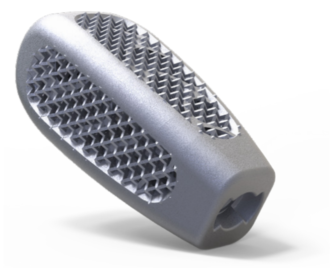
The Evolution
of Interbody Fusion

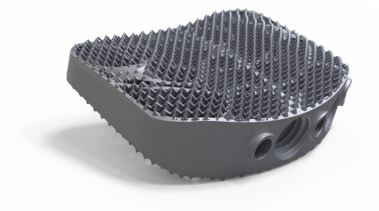
Avenue® - **T Ta**



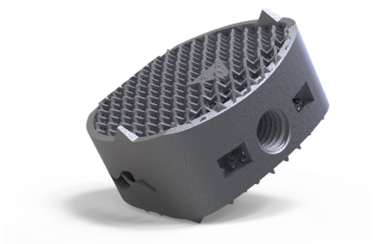
Avenue® - **P Ta**

Avenue® Ta

3D Printed **Tantalum** Cages Platform



Avenue® - **A Ta**



Avenue® - **C Ta**

Avenue® - **L Ta**

ZimVie

ZimVie SPINE SOLUTIONS

Introducing

Avenue® Ta

3D Printed **Tantalum** Cages Platform

Advancing patient care with our newest 3D printed tantalum interbody platform. Engineered for the perfect balance of porosity and strength, the distinctive structure of these spinal cages are designed for an optimal scaffold. Available in a broad range of sizes, the Avenue® Tx Interbody System is designed to fit the anatomy of all patients.

The comprehensive Avenue® Interbody product range consists of both static 3D printed Tantalum, and static, built-in fixation and expandable 3D printed Titanium.

The Evolution of Interbody Fusion

The Avenue Ta line of products is designed to have the following structural, functional, and physiological features:

Primary Stability

- The special "net" structure obtained through additive manufacturing technology, is designed to provide strong primary fixation and to minimize implant migration risk.

Wide Variety of Footprints, Heights and Lordosis Angles

- One system intended to match patients' natural anatomy and surgeons' preferences.

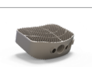
Fusion Promotion

- Pore size of the net structure and the surface roughness of the implant edges intended to facilitate fast and effective osteo-integration.
- The elasticity modulus of the implant, similar to PEEK, is designed to be close to natural bone characteristics.

Tantalum is one of the most Chemically Stable Metals

- Porous Trabecular Metal in Tantalum has been used in Orthopaedic implants for more than 25 years with plenty of clinical publications evaluating its use, amongst which we find those referred to in this document[1-13], and each one with its own references to other publications on this metal.

Avenue® Ta – 3D Printed Tantalum Interbody Platform

Description			Footprint	Lordosis	Height
	Avenue - P Ta	PLIF	24 x 10 mm, 29 x 10 mm	0°, 5°, 8°, 14°	7 - 15 mm (1 mm increments)
	Avenue - T Ta	TLIF	29 x 9 mm, 32 x 9 mm, 32 x 10 mm	5°, 8°, 15°	7 - 15 mm (1 mm increments)
	Avenue - L Ta	LLIF	42 x 18 mm, 48 x 18 mm, 52 x 18 mm, 58 x 18 mm	5°, 8°, 14°	7, 9, 11, 13 mm
	Avenue - A Ta	ALIF	30 x 24 mm, 32 x 22 mm, 32 x 24 mm, 38 x 28 mm	5°, 8°, 14°	8, 10, 12, 14, 15mm
	Avenue - C Ta	ACDF	14x12mm, 14x14mm, 16x14mm, 18x16mm	5°	5 - 9 mm (1 mm increments)

NOTE: Variations of sizes may not be available in all markets.

Tantalum in Medical Applications[1]

Numerous articles have been published that reviewed the use of tantalum for orthopedic applications[2].

These articles review the reported attributes in these applications, such as Tantalum's inert bioactivity[3], antithrombotic property; enhancement of macrophage response[4] and bactericidal properties[5].

Specific studies have noted the porous Tantalum morphology as a framework for bone growth and osteoblast interaction[6].

According to one of the publications reviewed, additional evidence have indicated that human osteoblasts (cell line hFOB) exhibit potentially six time higher living cell density on Tantalum as compared to Titanium[7].

Selective Laser Melting (SLM) produced tantalum porous-structure also seemed to demonstrate mechanical properties relatively similar to human bone and osseointegration as compared to similar porous Ti-6Al-4V structures. A conclusion reached from one of these works was that "laser-melted tantalum shows excellent osteoconductive properties, has higher normalized fatigue strength and allows for more plastic deformation due to its high ductility"[8].

Osteoconductive

Osseointegration

Fatigue Strength

Bacterial Adherence to Tantalum Versus Commonly Used Orthopedic Metallic Implant Materials[9]

Based on the results of this study[9], Pure tantalum presents with a lower or similar S. aureus and S. epidermidis adhesion when compared with other commonly used materials.

