



Trabecular  
Metal™  
Technology

The Best Thing Next to Bone™

Introducing osseoincorporation to implant dentistry.



**zimmer** | dental

# TRABECULAR METAL TECHNOLOGY

**Trabecular Metal Technology is an innovative material utilized by Zimmer for over 15 years in implantable orthopaedic devices. Uses of Trabecular Metal Material are varied and have included joint reconstruction, bone void filling and soft tissue repair.<sup>1-3</sup> Zimmer Dental is currently working on multiple ways to integrate Trabecular Metal Technology into its oral rehabilitation portfolio.**

## What is Trabecular Metal Technology?

Trabecular Metal Technology is a three-dimensional material, not an implant surface or coating. Its structure is similar to cancellous bone.<sup>4-6</sup>

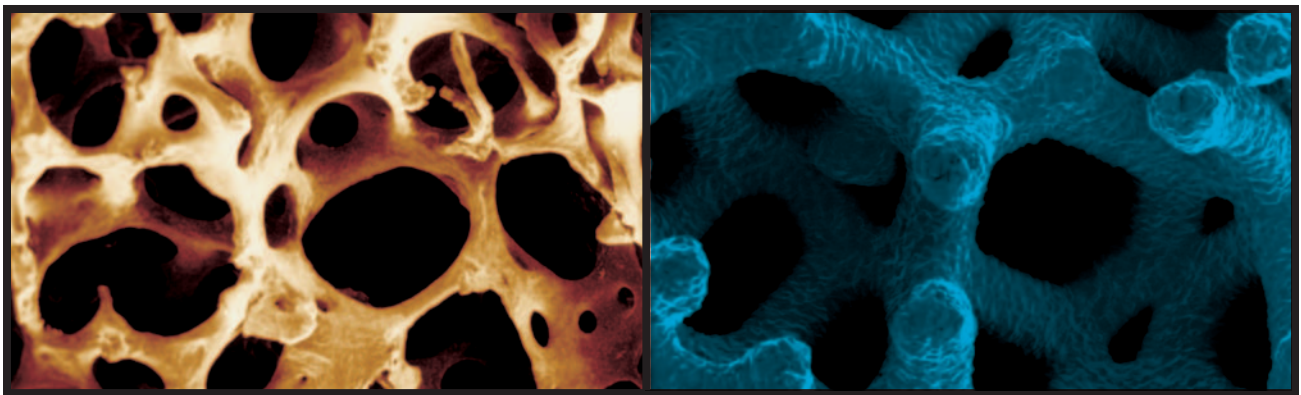


Figure 1 Trabecular Metal Material's structure is similar to cancellous bone<sup>4-6</sup>

40 2 8 18 10 2 <b>Zr</b> Zirconium 91.224	41 2 8 18 12 1 <b>Nb</b> Niobium 92.90638	42 2 8 18 13 1 <b>Mo</b> Molybdenum 95.94
72 2 8 18 32 10 2 <b>Hf</b> Hafnium 178.49	73 2 8 18 32 11 2 <b>Ta</b> Tantalum 180.9479	74 2 8 18 32 12 2 <b>W</b> Tungsten 183.84
104 2 8 18 32 33 10 2 <b>Rf</b> Rutherfordium (261)	105 2 8 18 32 32 11 2 <b>Db</b> Dubnium (262)	106 2 8 18 32 32 12 2 <b>Sg</b> Seaborgium (266)

Figure 2 Tantalum is element 73 in the periodic table

## Tantalum

Trabecular Metal Material is made of tantalum, element number 73 in the periodic table. Tantalum is a highly biocompatible and corrosion-resistant metal<sup>7-11</sup> used in various implantable devices for over 60 years,<sup>12-16</sup> including a dental implant in the 1940s.<sup>16</sup> Per-Ingvar Brånemark, known as the father of modern dental implantology, conducted osseointegration research in the 1950s utilizing tantalum.<sup>17</sup>

While the highly biocompatible and passive characteristics of tantalum were documented long ago, its cost and methods of production limited its use<sup>12</sup> until the late 1990s. Since then, hundreds of thousands of Zimmer Trabecular Metal Implants have been sold.<sup>18</sup>

