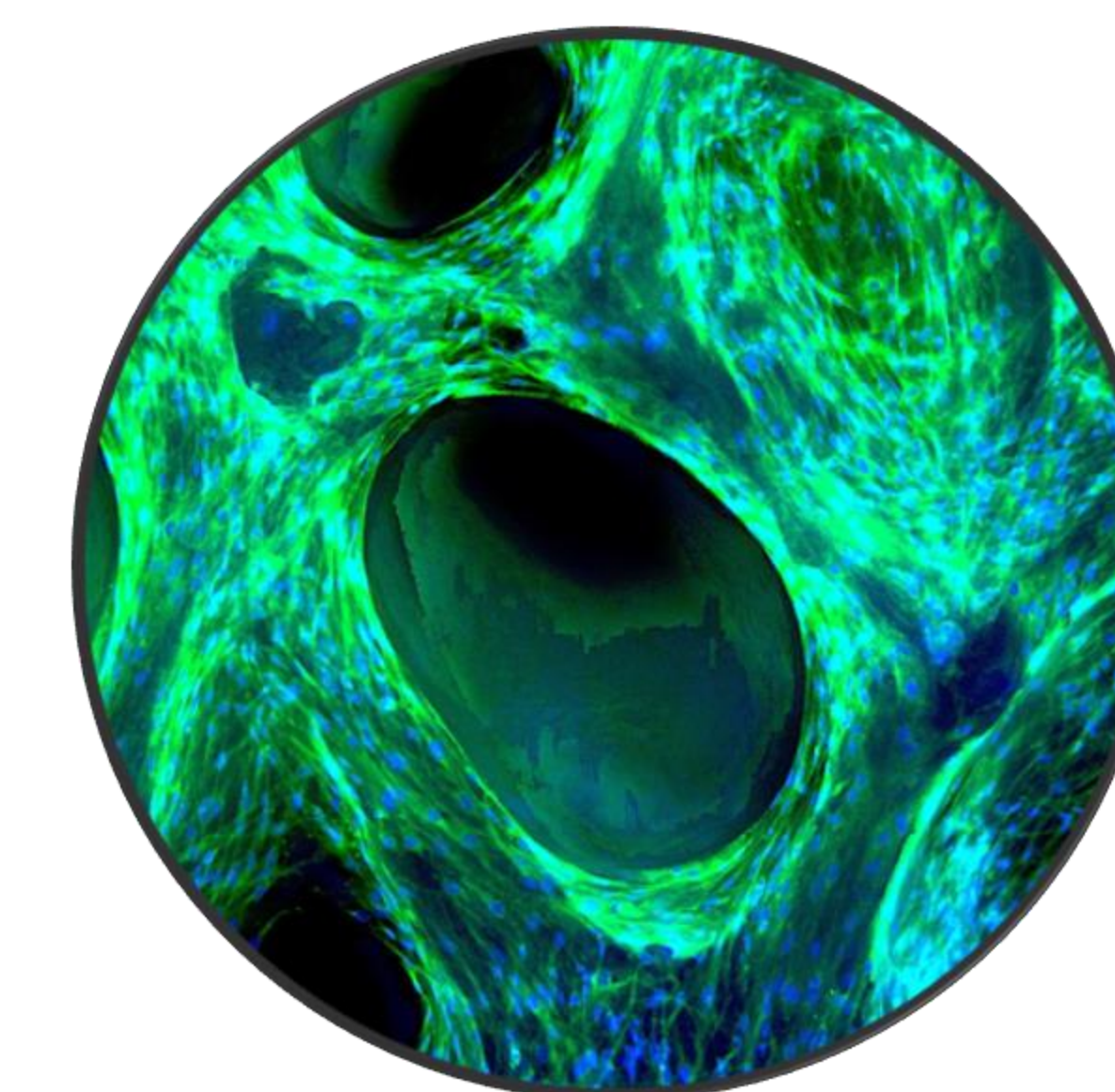


Enlarged Surface Design of Bioceramic Bone Grafts Enhances Proliferation and Promotes Bone Regeneration

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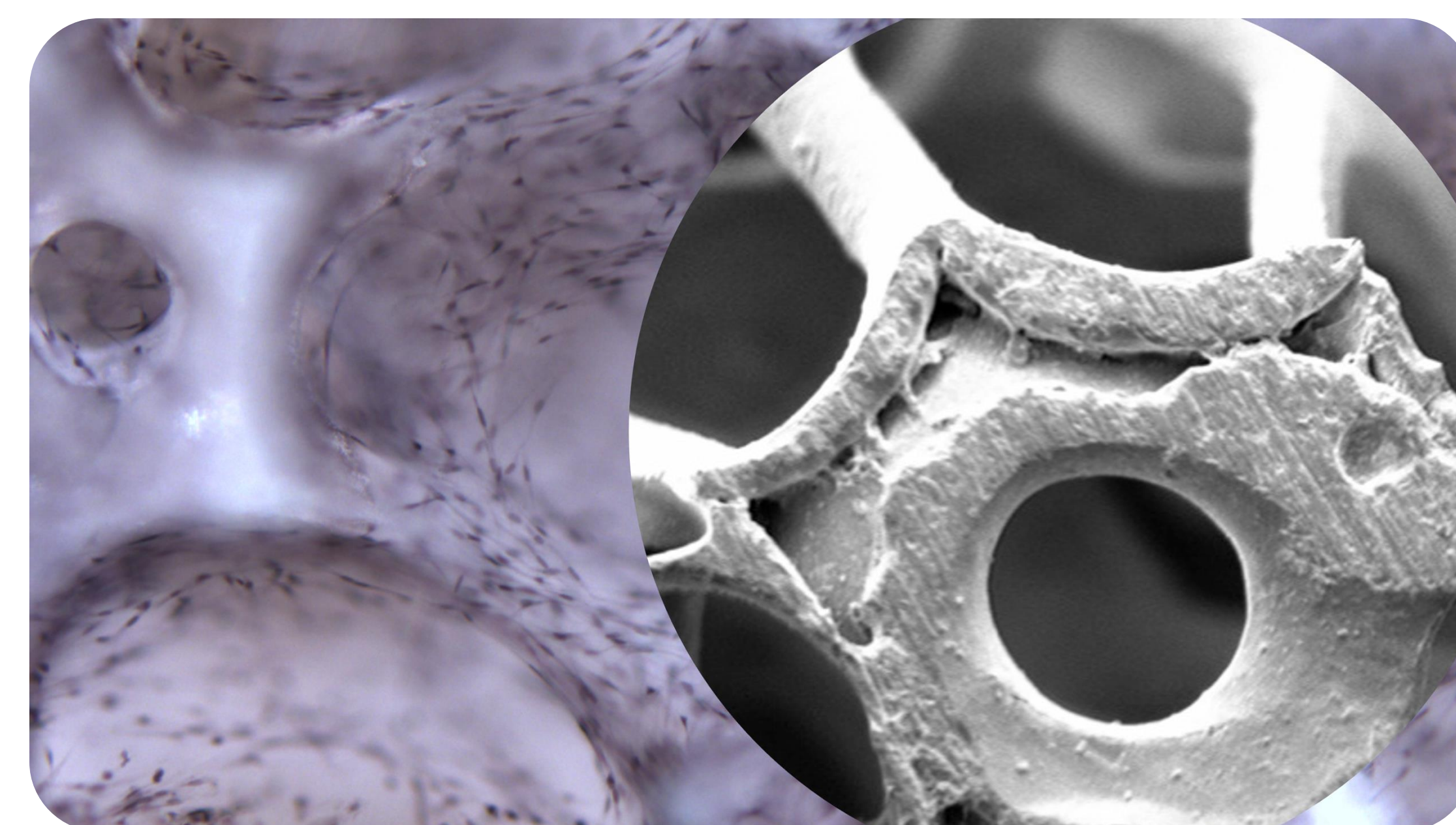


