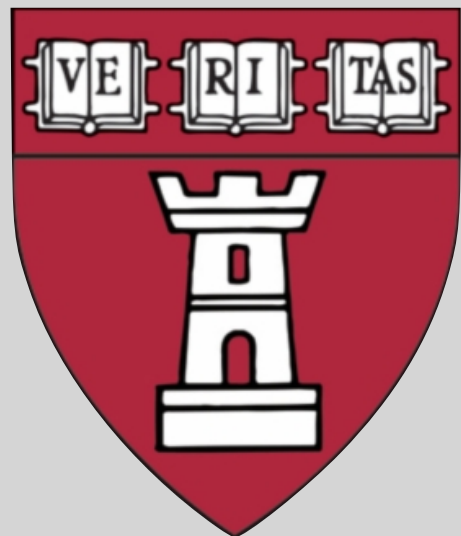




Effect of Er,Cr:YSGG Laser Irradiation on the Surface Modification and Cell Adhesion on Titanium Discs: An In Vitro Study

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Introduction:

A proper method for debridement of the contaminated titanium implants has yet to be established. This study evaluates **optimal Er,Cr:YSGG laser irradiation conditions for peri-implantitis treatment** applied on a titanium disc surface to promote the proliferation of fibroblasts and osteoblasts.

Methods:

The disks were treated with Er,Cr:YSGG laser, the ultrasonic device with stainless tip, or titanium curette. After implementing these debridement methods, specimens were analyzed by profilometer, scanning electron microscopy (SEM), and energy dispersive X-ray photoelectron spectroscopy (EDS) to investigate the changes in the surface properties. Cell adhesion and proliferation on each disc were evaluated after seeding cells on titanium discs for 72 hours. Qualitative assessment was performed through SEM in the backscattered electrons (BSE) mode imaging for cell morphology. Quantitative assessment includes cell density measurements of fibroblasts and osteoblasts using cell viability assays.

Statistical analyses:

One-way analysis of variance (ANOVA) was conducted to compare measurements between the different groups, and the Tukey HSD post hoc test was applied to assess statistically significant differences. Data that did not show normal distribution after testing for normality was analyzed using the Kruskal-Wallis non-parametric test and post hoc Dunn's multiple comparison test. Statistical significance was determined for p-values less than 0.05.

Surface Treatment Methods:

1) Control group: No treatment

2) Hand instrumentation group: discs were treated with titanium curettes (Brasseler USA) with 20 strokes of the instrument on each disc.

3) Ultrasonic instrumentation group: discs were treated with the ultrasonic instrument (Cavitron Plus Ultrasonic Scaler) with 20 strokes on each disc.

4-5) Laser-treated groups: discs were treated with the **Er,Cr:YSGG laser** (Waterlase iPlus) with a wavelength of 2780 nm in short pulse “H” mode (60μs, pulse rate 30 Hz or 40 Hz) via an end firing tip with a spot size of 1 mm. The power setting was 1.5 W with air/water of 40%/50% to simulate the recommended clinical setting for treating peri-implant disease using this laser. The laser tip was slowly moved along the titanium surface while keeping about 0.5 mm between the tip and the surface.