## How is Trabecular Metal Material Made?

*Trabecular Metal* Material is fabricated in Zimmer's TMT facility in Parsippany, New Jersey. The *Trabecular Metal* material process demands strict specifications for pore size, shape and interconnectivity to ensure a cancellous bone-like structure is obtained. Utilizing a thermal deposition process, elemental tantalum is deposited onto a substrate, creating a nanotextured surface topography to build *Trabecular Metal* Material, one atom at a time. This proprietary process utilizes the physical and biological properties of tantalum to create a unique material that has a structure similar to cancellous bone.<sup>4-6</sup>



Figure 3 Numerous Zimmer Implants contain *Trabecular Metal* Material

## Material Properties

*Trabecular Metal* Material has a low modulus of elasticity (2.5-3.9 GPa) closer in value to cancellous bone than titanium (106-115 GPa).<sup>4,5</sup> In compression testing, *Trabecular Metal* Material exhibits high ductility without mechanical failure.<sup>19\*</sup>

The *Trabecular Metal* Material has been demonstrated to contribute to the primary stability of the implant based on in vitro insertion torque testing.<sup>20-23</sup>

\*NOTE: In the dental implant configuration, the overall compression strength and elasticity will be a function of multiple materials.

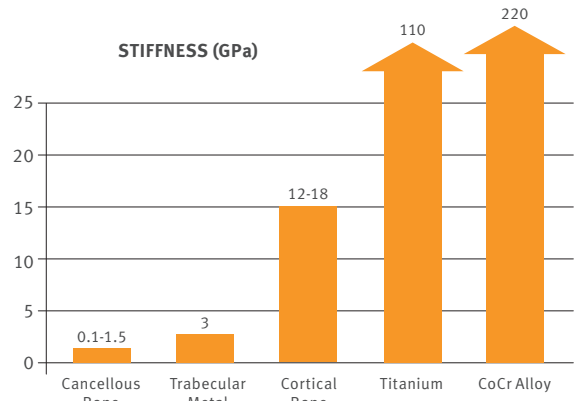


Figure 4 *Trabecular Metal* Material's modulus of elasticity (2.5-3.9 GPa) is closer to both cancellous bone (6.8 GPa) and cortical bone (13-17 GPa) than titanium (106-115 GPa), cobalt chromium (210 GPa) or stainless steel (230 GPa).<sup>4,5</sup>

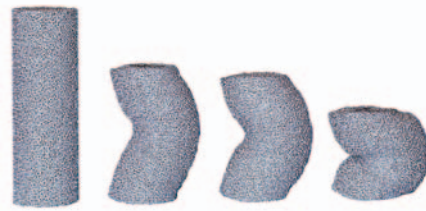
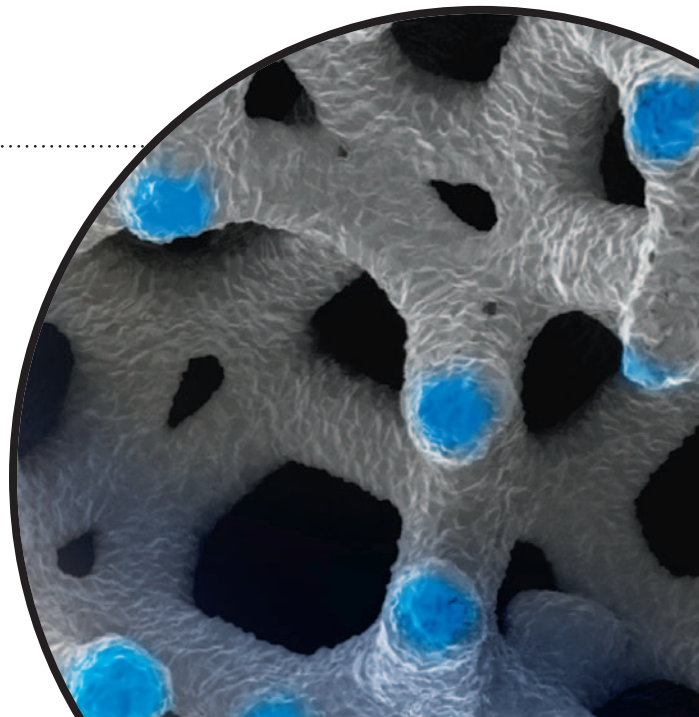


Figure 5 Ductility without mechanical failure<sup>19</sup>

Figure 6 *Trabecular Metal* Material forms a frictional interface with bone<sup>20-23</sup>