Introduction

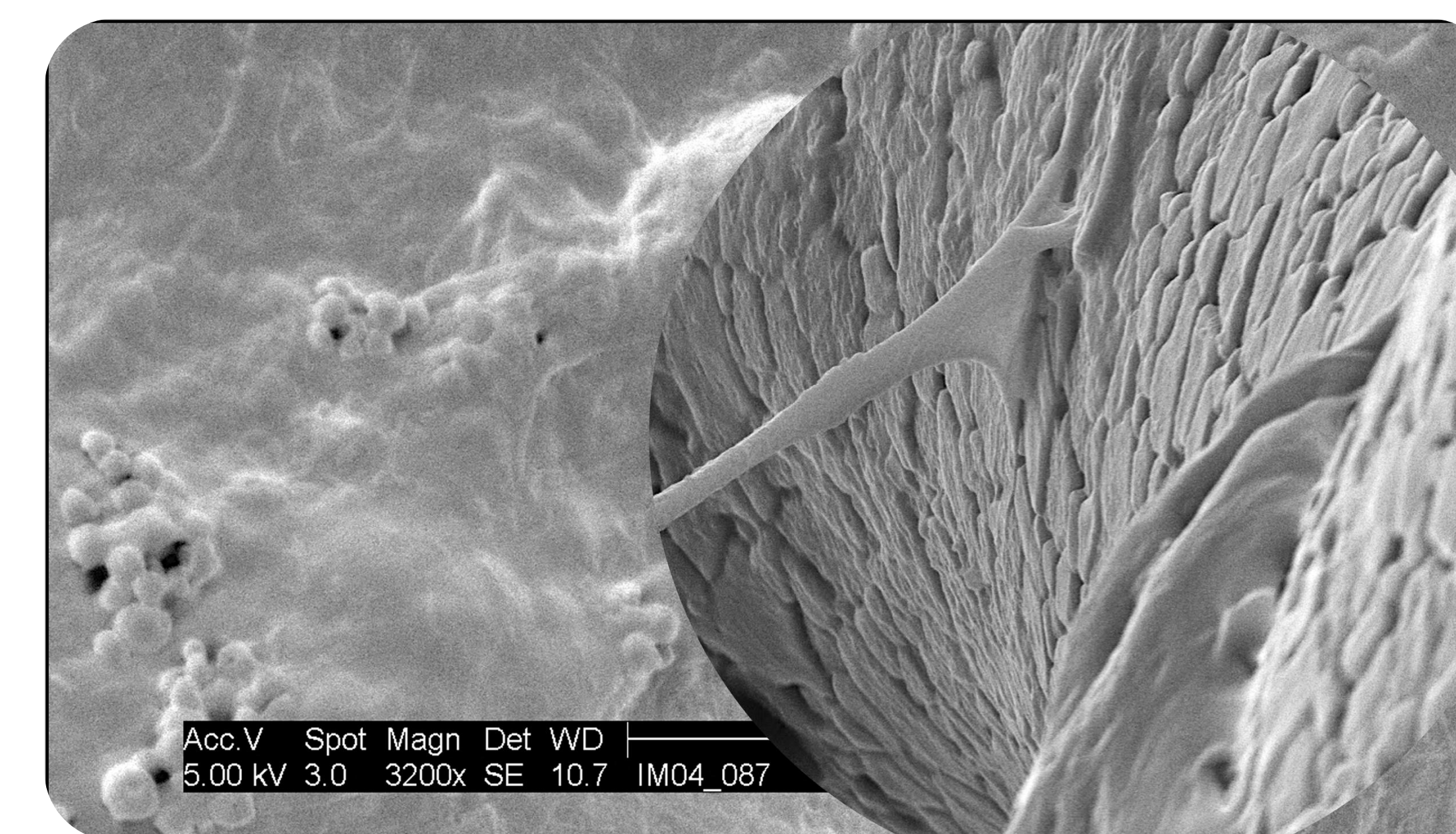
This study addresses the ongoing challenge of bone regeneration in orthopedic, dental, and maxillofacial applications by examining the impact of an enlarged surface design on bioceramic bone grafts. It focuses on enhancing cellular proliferation rates and bone regeneration outcomes, aiming to improve the efficacy of biocompatible, osteoconductive alternatives to autologous grafts through optimized surface characteristics.

Increased surface area, particularly with micro or nanoroughness, is crucial for osteoblast attachment and bone tissue healing because it provides more sites for cell attachment and promotes protein adsorption, which in turn influences cell adhesion, proliferation, and differentiation.

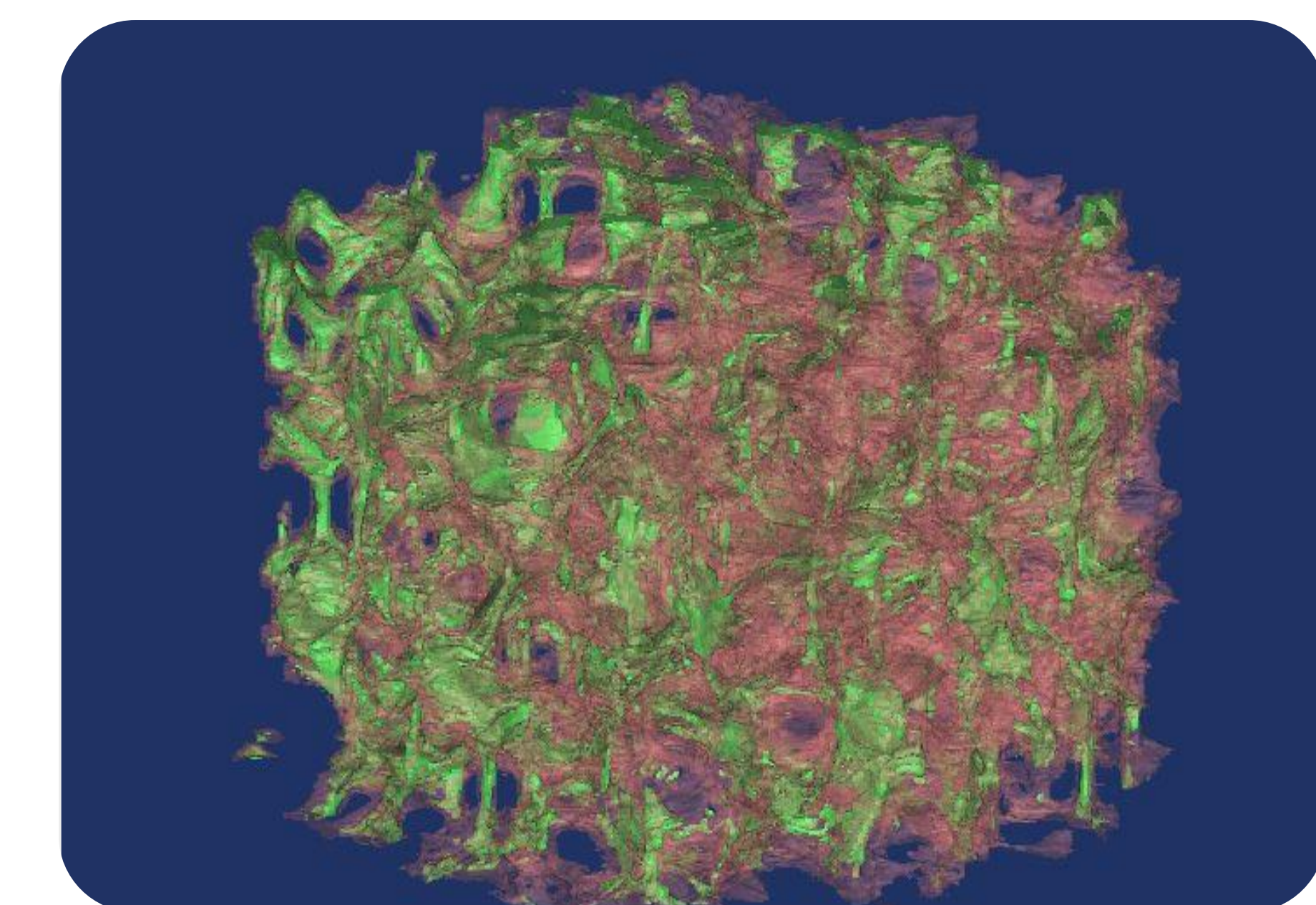
Higher Surface Area → Increased Cell Attachment & Proliferation