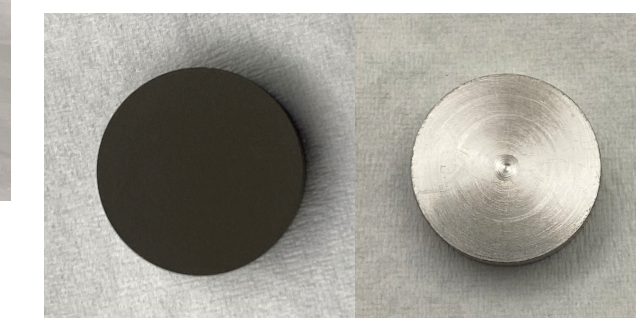
Titanium
curette



Ultrasonic
device



Er,Cr:YAGG
laser

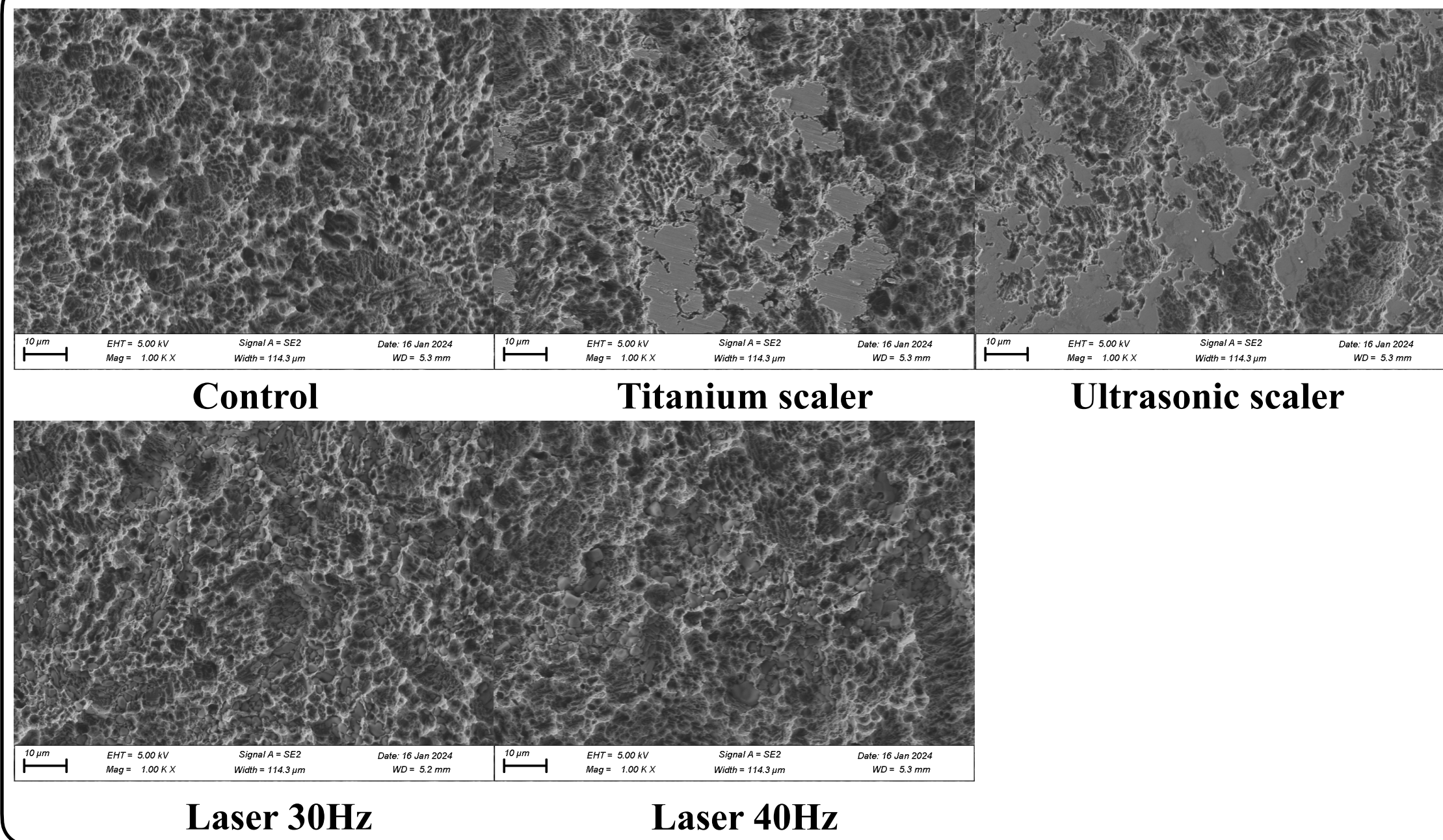
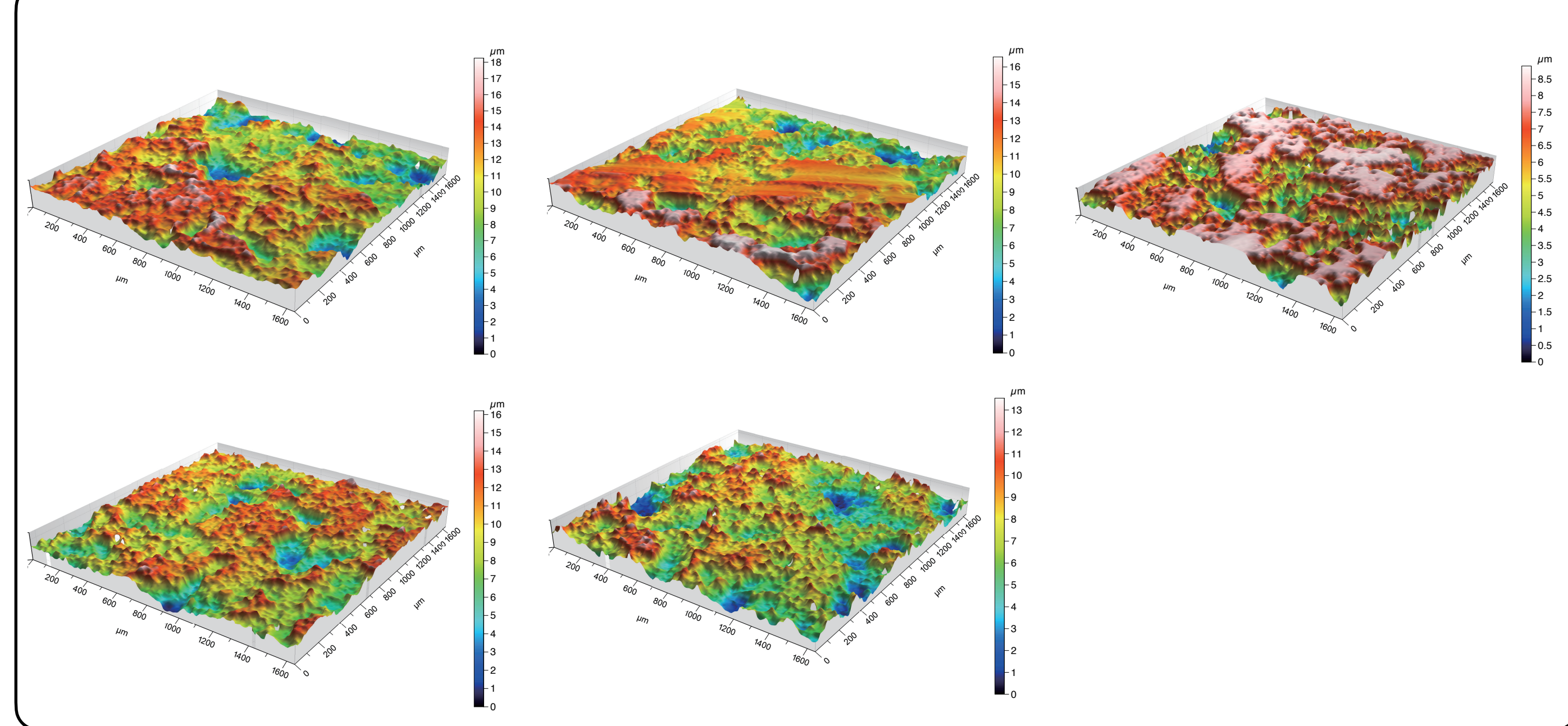


