NANOVIS®

Anti-Aging Nanosurface to Preserve Nanosurface Functionality

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Introduction

Nanosurfaces are becoming more common in orthopedic, spine and dental implants because of their beneficial biological properties. One thing that they all suffer from is aging. Nanosurface aging is the changes in hydrophilicity and biological capability that occurs when implants are stored for a few months in packaging after manufacturing. The nanosurfaces create a high energy surface to better interact with ions and proteins in the host tissue so that they can better interact with cells. The high energy nanosurfaces also attract hydrocarbons from the environment while being stored in packaging. The degradation in biological properties starts within the first month, with full degradation occurring by 6 months[1-3]. Most implants sit on the shelf for several months to years before being implanted. There are some expensive and exclusive solutions such as packaging in wet solution or vacuum packing in metal foil to maintain the surface energy and prevent hydrocarbon contamination. So how does Nanovis protect implant nanosurfaces from losing their desired biological properties without cost prohibitive packaging solutions? A nano-thin calcium phosphate layer deposited onto nanotubes to preserve the high energy hydrophilic state of the surface. This paper highlights how the nanoVIS Ti™ surface prevented aging through tests on real-time aged screws and coupons for total organic carbon (TOC) and cell-based mineralization assay.

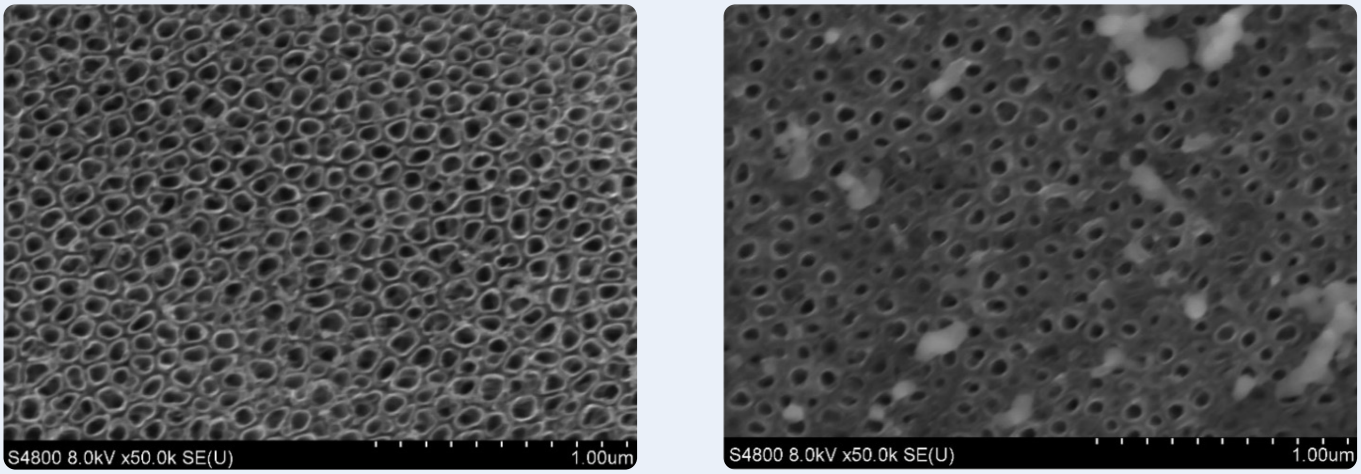


Figure 1: SEM images of nanoVIS Ti™ surface before (left) and after (right) application of calcium phosphate.