Active Cell Recruitment
(Attract)



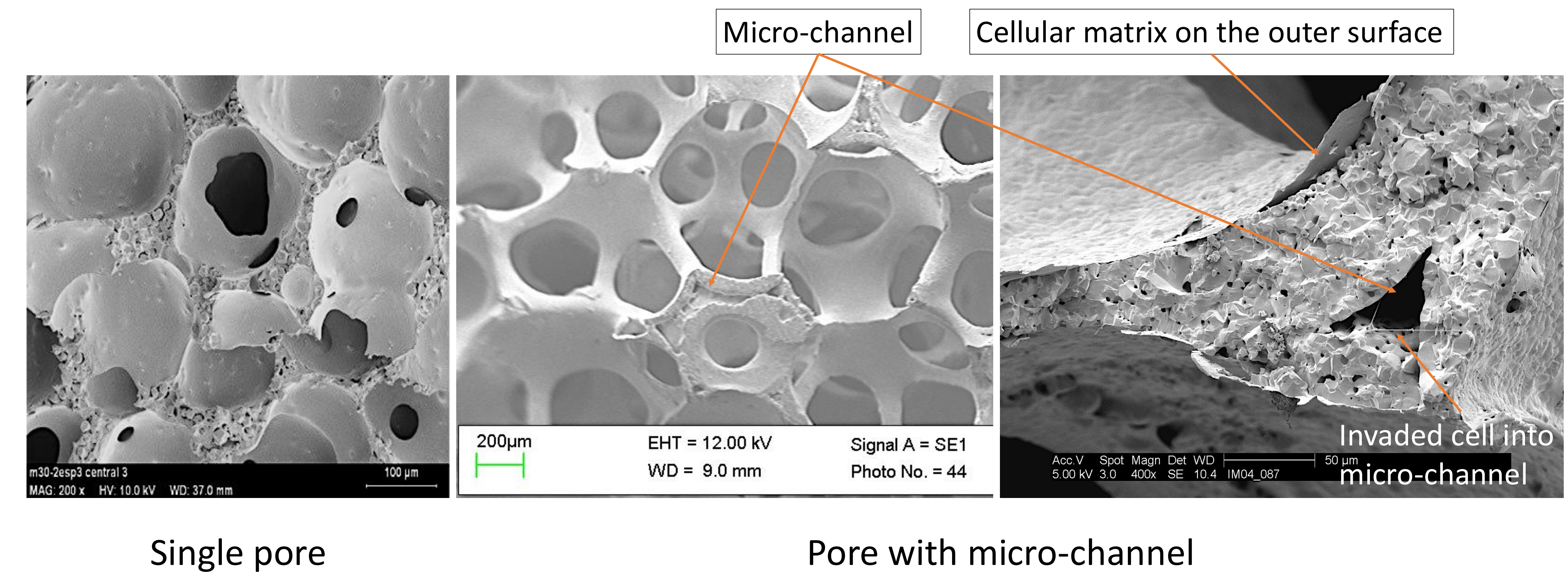
Promote Cellular Responses
(Activate)



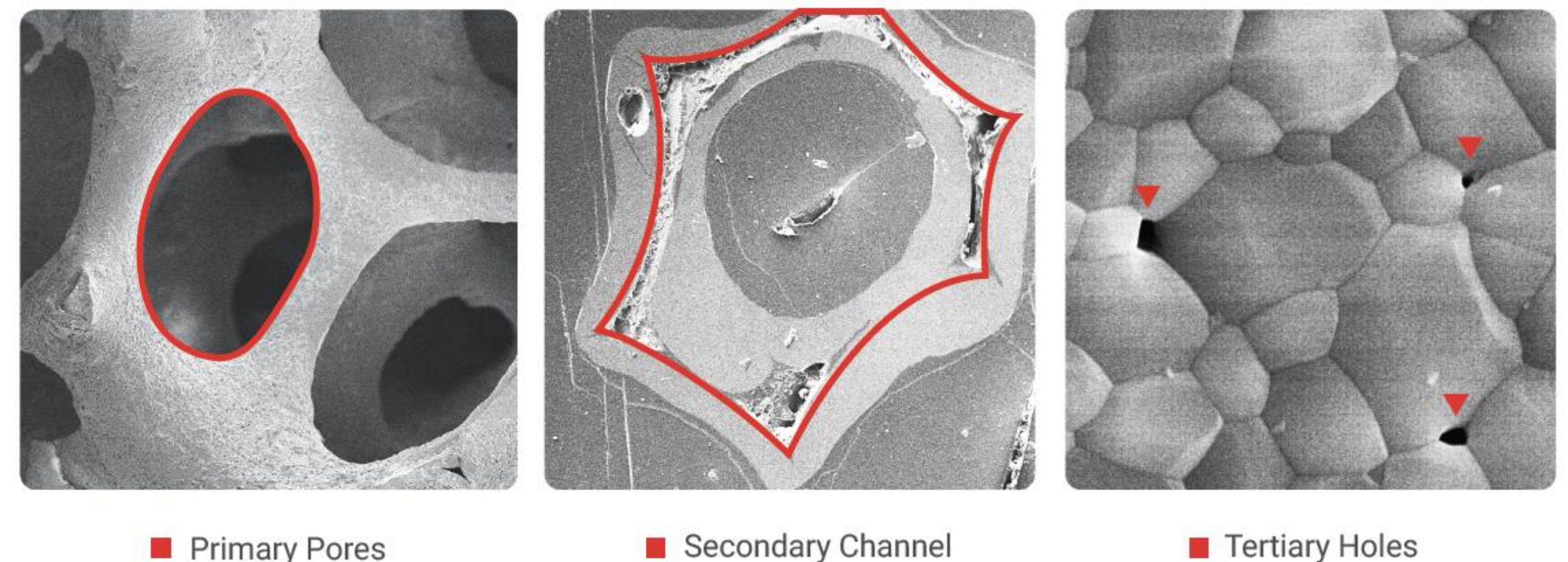
Enhancing Bone Regeneration
(Amplify)

Materials and Methods

Two types of granulated bone grafts were developed: one featuring a single-pore structure and the other incorporating both pores and microchannels. The single-pore graft contained interconnected primary pores ranging from 200 to 350 μm , whereas the dual-structure graft included primary pores of the same size along with secondary microchannels measuring 25 to 75 μm . Theoretical porosity and surface area were estimated using computer simulations for comparative analysis. Both graft types were cultured with MC3T3-E1 cells, and after three days, cell proliferation and extracellular matrix formation were evaluated through H&E staining and fluorescence microscopy.