Rough
surface

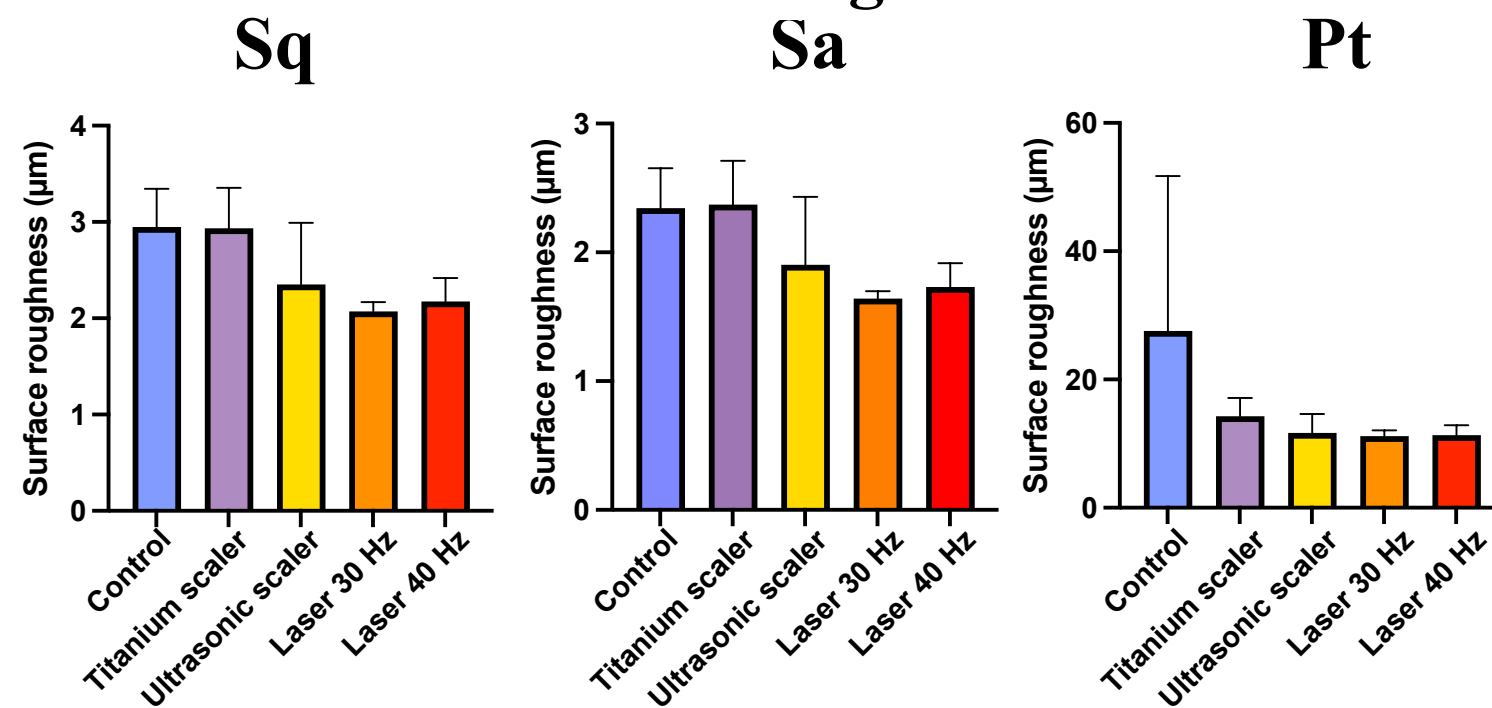
Machine
surface

SEM (X1000) Rough Surface Features after the Treatment

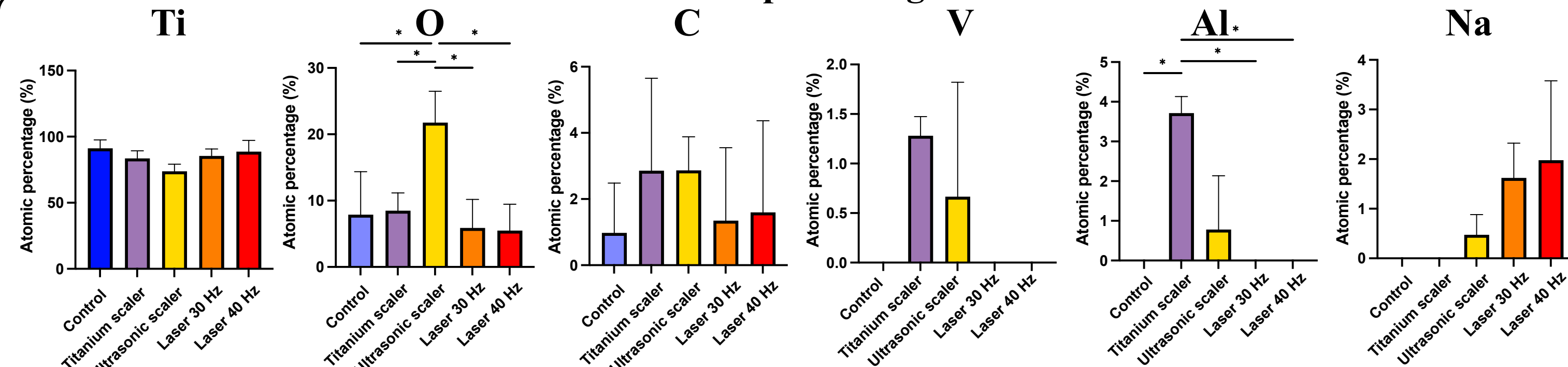
Profilometric surface topography



Surface roughness



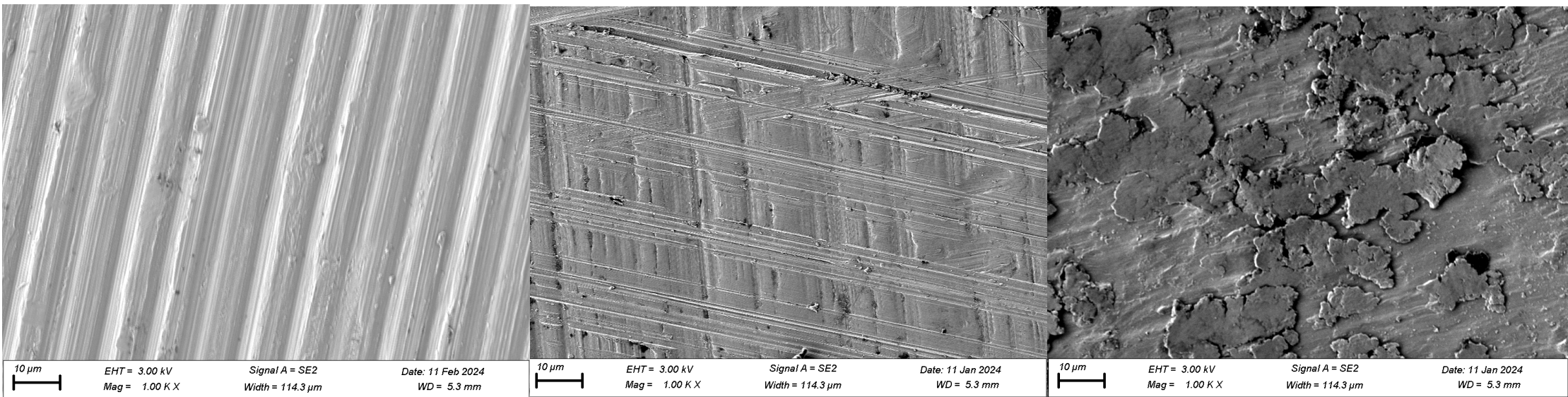
Atomic percentage



The titanium scaler and ultrasonic device changed the structure of the rough surface. Meanwhile, laser irradiation did not cause altered titanium microstructures. Deposits of oxygen on the surfaces when using the ultrasonic devices were statistically higher than in other groups. The aluminum deposit of the titanium scaler group statistically increased more than that of the laser and the control group.