# POTENTIAL FOR BONE INGROWTH

## Topography

A glimpse inside *Trabecular Metal* Material reveals its uniform three-dimensional cellular architecture with up to 80% porosity.<sup>2-4,6,24,25</sup> The entire surface area of *Trabecular Metal* Material exhibits a nanotextured topography.<sup>26,27</sup>

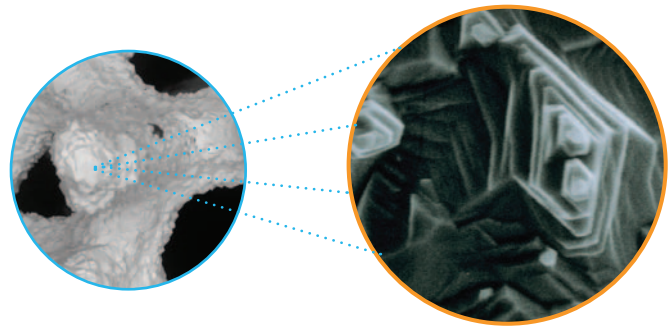
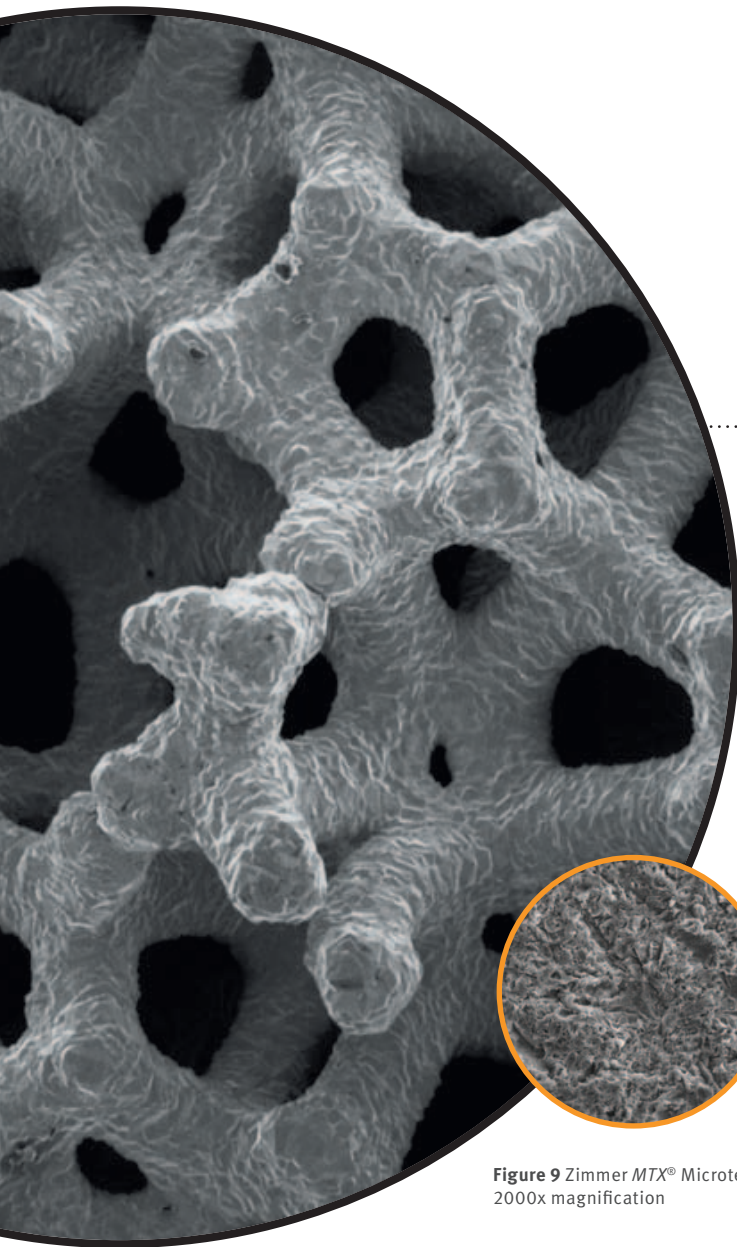


Figure 8 Nanotextured surface topography of *Trabecular Metal* struts

## Osseoincorporation

Conventional textured or coated implant surfaces achieve bone-to-implant contact, or ongrowth.<sup>17</sup> However, *Trabecular Metal* Material's consistent, open and interconnected network of pores is designed for both ongrowth AND ingrowth, or osseoincorporation.<sup>2,4,24</sup> Bone has the potential to grow onto the nanosurface of the *Trabecular Metal* Material, into its interconnected pores and around its struts.<sup>4,5,25,28,32</sup>

