Materials and Metallurgy for Stents and IntraVascular Implants: From Patients to the Lab, and (then) back to the Patient

Diego Mantovani, PhD, ing., FBSE, FASM, FAIMBE, FCAE
Laboratory for Biomaterials and Bioengineering, CRC-I, Department of Min-Met-Materials Eng., & University Hospital Research Center, Regenerative Medicine, Laval University, QC City, Canada,
E-mail: Diego.Mantovani@gmn.ulaval.ca ; www.lbb.ulaval.ca

Since the new century started, intravascular clinics literally revolutionized the practice of Surgery, and how clinicians therapeutically and surgically treated patients with severe arteriopathies. From the Glory day of stainless steel 316L, to Cr-Co alloys, going through Nitinol, materials and metallurgy progressively played an important role in what happens and how patients are treated on the Operating Theater. Today, metallic biodegradable alloys constitute a new class of biomaterials for temporary support for reparative and regenerative medicine. However, rare are the applications in intravascular clinics. Lack in mechanical properties constitutes the main reason. And again, materials and metallurgy scientists are in a privileged position to provide new insights and accelerate the germination of new clinical treatments to assist patients' healing.

Biodegradable metals represent a paradigm shift in biomaterials science and engineering, mainly because the degradation of the alloy, under controlled mechanisms, constitutes the expected event after implantation, even stimulating the healing process. Their successful implantation involves their complete absorption and elimination by the surrounding tissue and the body. Mainly composed of Fe, Mg or Zn, these alloys have been inestigated, from bench to clinics, for orthopedic, cardiovascular, and dental applications. intravascular therapies for patient's health.

This presentation will highlight the rationale behind the development of these applications, starting in the diseased human body, during the medical visit. The needs and evidence for intravascular clinical applications are then presented and discussed. A list of properties fulfilling the requirements demanded by clinicians for their use and implantation, will be discussed, highlighting the synergy between microstructure, properties and expected benefits for the patients, including their clinical relevance. In a rather personal perspective, the importance of complementary developments for the full characterization of their properties before, at and post implantation will be depicted. Predicting their clinical behavior leading to success remains the main challenge for all biomaterials. This talk aims is to depict the potential that metallurgical processes applied to vmaterials may, or may not, represent for the future of clinical

Bibliography

[1] *H.S. Han, I. Jun, H.K. Seok, K.S. Lee, K. Lee, F. Witte, D. Mantovani, Y.C. Kim, S. Glyn-Jones, J.R. Edwards. Biodegradable Magnesium Alloys Promote Angio-Osteogenesis to Enhance Bone Repair. Advanced Science, 10.1002/advs.202000800, 2020.*

[2] *S. Loffredo, C. Paternoster, N. Giguère, G. Barucca, M. Vedani, D. Mantovani. The addition of silver affects the deformation mechanism of a twinning-induced plasticity steel: Potential for thinner degradable stents. Acta Biomaterialia, 10.1016/j.actbio.2019.04.030, 2019.*

[3] *H.S. Han, S. Loffredo, I. Jun, J. Edwards, Y.C. Kim, H.K. Seok, F. Witte, D. Mantovani, S. Glyn-Jones. Current status outlook on the clinical translation of biodegradable metals. Materials Today, 10.1016/j.mattod.2018.05.018, 2019.*

[4] *S. Loffredo, S. Gambaro, F. Copes, C. Paternoster, N. Giguère, M. Vedani, D. Mantovani. Effect of silver in thermal treatments of Fe-Mn-C degradable metals: Implications for stent processing. Bioactive materials, 10.1016/j.bioactmat.2021.10.020, 2021.*

[5] *E. Mostaed, M. Sikora-Jasinska, A. Mostaed, S. Loffredo, A.G. Demir, B. Previtali, D. Mantovani, R. Beanland, M. Vedani. Novel Zn-Based Alloys for Biodegradable Stent Applications: Design, Development and In vitro Degradation. Journal of the mechanical behaviour of biomedical materials, 10.1016/j.mattod.2018.05.018 , 2016.*

[6] *C.H.M. Beraldo, C. Paternoster, F. Copes, I. Bilem, L. Dion-Albert, H.J. Wiggers, P. Mengucci and D. Mantovani. On the feasibility of electroforming Fe-Co alloys for biodegradable tiny medical devices, J Materials Research and Technology, 10.1016/j.jmrt.2026.01.020, 2026.*

[7] *H. Hermawan and D. Mantovani. Process of prototyping coronary stents from biodegradable Fe–Mn alloys. Acta Biomaterialia, 10.1016/j.actbio.2013.04.027, 2016.*

[8] *C.C. Bortolan, L.C. Campanelli, P. Mengucci, G. Barucca, N. Giguere, N. Brodusch, C. Paternoster, C. Bolfarini, R. Gauvin, D. Mantovani. Development of Ti-Mo-Fe alloys combining different plastic deformation mechanisms for improved strength-ductility trade-off and high work hardening rate , J. Alloys and Compounds, 10.1016/j.jallcom.2022.166757, 2022.*