SEM (X1000) Machine Surface Features after the Treatment

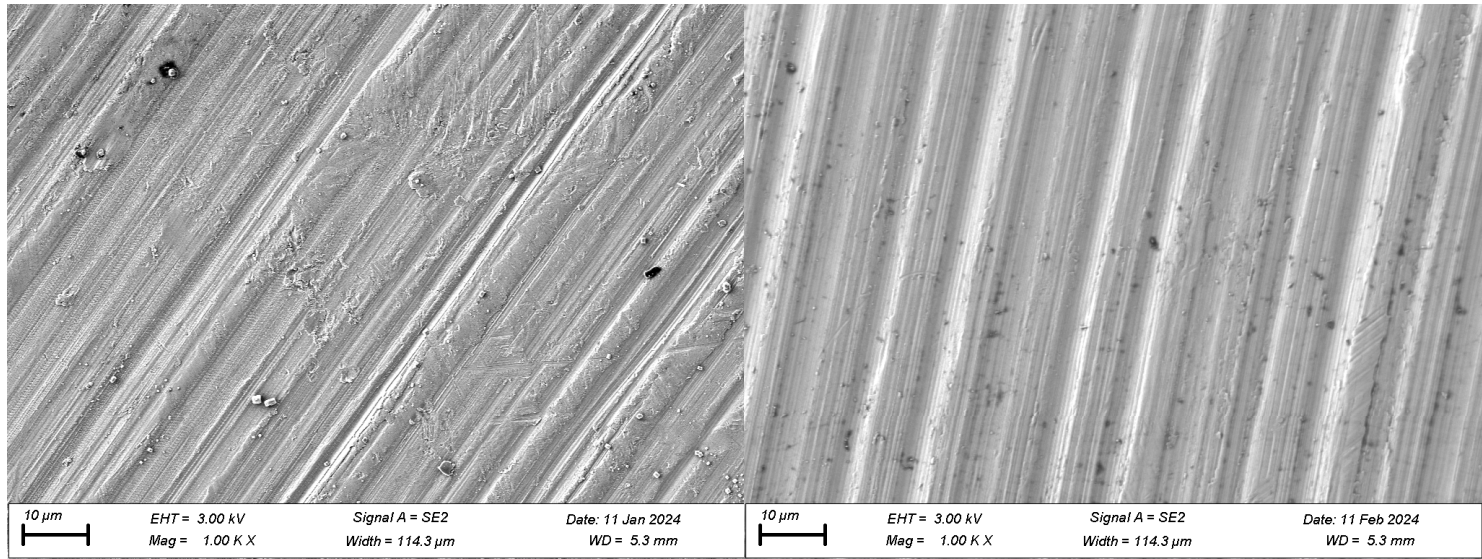
Profilometric surface topography



Control

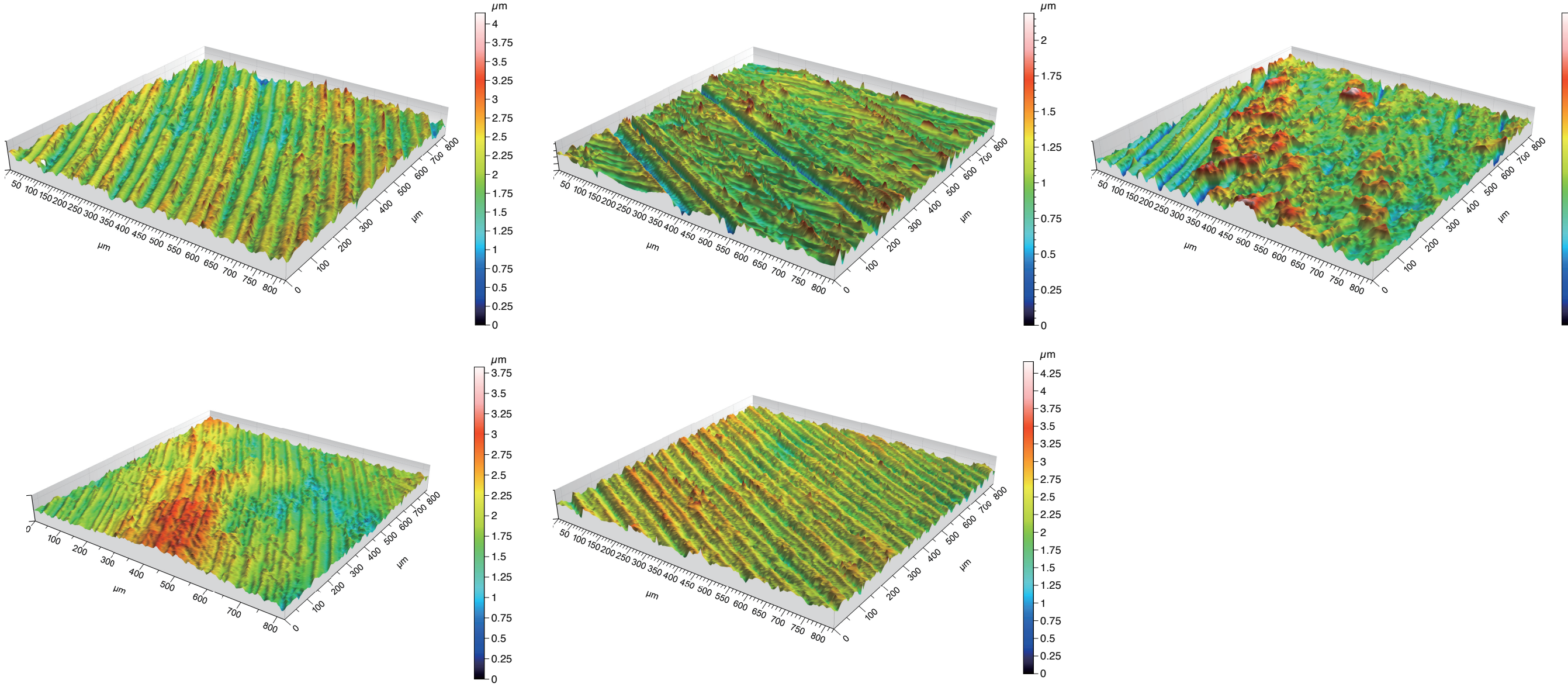
Titanium scaler

Ultrasonic scaler

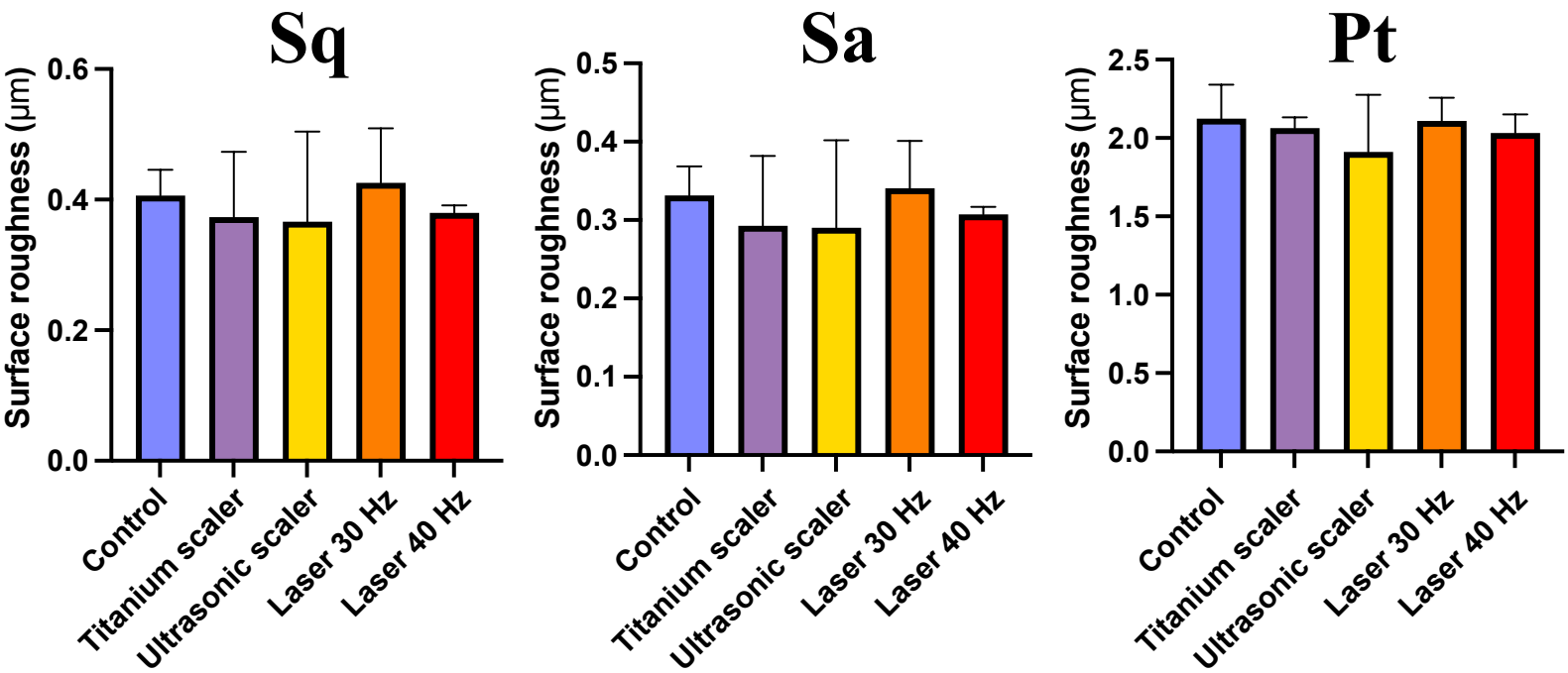


Laser 30Hz

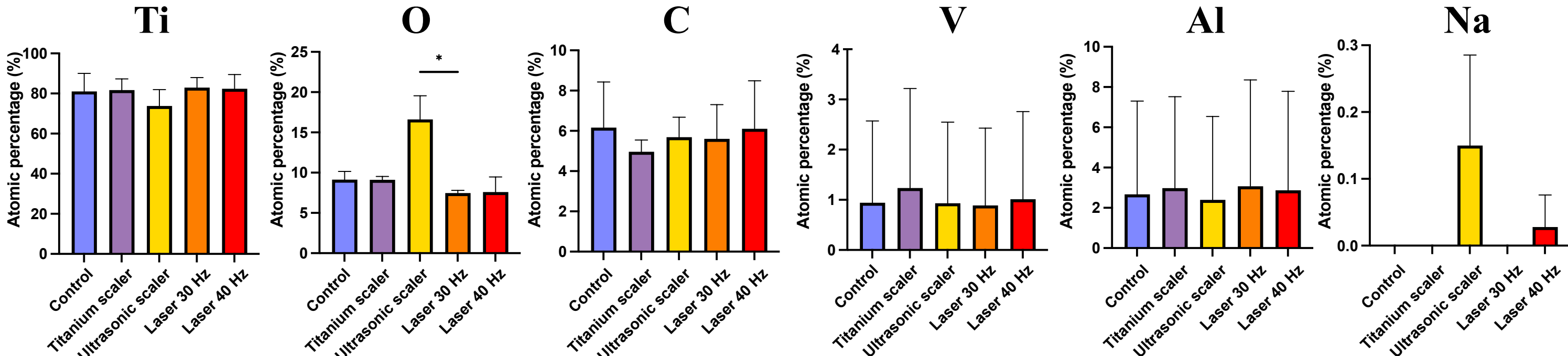
Laser 40Hz



Surface roughness