Methods

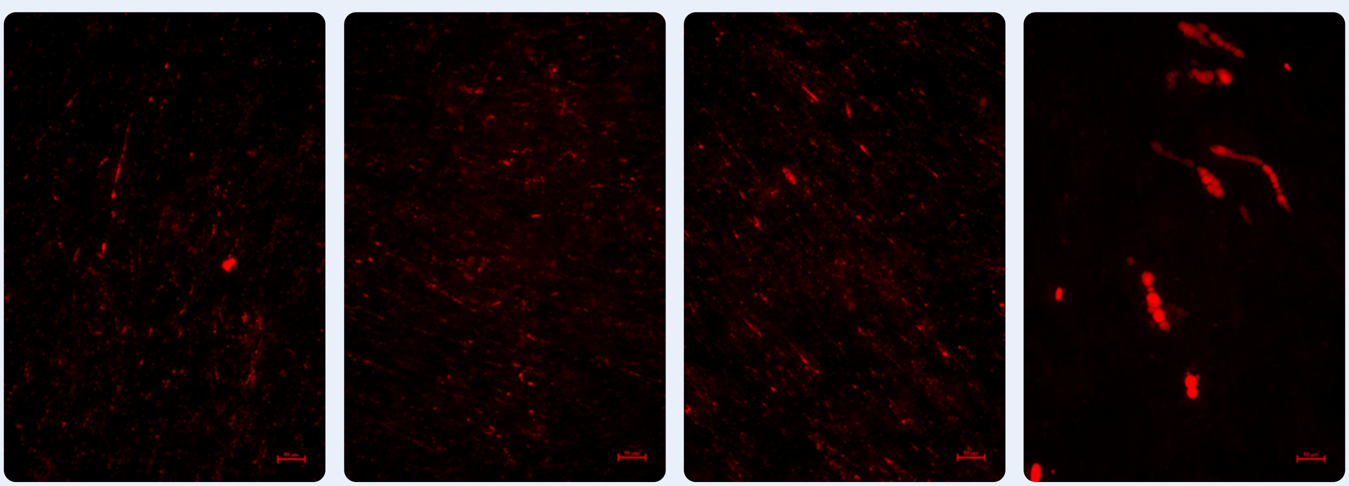
Real-time aging of screws in packaging was done with standard screw packaging: a thermoplastic polyurethane tip and thread protector double packed in Tyvek bags followed by gamma sterilization. The screws aged real-time on the shelf for 1 year prior to total organic carbon (TOC) testing at Nelson Laboratories. To measure the release of TOC from the screws, the screws were placed into deionized water for 72 hours at 37°C to allow the calcium phosphate to dissolve.

Mineralization testing was done with human osteoblasts on a group of surfaces: untreated control, acid etched nano roughened, calcium phosphate (CaP) control, and nanoVIS Ti™. Titanium coupons were used in place of screws. Coupons were packaged in double Tyvek pouches and gamma sterilized and allowed to age for 6-months real-time prior to testing. Osteoblasts created extracellular matrix that became mineralized over 21 days. Cells were fixed and stained with Alizarin Red to identify calcium deposition. The calcium deposition was imaged with fluorescent microscopy and quantified for total Alizarin Red staining.

Results

The real-time aging of screw test showed that after 72-hours the total calcium layer was almost completely dissolved. The TOC tests revealed a total of 10.2 µg TOC on control samples while the experimental nanoVIS Ti™ group had 3.6 µg TOC, a reduction of 64.8%

The real-time aging of the screws tested showed larger and more mature nodules on the nano FortiFix with nanoVIS Ti™ Surface Technology, Figure 2. The nano roughened acid etched surface showed no difference from either of the control surfaces. The nanoVIS Ti™ surface improved total mineralization by 31% over the control surface, Figure 3.



Untreated Control | **Nanorough Acid-Etch** | **CaP Control** | **Nano FortiFix™**

Figure 2: Human osteoblasts after 21 days of differentiation on 6-month real-time aged titanium alloy surfaces.