Because bacterial adhesion is an important predisposing factor in the development of clinical implant infection, **Tantalum may offer benefits as an adjunct or alternative material compared with current materials commonly used for orthopedic implants.**

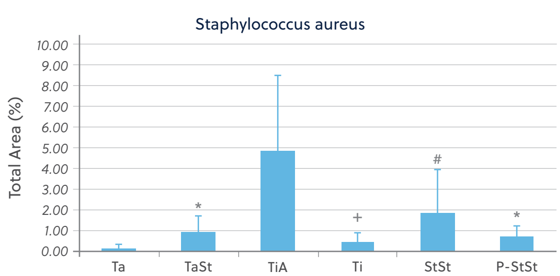


Figure 1[9]. Adhesion of S. aureus to metallic implants. The data (mean values ± SD of independent experiments, n = 5) represent the percentage of metallic surface area covered by bacteria as analyzed by fluorescence microscopy and digital image processing.

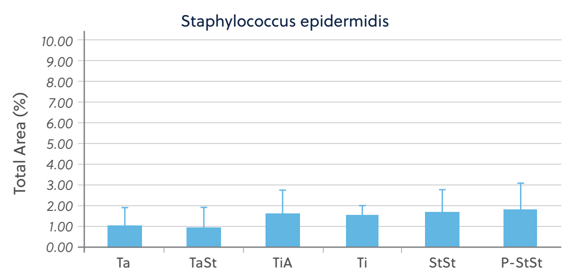


Figure 2[9]. Adhesion of S. epidermidis to metallic implants. The data (mean values ± SD of independent experiments, n = 5) represent the percentage of metallic surface area covered by bacteria as analyzed by fluorescence microscopy and digital image processing.

According to another publication[10], the adhesion of fibroblasts to tantalum was faster and better than that of titanium.
Moreover, what is more, interesting is that, in an early period, bacteria were more likely to adhere to cells that had already attached to the surface of tantalum than to the bare surface of it, and over time, the cells eventually fell off the biomaterials and took away more bacteria in tantalum, **making it possible for tantalum to reduce the probability of infection in the body through this mechanism[10].**

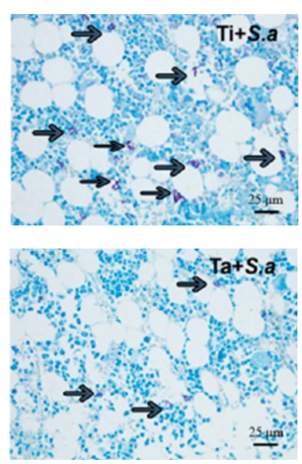


Figure 3[10]. Giemsa staining of Ti + S. a and Ta+ S. a groups and scale bar = 25 m. (the black arrow represents bacteria)

Reduced probability of infection[10]

Tantalum Imaging Basics

Based on collected data, on **Magnetic Resonance Imaging**, the porous tantalum implant demonstrated less artifact than did the titanium spacer on T1- and T2-weighted spin echo and on T2*-weighted gradient-echo magnetic resonance images. On **Computed Tomographic** scans, more streak artifact was associated with the tantalum implants than with the titanium[12, 13].

Imaging devices manufacturers typically offer different tools and recommendations to minimize artifacts generated by metal implants on both MRI and CT. Check corresponding device manuals for further information.

Figure 4[13]. 1 year following ACDF, new onset symptoms prompted a Magnetic Resonance Imaging (MRI) study. a) Axial T1 images. b) sagittal T2 images both show excellent resolution of neural structures.

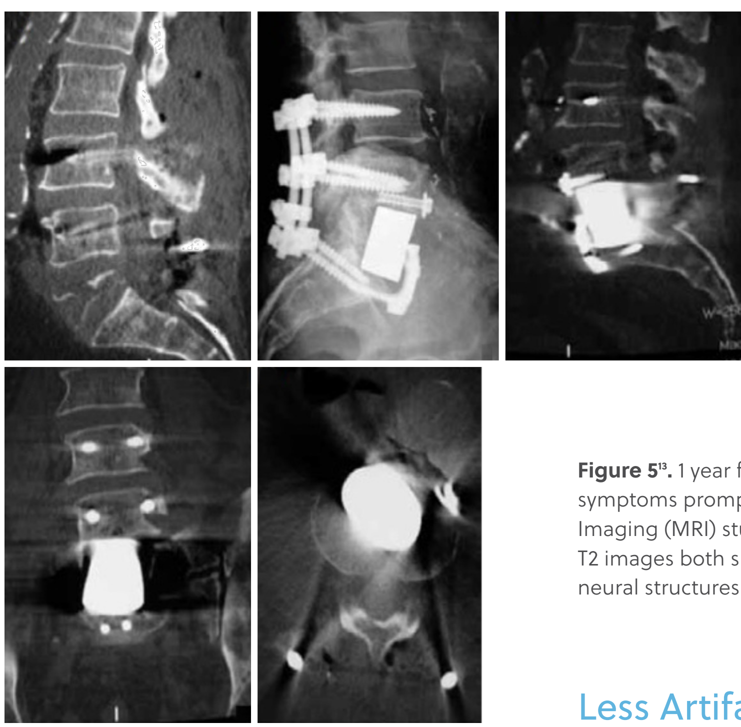


Figure 5[13]. 1 year following ACDF, new onset symptoms prompted a Magnetic Resonance Imaging (MRI) study. a) Axial T1 images. b) sagittal T2 images both show excellent resolution of neural structures.