Atomic percentage

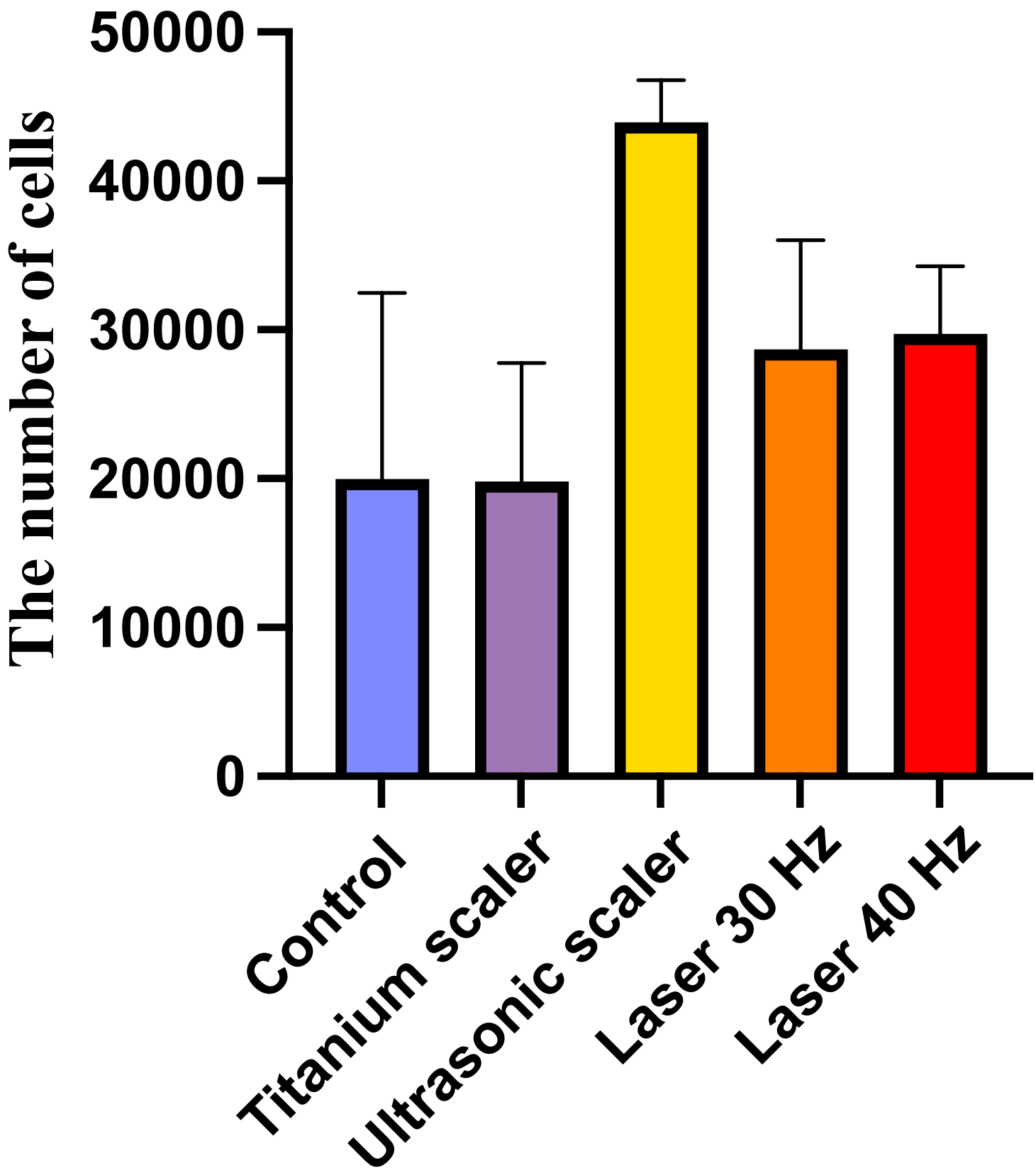


The titanium scaler and ultrasonic device dramatically changed the structure of the titanium machine surface as well. Meanwhile, laser irradiation did not result in altered titanium microstructures, and the surface roughnesses did not show statistical differences between groups. Deposits of oxygen on