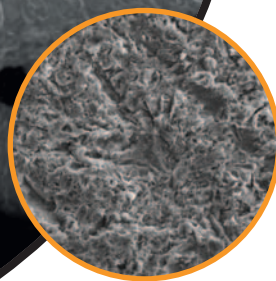


Figure 9 Zimmer MTX® Microtexture at 2000x magnification

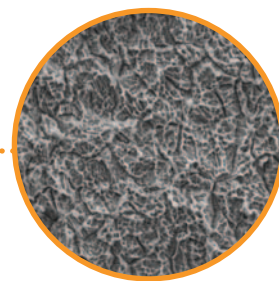


Figure 10 Straumann SLActive™ at 2000x magnification

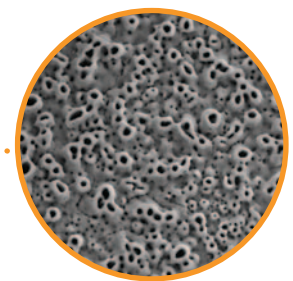


Figure 11 Nobel Biocare TiUnite® at 2000x magnification

Figure 7 Three-dimensional uniformity with up to 80% porosity<sup>2-4,6,24,25</sup>

Traditional Implant Surfaces Have the Potential for Bone Ongoing,<sup>17</sup>  
But Not Bone Ingrowth

# AS WELL AS ONGROWTH

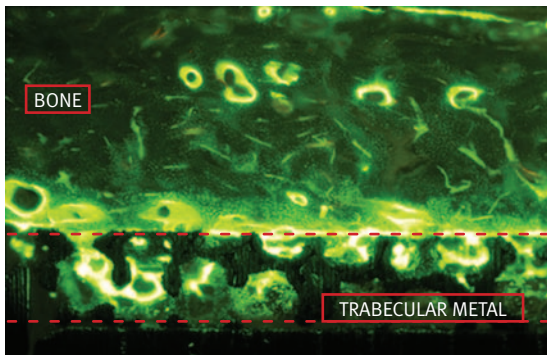


Figure 12 Documented ingrowth in canine mandible

## Bone Ingrowth in Canine Mandibular Models

In a study of *Trabecular Metal* Implants placed in canine mandibular models, evidence of ingrowth by maturing bone has been documented as early as two weeks after implantation.<sup>33,34</sup> Further research is required to determine the rate of ingrowth and its effects on secondary stability in human dental applications.

While other manufacturers have tried to mimic the attributes of *Trabecular Metal* Technology, sintered bead and other conventional porous coatings and materials differ significantly from *Trabecular Metal* Material's high degree of interconnected porosity, low modulus of elasticity and consistency in pore size and shape.<sup>24,29-31,35-37</sup>

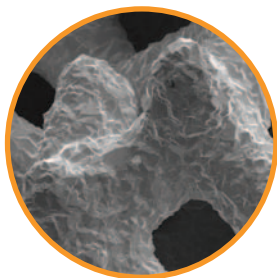


Figure 13 Zimmer *Trabecular Metal* at 500x magnification

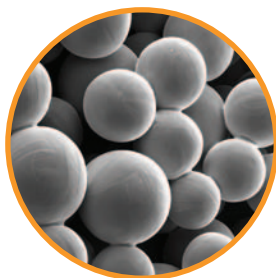


Figure 14 Sybron Endopore® at 500x magnification

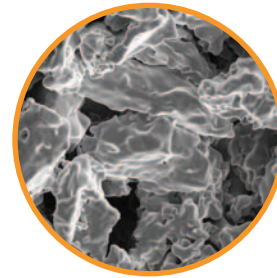


Figure 15 Zimmer CSTi™ at 500x magnification

Conventional Three-Dimensional Surfaces Do Not Have the Interconnected, Cancellous Porosity of *Trabecular Metal* Material<sup>24,29-31,35-37</sup>

**The cancellous-like structure, interconnected porosity and bone ingrowth potential are a unique combination of attributes that contribute to the osteoconductive properties of *Trabecular Metal* Technology.**<sup>1-6,24,25</sup>