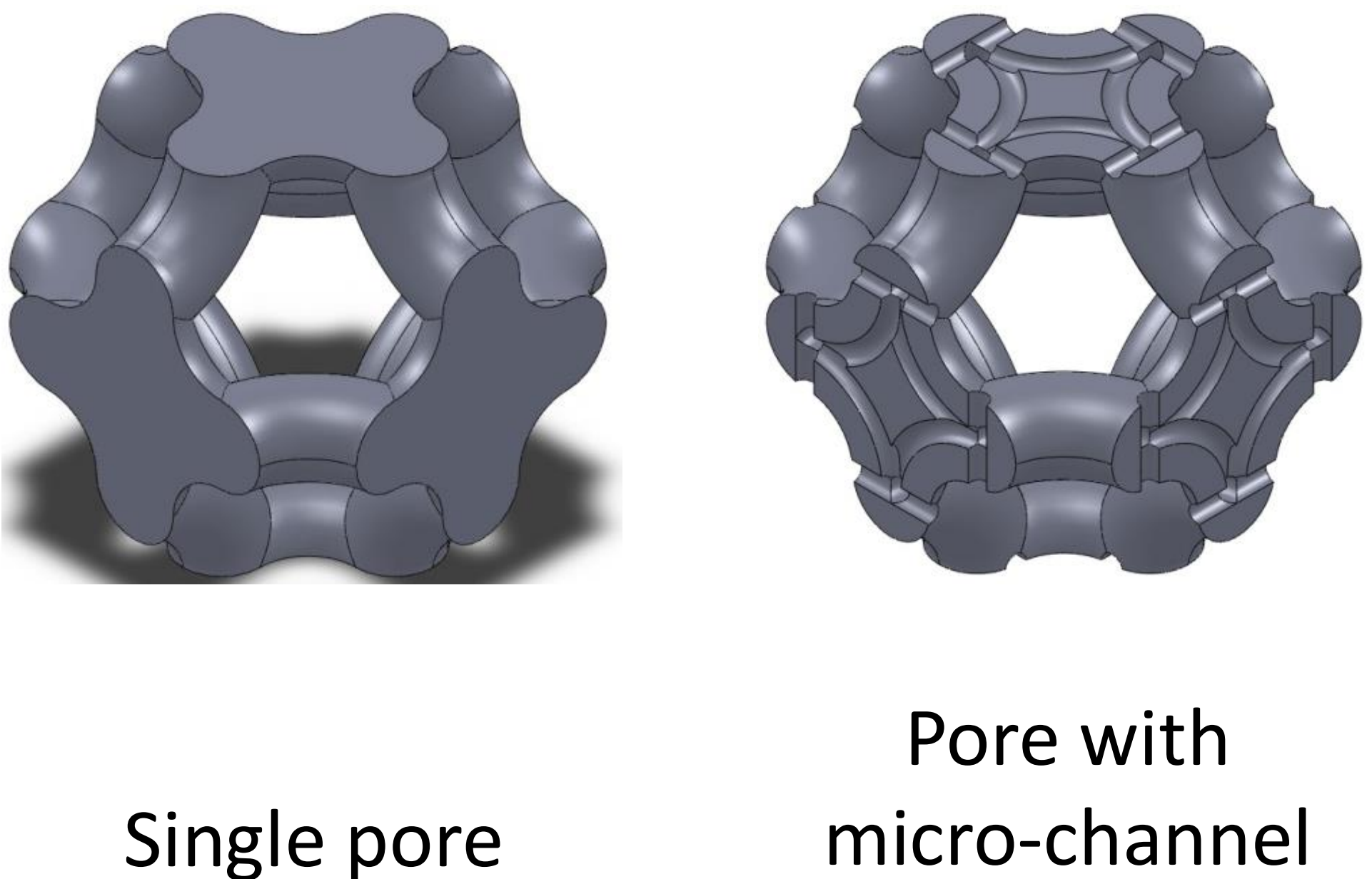
Interconnected Multi-porous Structure



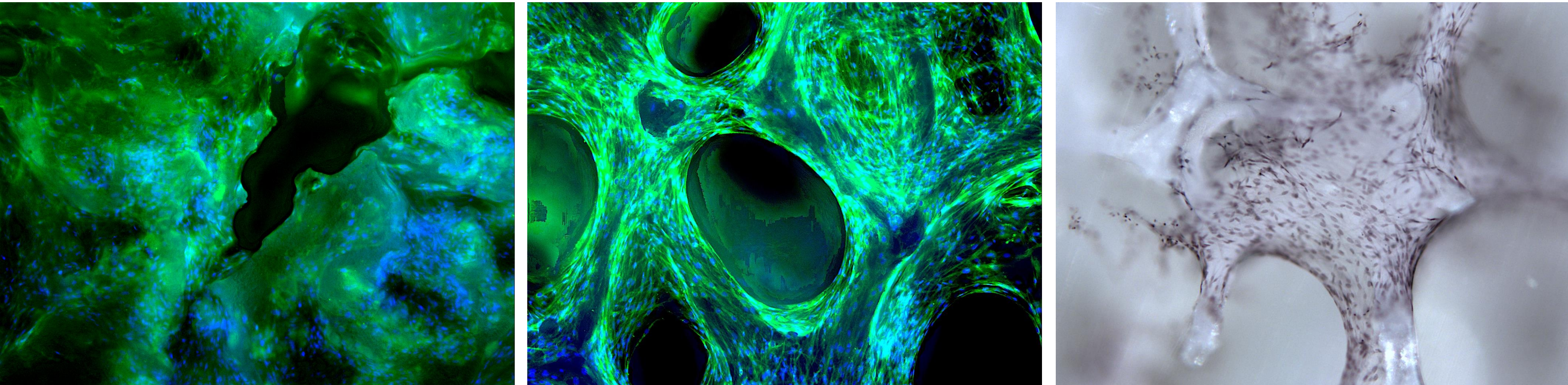
Results

The overall outer structure and shape remain largely unchanged between the single-pore and micro-channel pore structures. The porosity difference is minimal, at just 3.04%, with the single-pore structure at 75.6% and the micro-channel structure at 77.9%. Surface area calculations show an increase from 28.697 mm² in the single-pore structure to 36.743 mm² in the micro-channel structure, reflecting a 130% rise due to the micro-channel design. Furthermore, the proliferation rate in the micro-channel pore structure was three times higher than that of the single-pore structure.