the surfaces when using the ultrasonic devices were statistically more than the 30 Hz laser group.

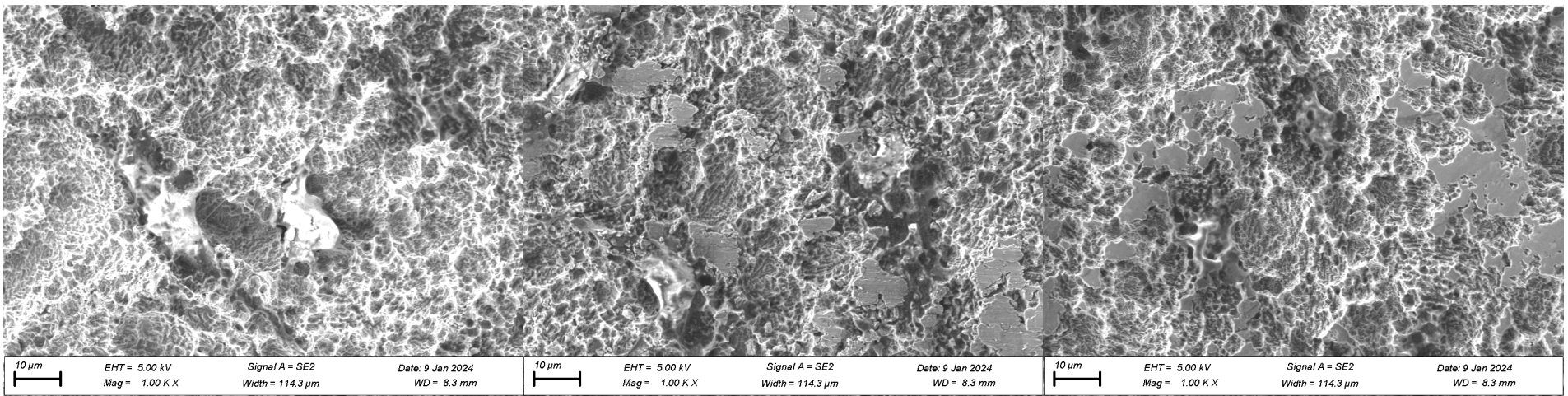
Cell Attachment on Rough Surfaces following the Surface Treatment

Osteoblast cell attachment

The number of osteoblast cell (MC3T-E1)
after 72 hours culture



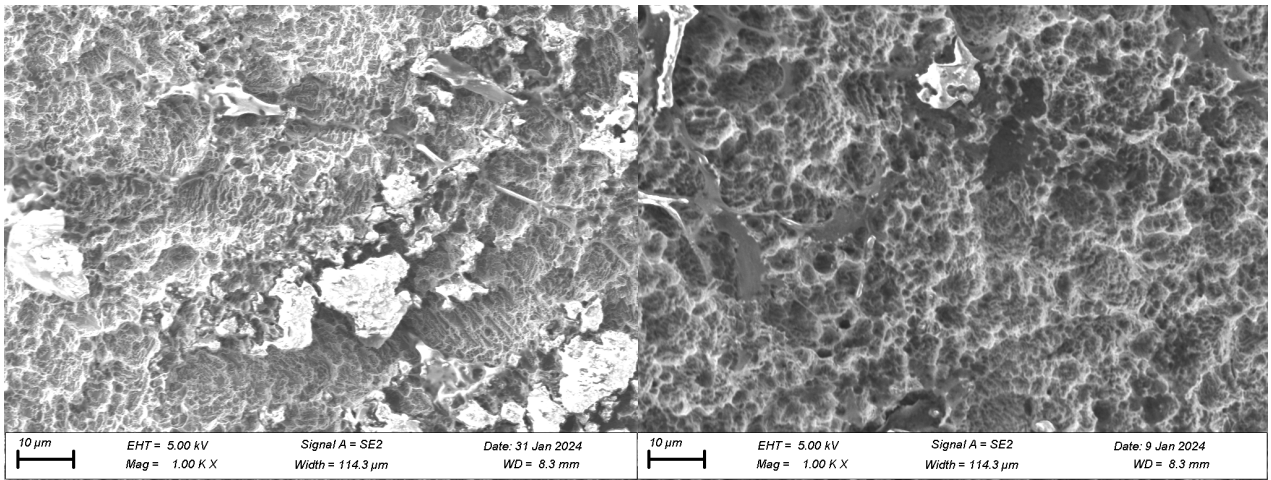
SEM (X1000)