# REFERENCES

---

1. Macheras GA, Papagelopoulos PJ, Kateros K, Kostakos AT, Baltas D, Karachalios TS. Radiological evaluation of the metal-bone interface of a porous tantalum monoblock acetabular component. *J Bone Joint Surg Br.* 2006;88-B:304-309.
2. Wigfield C, Robertson J, Gill S, Nelson R. Clinical experience with porous tantalum cervical interbody implants in a prospective randomized controlled trial. *Br J Neurosurg.* 2003;17(5):418-425.
3. Nasser S, Poggie RA. Revision and salvage patellar arthroplasty using a porous tantalum implant. *J Arthroplasty.* 2004;19(5):562-572.
4. Unger AS, Lewis RJ, Gruen T. Evaluation of a porous tantalum uncemented acetabular cup in revision total hip arthroplasty. Clinical and radiological results of 60 hips. *J Arthroplasty.* 2005;20(8):1002-1009.
5. Cohen R. A porous tantalum trabecular metal: basic science. *Am J Orthop.* 2002;31(4):216-217.
6. Bobynd JD. UHMWPE: the good, bad, & ugly. Fixation and bearing surfaces for the next millennium. *Orthop.* 1999;22(9):810-812.
7. Black J. Biological performance of tantalum. *Clin Mater.* 1994;16:167-173.
8. Bellinger DH. Preliminary report on the use of tantalum in maxillofacial and oral surgery. *J Oral Surg.* 1947;5(1):108-122.
9. Burke GL. The corrosion of metals in tissues; and an introduction to tantalum. *Can Med Ass J.* 1940;43(2):125.
10. Matsuno H, Yokoyama A, Watari F, Uo M, Kawasaki T. Biocompatibility and osteogenesis of refractory metal implants, titanium, hafnium, niobium, tantalum, and rhenium. *Biomaterials.* 2001;22:1253-1262.
11. Wellton KJ, Atkins GJ, Howie DW, Findlay DM. Primary human osteoblasts grow into porous tantalum and maintain an osteoblastic phenotype. *J Biomed Mater Res A.* 2008;84(3):691-701.
12. Venable CS, Stuck WG. A general consideration of metals for buried appliances in surgery. *Int Abst Surg.* 1943;66:297-304.
13. Pudenz RH. The use of tantalum clips for hemostasis in neurosurgery. *Surgery.* 1942;12:791-791.
14. Robertson RCL, Peacher WG. The use of tantalum foil in the subdural space. *J Neurosurg.* 1945;2:281-284.
15. Echols DH, Colelough JA. Cranioplasty with tantalum plate. Report of eight cases. *Surgery.* 1945;14:304-314.
16. Linkow LI, Rinaldi AW. Evolution of the Vent-Plant osseointegrated compatible implant system. *Int J Oral Maxillofac Implants.* 1988;3:109-122.
17. Brånemark PI. Introduction to osseointegration. In Brånemark PI, Zarb GA, and Albrektsson T, eds.: *Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry.* Chicago, IL: Quintessence Publishing Co, Inc.; 1985:11-76.
18. Zimmer internal *Trabecular Metal* component sales data from January 2002 through July 2010.
19. Gunson A, Kral M, Poggie RA. Three-dimensional reconstruction and modeling of a porous tantalum biomaterial. Paper presented at: Annual Meeting of the American Society for Biomaterials; April 24-29, 2001; Toronto, Ontario, Canada.
20. Data on file with Zimmer Dental Inc.
21. Shirazi-Adl A, Dammak M, Paiement G. Experimental determination of friction characteristics at the trabecular bone/porous-coated metal interface in cementless implants. *J Biomed Mater Res.* 1993; 27:167-175.