Structure	Porosity	Pore diameter	Channel diameter	Surface area
Single pore	75.6%	250 μm	None	28.697 mm ²
With channel	77.9%	250 μm	47.77 μm	36.743 mm ²
	+ 3.04%			+ 28.04%



Comparison of Parameters and computerized model: Single Pore Structure vs. Pore with Micro-Channel Structure.



Single pore

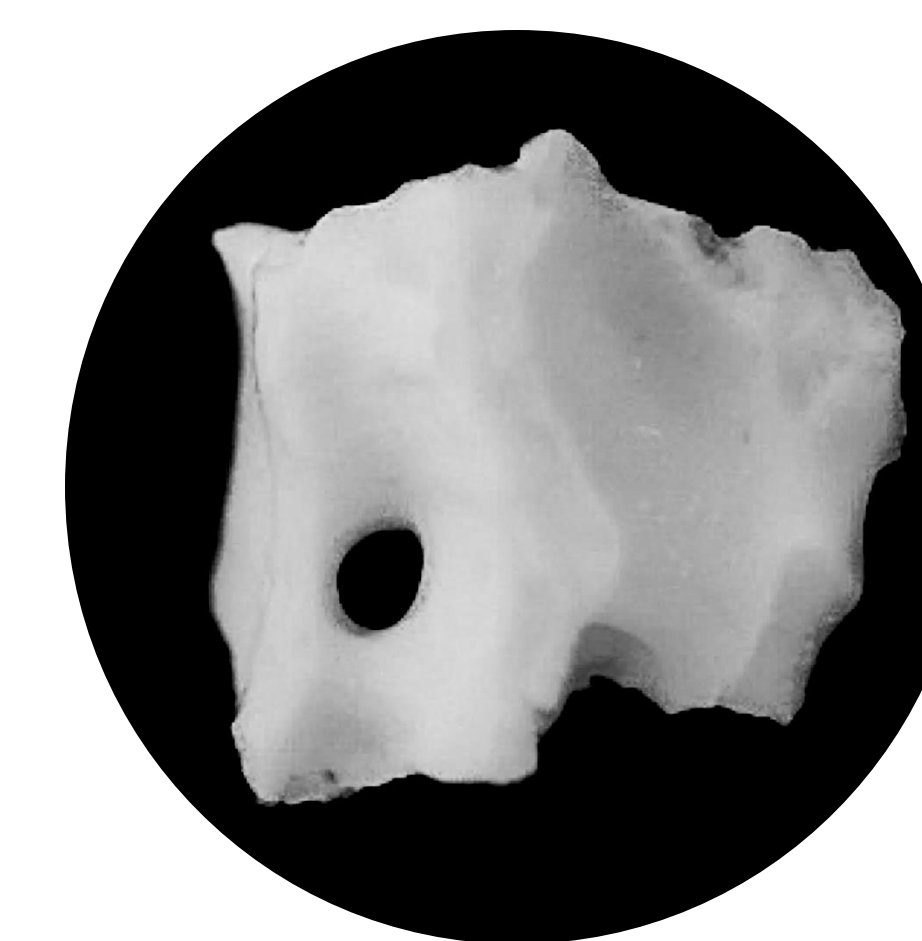
Pore with micro-channel

Cell attachment onto the surface (green: action filament, blue: nuclei)

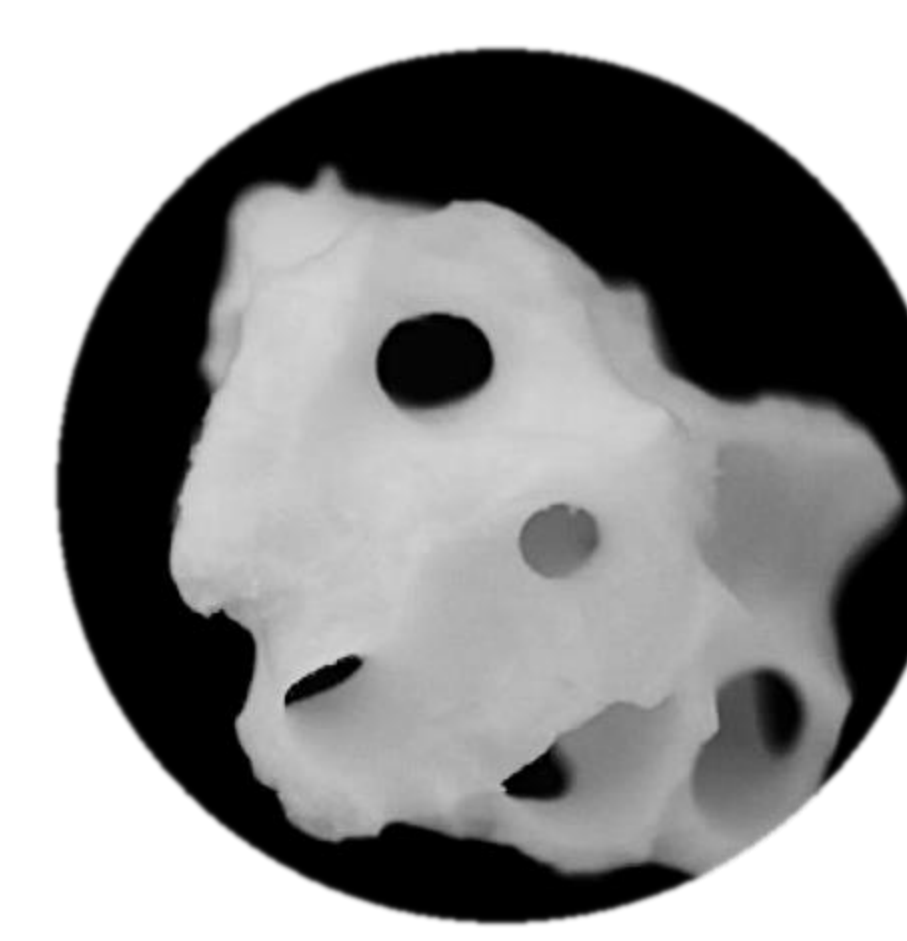
Cell invasion into the internal space of InRoad bioceramic bone graft. (H&E stain)