Control

Titanium scaler

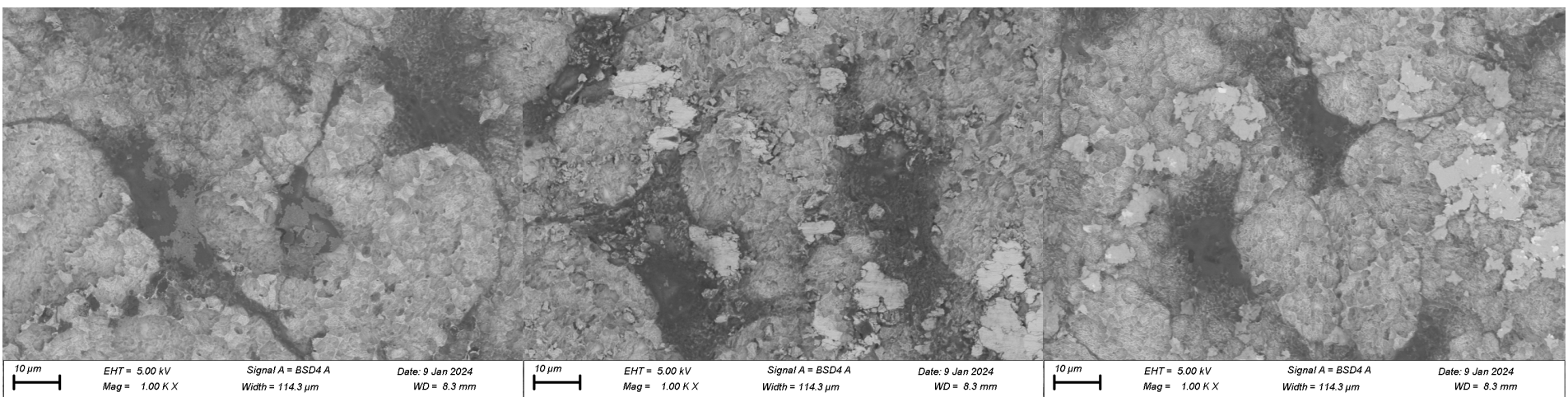
Ultrasonic scaler



Laser 30Hz

Laser 40Hz

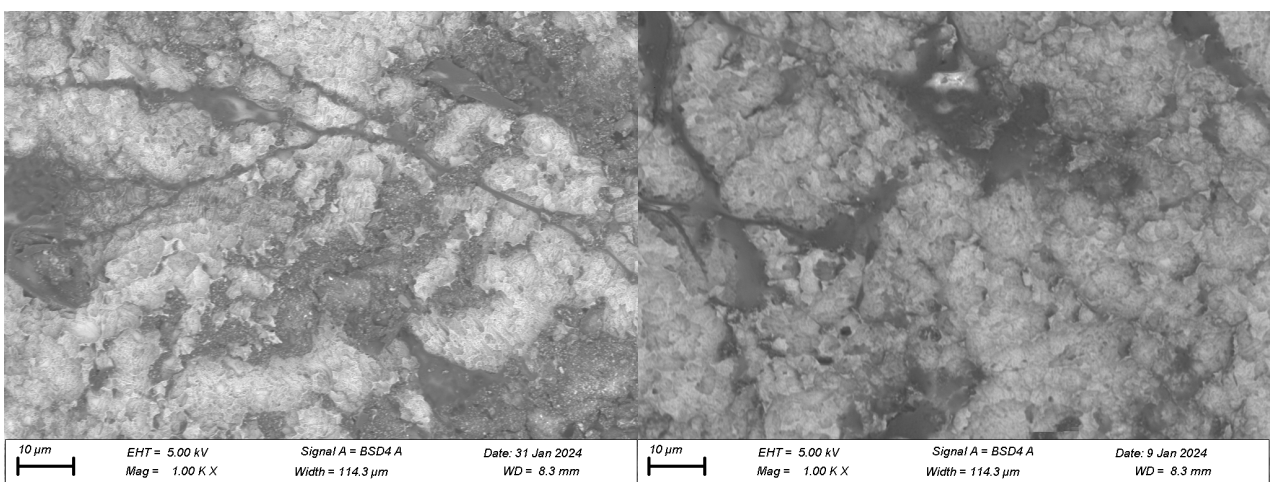
SEM in BSE (X1000)



