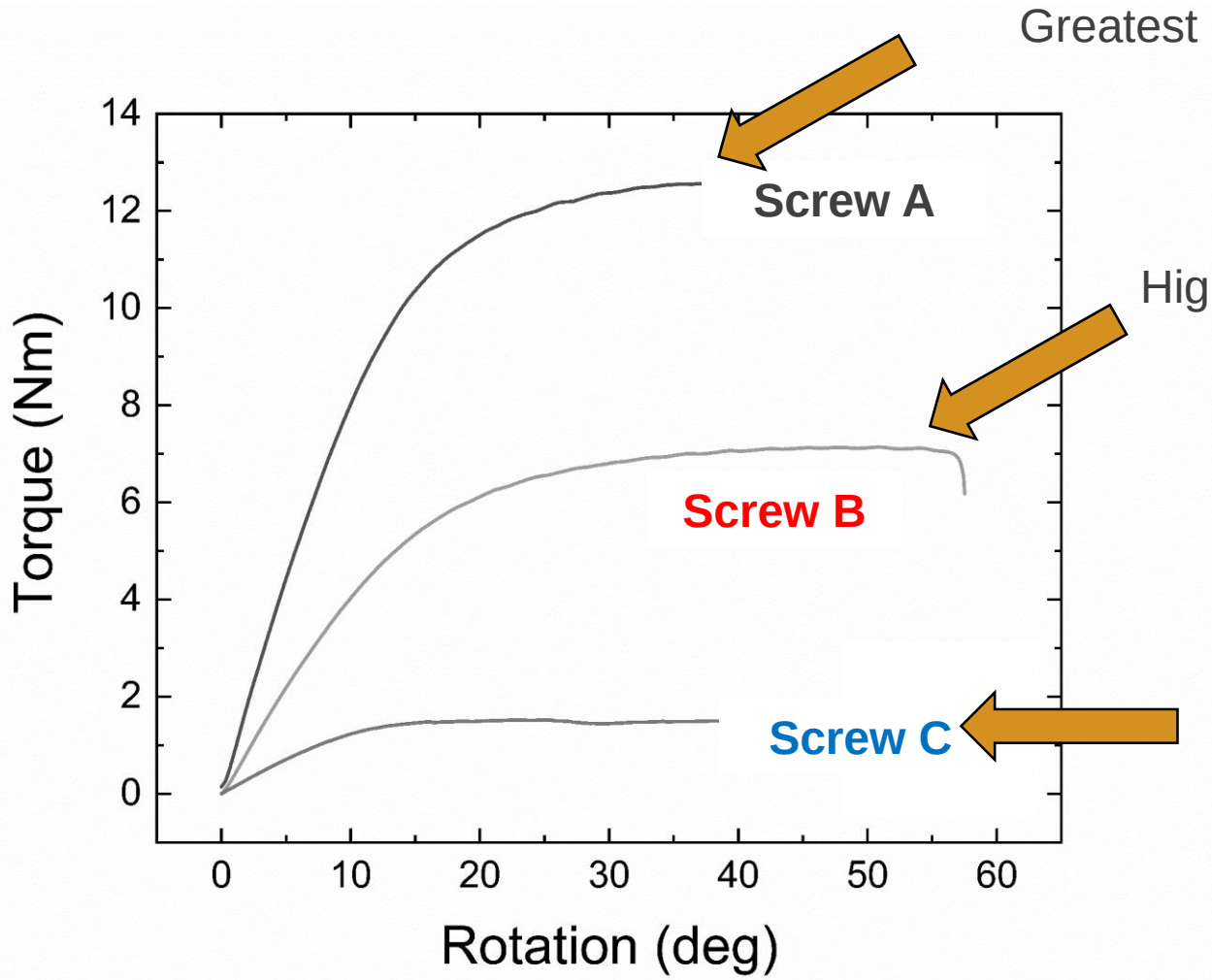

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Highest elongation for screw B