- 
22. Zhang Y, et al. Interfacial frictional behavior: Cancellous bone, cortical bone, and a novel porous tantalum biomaterial. *J Musculoskel Res.* 1999;3(4):245-251.
  23. Data on file with Zimmer Dental Inc.
  24. Bobyn JD, Stackpool GJ, Hacking SA, Tanzer M, Krygier JJ. Characteristics of bone ingrowth and interface mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg Br.* 1999; 81:907-914.
  25. Tsao AK, Roberson JR, Christie MJ, Dore DD, Heck DA, Robertson DD, Poggie RA. Biomechanical and clinical evaluations of a porous tantalum implant for the treatment of early-stage osteonecrosis. *J Bone Joint Surg.* 2005;87-A(Suppl 2):22-27.
  26. Data on file with Zimmer Dental Inc.
  27. Bobyn JD, Hacking SA, Chan SP, et al. Characterization of a new porous tantalum biomaterial for reconstructive orthopaedics. Scientific Exhibit, Proc of AAOS, Anaheim, CA, 1999.
  28. Wen HB, Schlee M, van der Schoor WB, Kim DG, Nambisan AB, Kottalgi S, Lee JW, Wanner MM. Combination titanium and porous tantalum implants: early clinical findings. Submitted to the *Journal of Dental Research*, 2012. Manuscript available upon request.
  29. Zardiackas LD, Parsell DE, Dillion LD, Mitchell DW, Nunnery LA, Poggie RA. Structure, metallurgy, and mechanical properties of a porous tantalum foam. *J Biomed Mater Res (Appl Biomater).* 2001;58:180-187.
  30. Khurana JS, Fordyce H, Sidebotham C, Smith G. Bone growth in a novel osteoconductive material for artificial bone replacement. Paper presented at: 45th Annual Meeting of the Orthopaedic Research Society; February 1-4, 1999; Anaheim, CA.
  31. Bobyn JD, Toh KK, Hacking A, Tanzer M, Krygier JJ. Tissue response to porous tantalum acetabular cups. *J Arthroplasty.* 1999;14:347-354.
  32. Bobyn JD, Poggie RA, Krygier JJ, Lewallen DF, Hanssen AD, Lewis RJ, Unger AS, O'Keefe TJ, Christie MH, Nasser S, Wood JE, Stulberg SD, Tanzer M. Clinical validation of a structural porous tantalum biomaterial for adult reconstruction. *J Bone Joint Surg.* 2004;86-A(Suppl 2):123-129.
  33. Data on file with Zimmer Dental Inc.
  34. Data on file with Zimmer Dental Inc.
  35. Shimko DA, Shimko VF, Sander EA, Dickson KF, Nauman EA. Effect of porosity on the fluid flow characteristics and mechanical properties of tantalum scaffolds. *J Biomed Mater Res. Part B: Appl Biomater.* 2005;73B:315-325.
  36. Deporter DA, Watson PA, Pilliar RM, Pharoah M, Chipman M, Smith DC. A clinical trial of a partially porous-coated, endosseous dental implant in humans: protocol and 6-month results. *Tissue Integration in Oral, Orthopaedic and Maxillofacial Reconstruction.* Eds. W.R. Laney and D.E. Tolman, Chicago, IL; Quintessence Books;1990:250-258.
  37. Cook SD, Rust-Dawicki AM. In vivo evaluation of a CSTi dental implant: a healing time course study. *J Oral Implantol.* 1995;21(3):82-90.

**For more information about our Products, Regenerative Materials and Educational Opportunities, contact us:**

1900 Aston Avenue  
Carlsbad, CA 92008-7308  
USA

**In the U.S. 1 (800) 854-7019**  
**To fax an order 1 (888) 225-2483**  
**Outside the U.S. +1 (760) 929-4300**  
**Australia +61 (0)2 9950 5434 or 1 (800) 241 916**  
**Canada + 1 (905) 567-2073 or 1 (800) 265-0968**  
**Chile +562 231 5185**

**China +86 21 22115147**  
**France +33 (0)1 45 12 35 35**  
**Germany +49 (0)761 1 56 47 0**  
**Israel +972 (0)3 6124242**  
**Italy +39 0438 37681**  
**Spain +34 93 846 05 43**

To receive our eNews visit us at [http://www.zimmerdental.com/news\\_eNewsLetterSignUp.aspx](http://www.zimmerdental.com/news_eNewsLetterSignUp.aspx)



[www.zimmerdental.com](http://www.zimmerdental.com)

Information on the products and procedures contained in this document is of a general nature and does not represent and does not constitute medical advice or recommendations. Because this information does not purport to constitute any diagnostic or therapeutic statement with regard to any individual medical case, each patient must be examined and advised individually, and this document does not replace the need for such examination and/or advice in whole or in part. Please refer to the package inserts for important product information, including, but not limited to, contraindications, warnings, precautions, and adverse effects.

©2012 Zimmer Dental Inc. All rights reserved. 2396, Rev. 10/12. SLActive is a trademark of Straumann AG. TiUrite is a registered trademark of Nobel Biocare. Endopore is a registered trademark of Sybron Implant Solutions. SEMs taken by Zimmer Dental Inc. Please note that not all products are registered or available in every country/region. Please check with a Zimmer Dental representative for availability and additional information.