Control

Titanium scaler

Ultrasonic scaler



Laser 30Hz

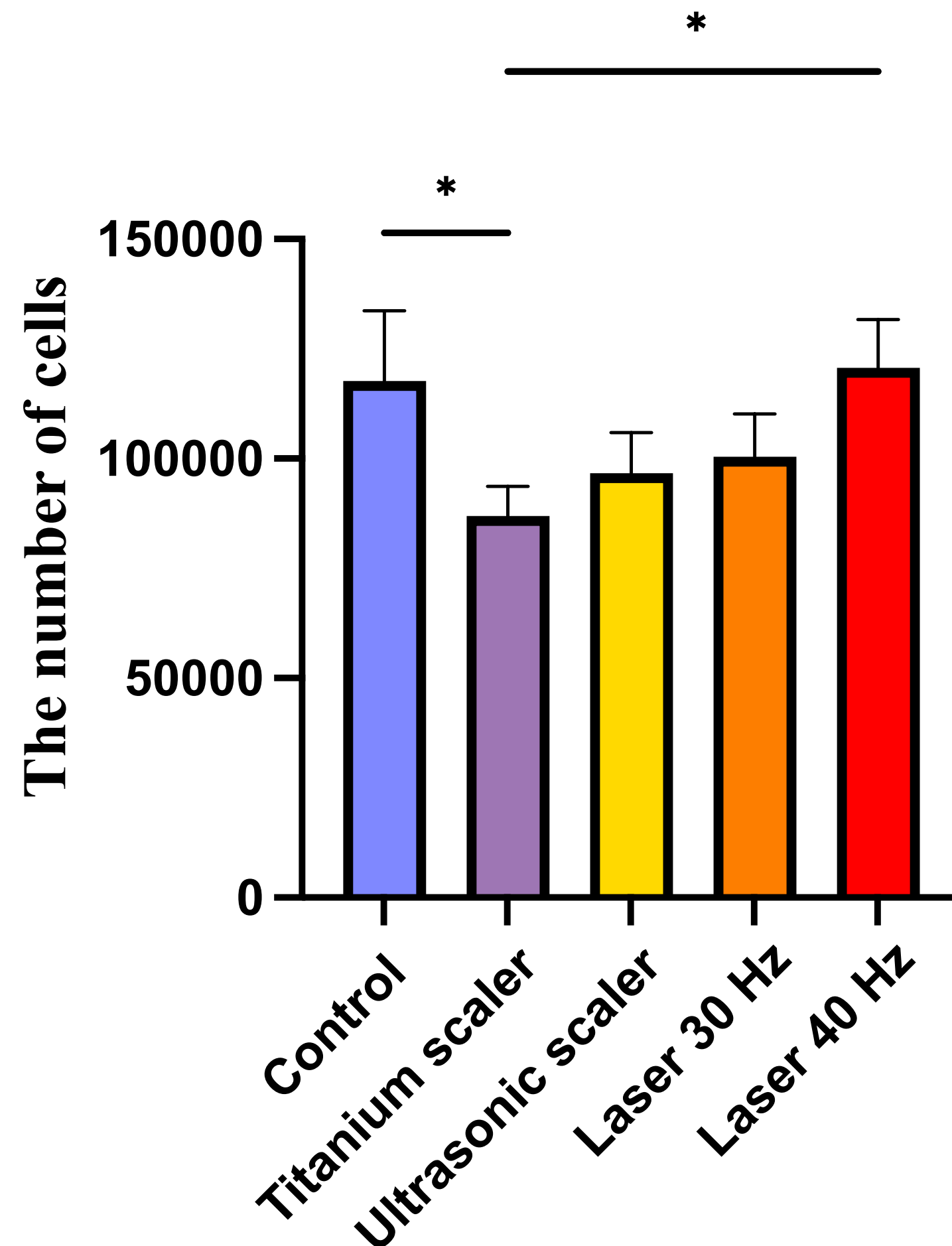
Laser 40Hz

The cell number of the ultrasonic scaler and Er,Cr:YSGG laser groups were more than that of the titanium scaler and control group. SEM and SEM in BSE corroborated the cell number of each group.

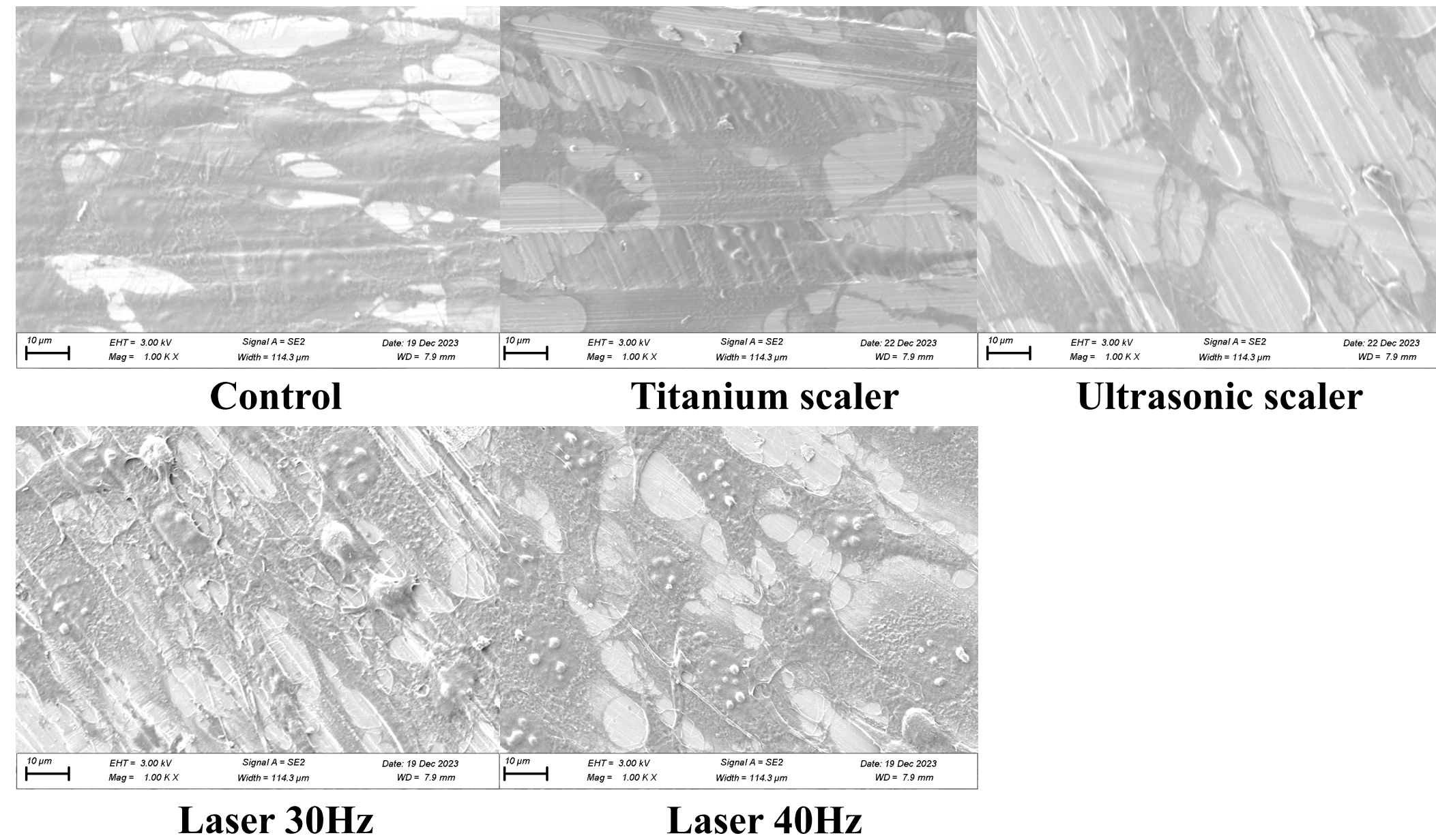
Cell Attachment on Machine Surfaces following the Surface Treatment

Fibroblast cell attachment

The number of fibroblast cell (NIH/3T3)
after 72 hours culture



SEM (X1000)



Er,Cr:YSGG laser with 40 Hz treatment group showed significantly higher fibroblast cell adhesion than the titanium scaler group. Further evaluations with SEM showed differences in cell morphology of Er,Cr:YSGG laser groups, indicating more adherent cells on Er,Cr:YSGG laser-treated surfaces.

Conclusion:

Our results demonstrated the surface changes when using ultrasonic instruments and hand scalers compared to the Er,Cr:YSGG laser group. The Er,Cr:YSGG laser was effectively promoting fibroblasts and osteoblasts to adhere to the titanium surface without significant surface changes, suggesting the Er,Cr:YSGG laser was superior compared to other debridement methods for the peri-implantitis treatment.