Less Artifacts than Ti on MRI

References

1. Tantalum in Medical Applications.Global Advanced Metals Report. 25-Jan-2019

2. Balla, Vamsi Krishna: Bodhak, Subhadip; Bose, Susmita and Bandyopadhyay, Amit. Porous Tantalum Structures for Bone Implants: Fabrication, Mechanical and In vitro Biological Properties. Acta Biomater. 2010 Aug; 6(8): 3349–3359. Paganias, Christos G.; Tsakotos , George A.; Koutsostathis, Stephanos D. and Macheras, George A. Osseous integration in porous tantalum implants. Indian J Orthop. 2012 Sep-Oct; 46(5): 505–513.

3. Barbinta AC, Chelariu R, Crimu CI, Istrate B, Nazarie S, Earar K, Munteanu C. Metallographic characterization of a new biomedical titanium-based alloy for orthopedic applications. Bulletin of the Transilvania University of Brasov. Series I: Engineering and Science. 2013; 6(55):83-8.

4. C. B. Johansson, H. A. Hansson, and T. Albrektsson, "Qualitative interfacial study between bone and tantalum, niobium or commercially pure titanium," Biomaterials, vol. 11, no. 4, pp. 277–280, 1990.

5. Schildhauer T.A., Peter E, Muhr G, Köller M. Activation of human leukocytes on tantalum trabecular metal in comparison to commonly used orthopedic metal implant materials. J Biomed Mater Res A. 2009 Feb;88(2):332-41.

6. D. M. Findlay, K. Welldon, G. J. Atkins, D.W.Howie, A. C.W. Zannettino, and D. Bobyn, "The proliferation and phenotypic expression of human osteoblasts on tantalum metal," Biomaterials,vol. 25, no. 12, pp. 2215–2227, 2004. Paganias, Christos G.; Tsakotos , George A.; Koutsostathis, Stephanos D. and Macheras, George A. Osseous integration in porous tantalum implants. Indian J Orthop. 2012 Sep-Oct; 46(5): 505–513.

7. Balla VK, Banerjee S, Bose S, Bandyopadhyay A. Direct Laser Processing of Tantalum Coating on Titanium for Bone Replacement Structures. Acta Biomater. 2009 doi:10.1016/j.actbio.2009.11.021.

8. Wauthle, Ruben; Van der Stok, Johan; Yavari, Saber Amin and Schrooten, Jan. Additively manufactured porous tantalum implants. Acta Biomaterialia. March 2015.

9. Bacterial Adherence to Tantalum Versus Commonly Used Orthopedic Metallic Implant Materials. Thomas A. Schildhauer, MD, Bruce Robie, PhD, Gert Muhr, MD, and Manfred Ko¨ller, PhD. J Orthop Trauma 2006;20:476–484

10. Why Is Tantalum Less Susceptible to Bacterial Infection? Chen, X.; Bi, Y.; Huang, M.; Cao, H.; Qin, H. J. Funct. Biomater. 2022, 13, 264. https://doi.org/10.3390/ jfb13040264

11. Is tantalum protective against infection in revision total hip arthroplasty? T. Tokarski, BS, Research Fellow. T. A. Novack, BS, Research Fellow. J. Parvizi, MD, FRCS, Orthopaedic Surgeon. Bone Joint J 2015; 97-B:45–9.

12. The radiographic and imaging characteristics of porous tantalum implants within the human cervical spine. Allan D.O. Levi, MD, phD, FRCS(C), * Won Gyu, MD, † Paul J. Keller, PhD, ‡ Joseph E. Heiserman, MD, ‡ Volker K.H. Sonntag, MD, FACS, ‡ and Curtis A. Dickman ‡. Spine, Volume 23, Number 11, pp 1245-1251. 1998

13. Advanced Radiographic Imaging Results in Patients with Trabecular Metal™ Spinal Implants. Whitmore et al., J Spine Neurosurg 2013, 2:5

For more information, visit ZimVie.com

BIOMET 3i Dental Iberica
SLU WTC Almeda Park, Ed. 4, Planta 2
C/Tirso de Molina, 40
08940 - Cornellà de Llobregat
(Barcelona) Spain

Tsunami Medical, S.r.l.
HQ: Via E. Giorgi 27 - 41124 Modena, Italy
OHQ: Via XXV Aprile 22 - 41037 Mirandola, Italy
Phone: +39 0535 38397
Fax: +39 0535 38399

ZimVie
Restoring Daily Life.®