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Objectives: Additive-manufacturing (AM) offers the ability to tailor implants to individual patients. In vitro studies show AM-fabricated 3D constructs with microstructured surface topography support osteoblast differentiation. This study used rat and rabbit models to determine if 3D titanium-aluminum-vanadium (Ti6Al4V) constructs can support osteogenesis in vivo.

Material and Methods: Ti6Al4V disks and wrap implants were produced by AM and acid-etched to create a specific microsurface. (A) 5.0mm disks with 0.05mm holes were implanted subperiosteally on the calvaria of male Sprague-Dawley rats. Prior to insertion, bone was treated by in-situ decalcification (Fig 1). Groups included no treatment, 24% EDTA, or 37% phosphoric acid (n=6/group). Animals were euthanized at 35 and 70 days. (B) Wrap implants were surgically affixed to left tibias of 30 New Zealand White rabbits. Animals were euthanized at 1 week (n=3), 3 weeks (n=16), or 6 weeks (n=11). Fixed samples were analyzed by microCT and histology.

Results: (A) Osteointegration was found on the base of the disks and bone infiltration into implant holes was achieved at 35 and 70 days. Bony ingrowth varied within each treatment group, but no difference was found between groups. (B) No new bone was observed in the wrap implants at 1w. At 3w bone formed outside the envelope and cartilage-in-transition-to bone was found. At 6w bone formed between implant and cortical bone with full osteointegration (Fig 2). Bone-implant-contact increased, and was significantly higher at 6w compared to earlier times (Fig 3).

Conclusion: Using a titanium alloy implant with a specific surface roughness allows for good osteoconduction and osteointegration, as well as the potential for bone to grow into a void space without the use of a bone graft substitute. In rats, there was no difference seen in pretreatment of the bone surface prior to implantation. However, all treatment groups showed vertical growth of bone into the holes of the implant after 70 days demonstrating the osteoconductive ability of the implant material. The titanium wrap used in rabbits allowed osteointegration as early as 6w, as well as the creation of vertical growth through the implant holes. These results suggest that this approach may enable consistent vertical growth of bone during implant placement as was demonstrated in two different animal models.

Support: All Ti6Al4V alloy implants were manufactured and provided by AB Dental (Ashdod, Israel). NIH AR052102.

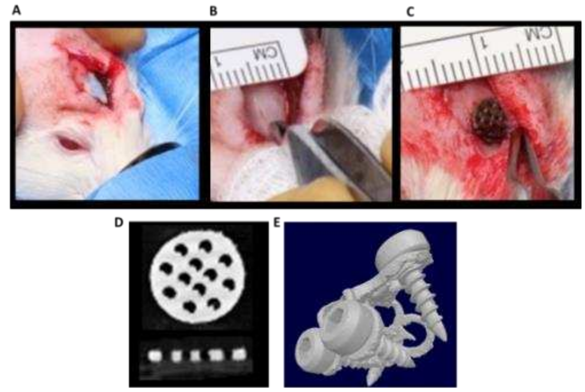

Fig.1: A) Application of treatment to bone surface. **B)** Calvaria following *in situ* decalcification. **C)** Implantation of disk. **D)** MicroCT image of disc implant **E)** MicroCT 3D image of wrap implant.

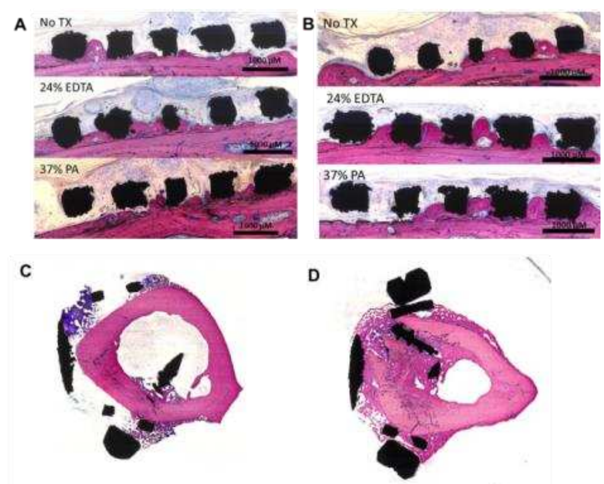

Fig 2: Stevenel's Blue Histologic Samples: **A)** Disk at 35 days. **B)** Disk at 70 days. **C)** Cartilage in transition to bone at 3w in wrap implant **D)** Wrap implant at 6w.

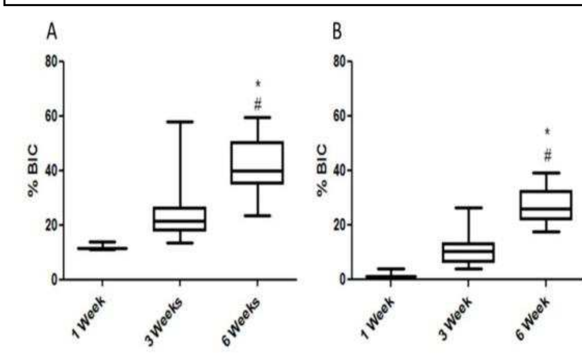

Figure 3: Wrap implant results: **A)** Bone-implant-contact analysis of microCT. **B)** Bone-implant-contact histomorphometric analysis. * $p<0.05$ v. 1w, # 3 w.