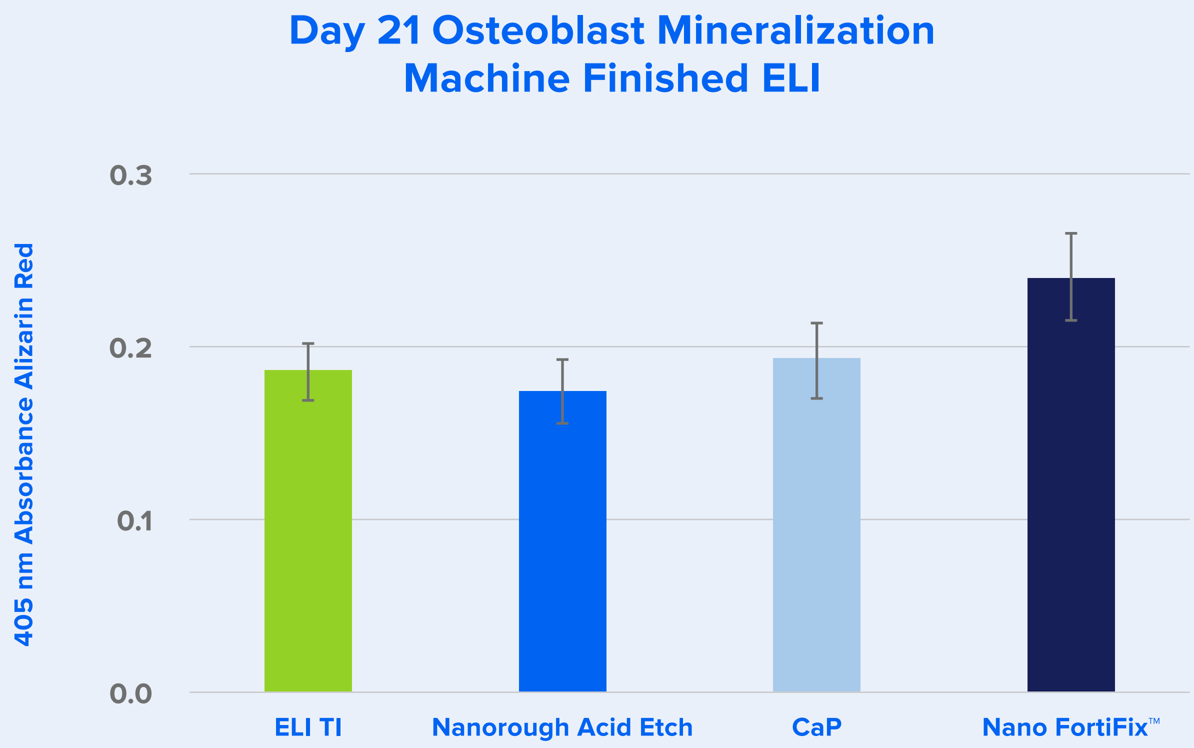


Figure 3: Quantified human osteoblast mineralization assay after 21 days in culture on various titanium alloy surfaces.

Discussion

Nanosurfaces can provide increased surface area and improved chemistry to bind proteins and cells and create structured spacing that allows for targeted differentiation of osteoblasts4. But the surface can only do its intended job if that surface is in a high energy state to interact with the ions and proteins when it is implanted[1-3]. Hydrocarbon accumulation on surfaces will occur on implants that sit on the shelf for more than a couple of weeks without special packaging[1-3]. Nanovis' nano-thin calcium phosphate deposition was demonstrated to be an effective alternative to preserve surface energy without the need for special packaging. Preserving the surface energy to give the patient the best possible outcome is an important consideration in the manufacture of implants with nanosurfaces.

Conclusion

Nanovis has engineered a titanium nanostructured surface that has received FDA clearance and a Nanotechnology Designation. The nanoVIS Ti™ surface is engineered to protect the high energy nanosurface while it sits on the shelf for up to 8 years. The protective calcium phosphate then dissolves away when implanted to reveal the high energy nanotubes that are engineered to increase and accelerate the production of calcified extracellular matrix. This technology provides a durable and functional implant surface that is cost-effective in the competitive implant marketplaces of spine, dental and orthopedics.

References

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