Conclusions

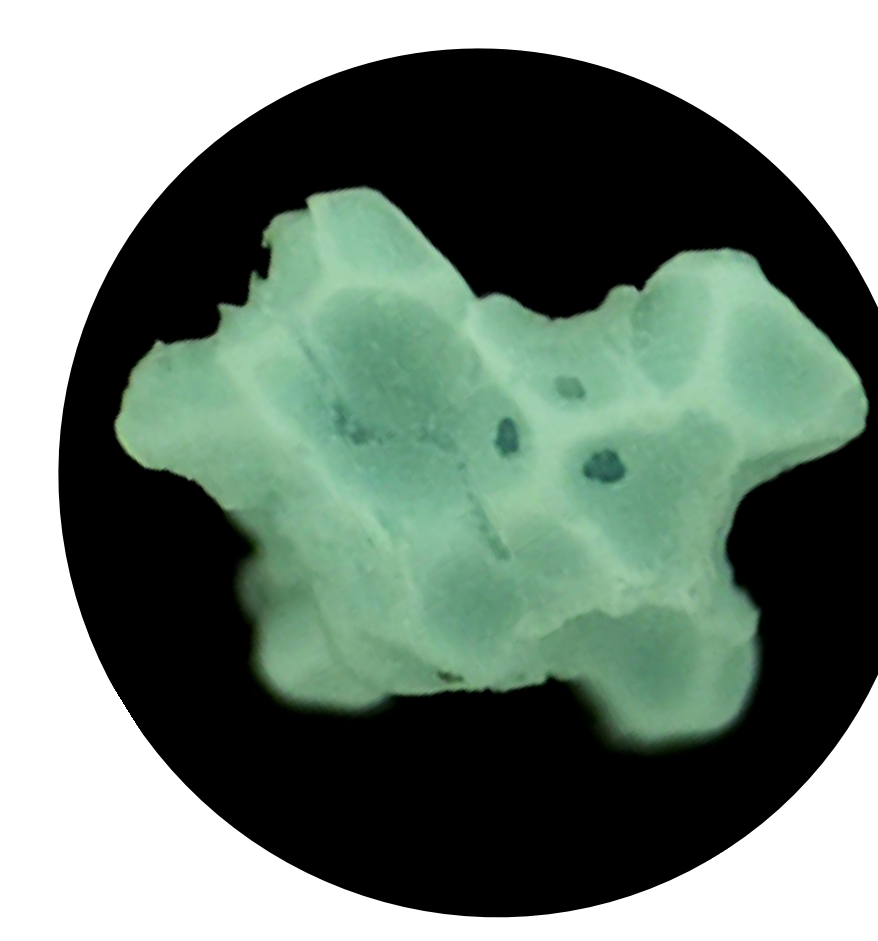
Even a minor design modification, such as incorporating a micro-channel in the strut, significantly increases the surface area—an essential factor for bone cell attachment. This enhancement fosters greater cell proliferation, making the design highly promising for more effective bone regeneration.