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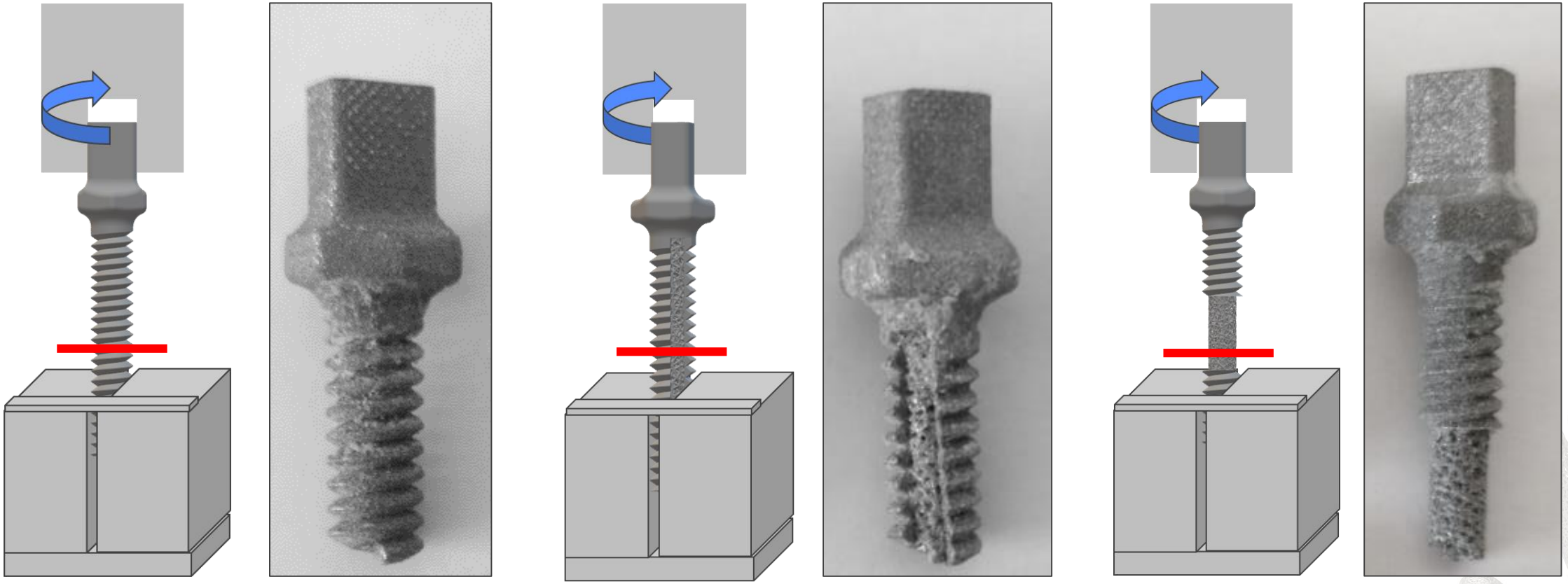
RESULTS: MECHANICAL CHARACTERIZATION

Where fracture happens?

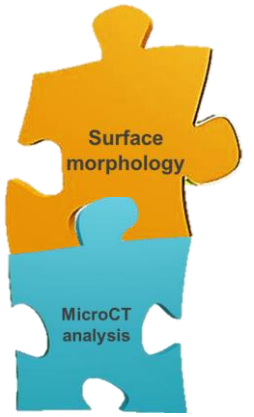


Screw A Screw B Screw C

CONCLUSIONS

- LBV structure can be added in additive bone screws.

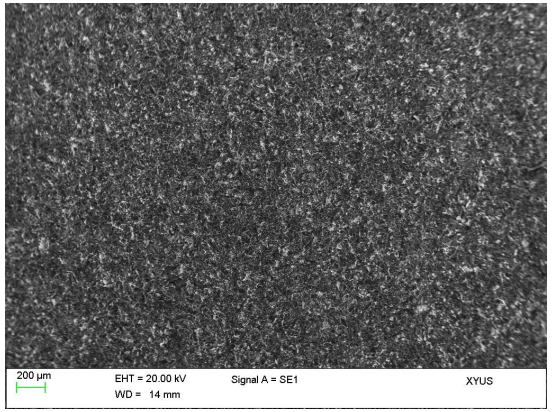
- The designed screws can be realized by means of LPBF process. The accuracy of the technique has been demonstrated by means of micro-CT analysis and surface microscope investigations.

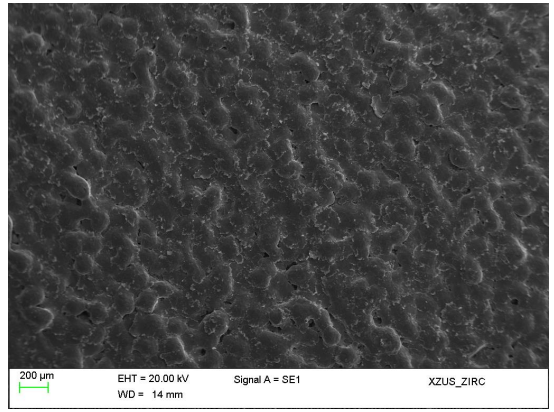


- Implants with LBV sector presented lower elastic modulus favourable to reduce the shear stress and improve the mechanical performance in contact with bone.

- The positioning of LBV structure strongly influences torsional strength: in particular, longitudinal LBV sectors may improve the plasticity of the device.

FUTURE DEVELOPMENTS





- Study different polishing technique and test their influence in mechanical performance
- Biological test to assess the bone growth on the implant
- Mechanical test to assess implant secondary stability

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October 17th–18th, 2022

THANK YOU VERY MUCH FOR YOUR ATTENTION

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