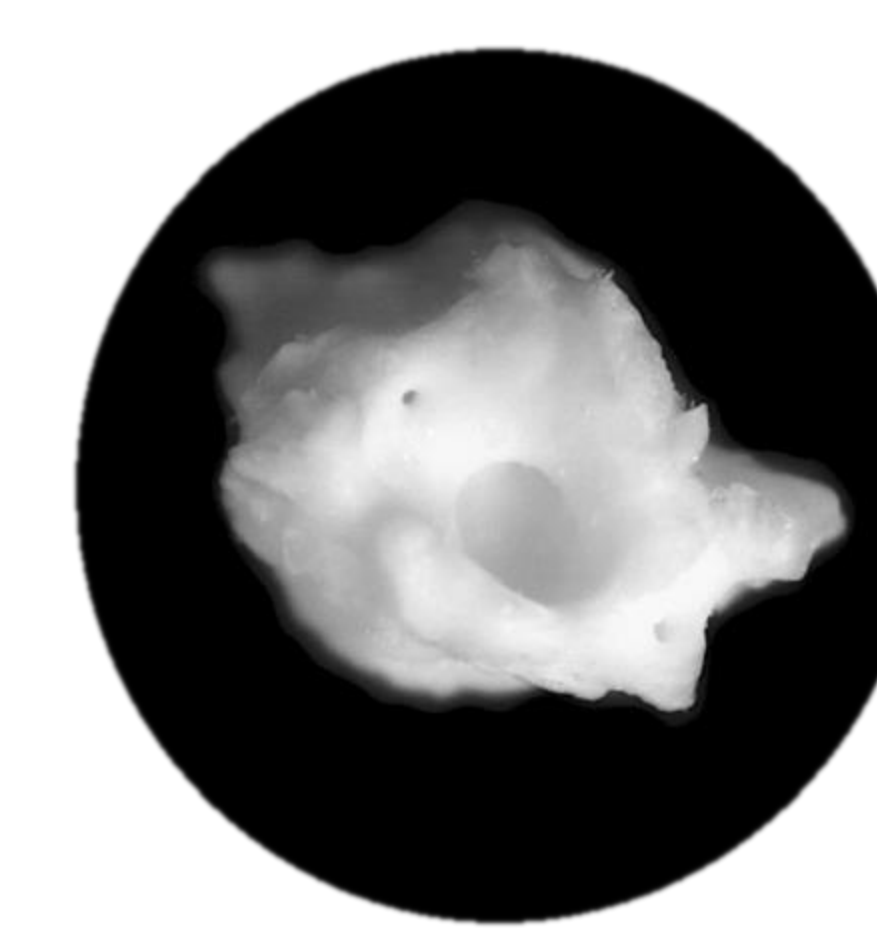
Animal



Human



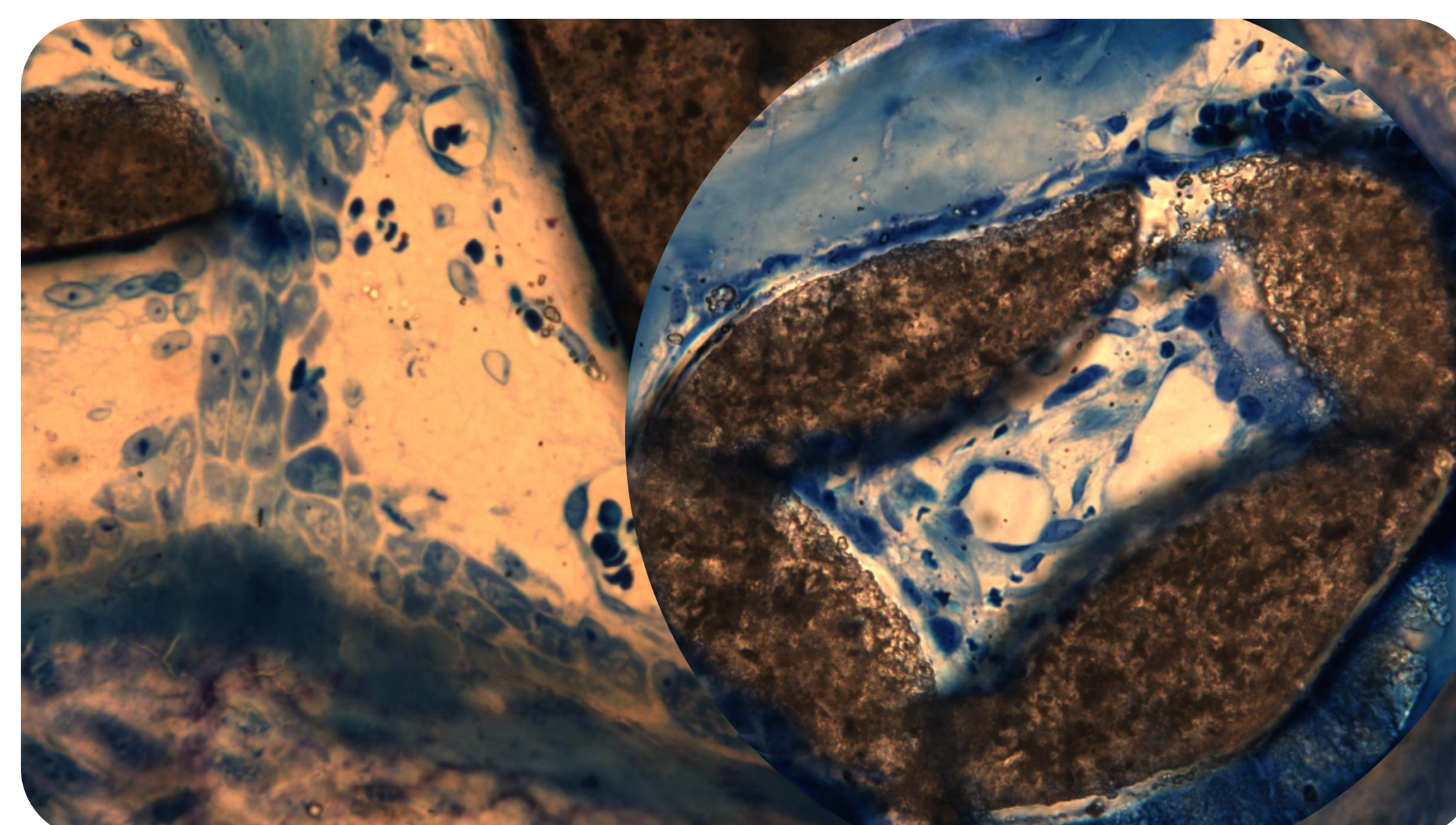
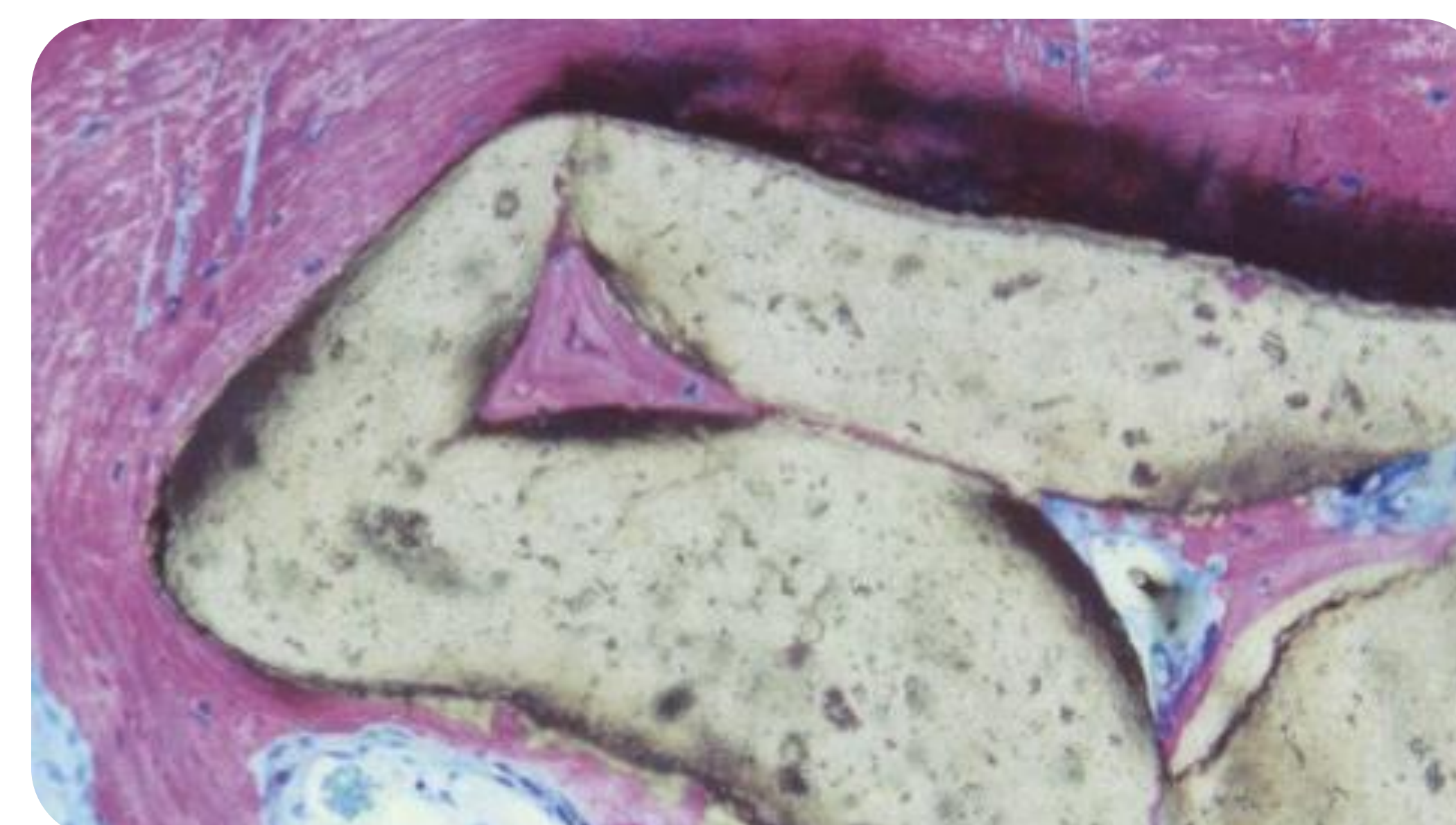
Other Synthetic



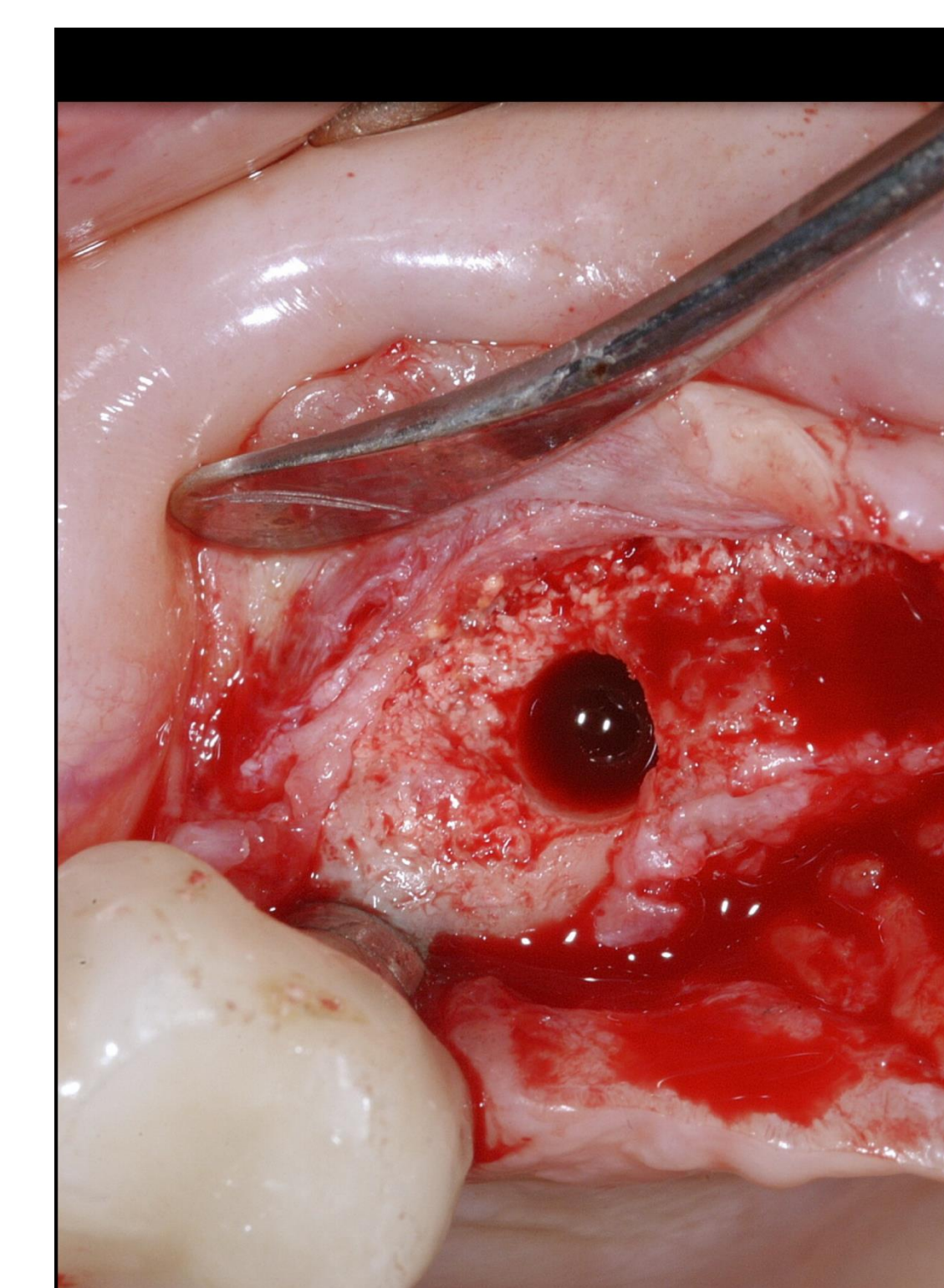
inroad
BIOCERAMIC BONE GRAFT

Less Space: Poor Bone Regeneration

Real Space:
Real Bone Regeneration

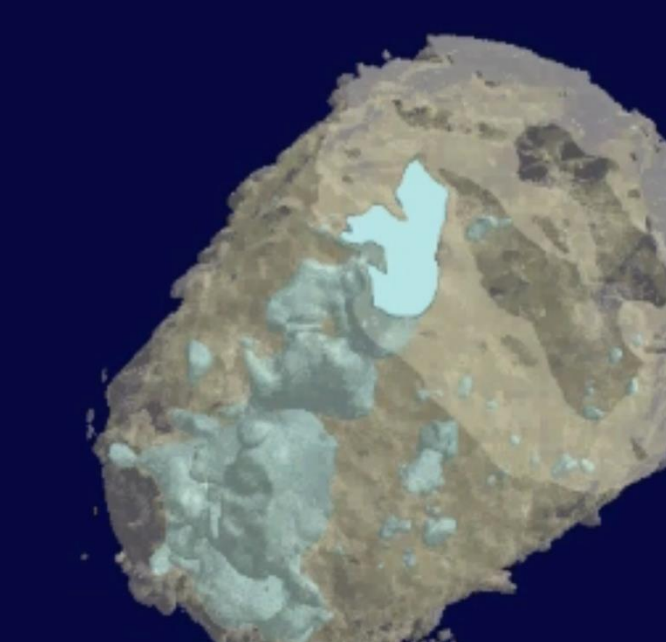
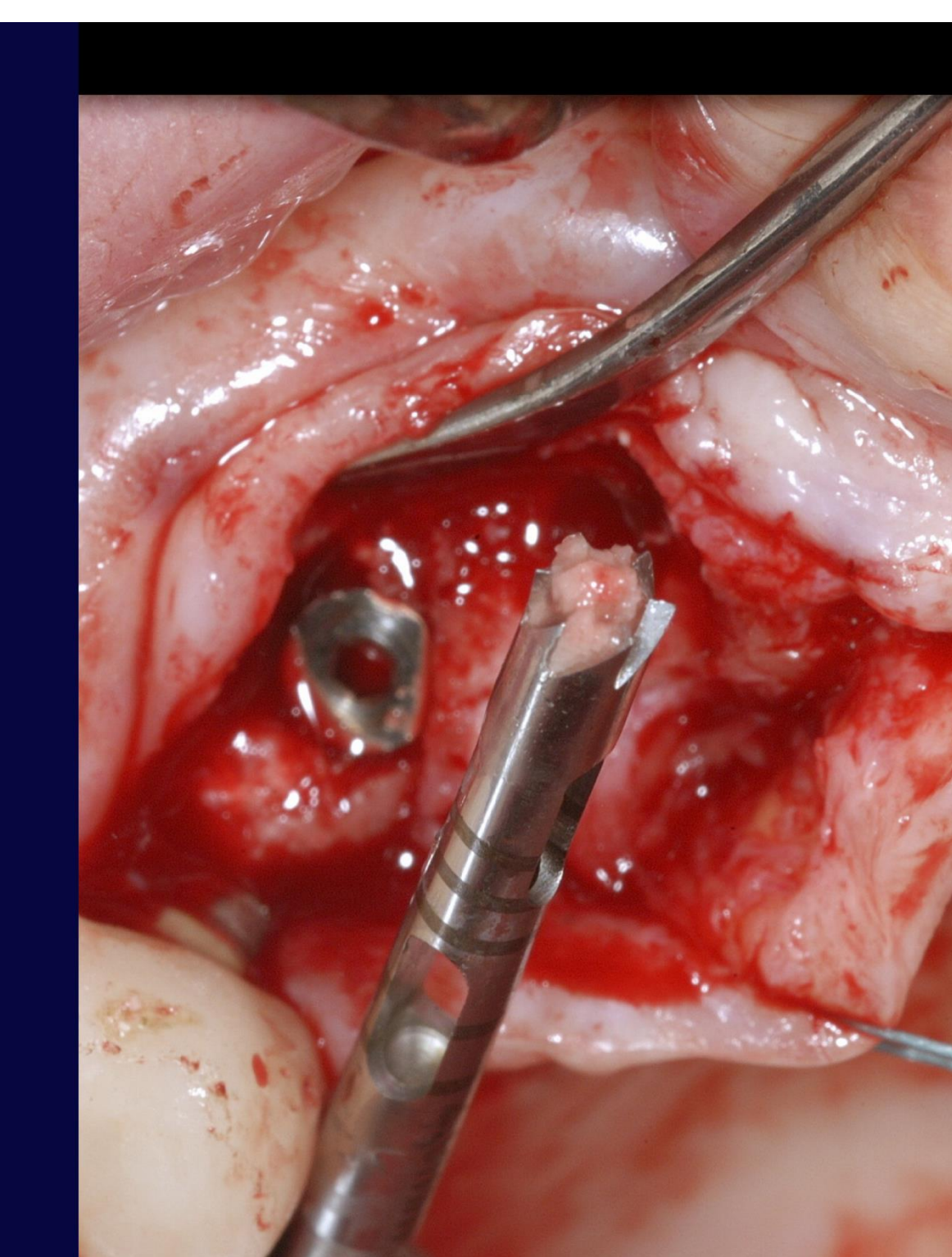


Substantial bone regeneration inside micro-channel of InRoad® and surrounding InRoad®



9 months post-op

Blue: inroad®
Brown: New bone



	New Bone	Material	Space
inroad®	≥ 60%	≤ 30%	≤ 10%
Others	≤ 40%	≥ 40%	≥ 20%