A Journey through Fe, Mg, and Zn – based bioabsorbable metals for the next generation of medical therapies: Structure, properties and more

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Metallic biodegradable alloys constitute a new class of biomaterials for temporary support for reparative and regenerative medicine. They 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, theses alloys have been investigated, from bench to clinics, for orthopaedic, cardiovascular, and dental applications.

Mg-based alloys constitutes the most advanced family for bioabsorbable metals. Its intrinsic osteogenic ability, and the capacity of Mg and its alloys to stimulate new bone formation during degradation is considered a key factor in their development for bone contact applications. Strategies for improving the (generally) limited mechanical properties, including low ductility, low elastic yield, and limited resistance have been investigated. These strategies include alloying with selected elements, including rare elements, or applying severe plastic deformation, and thermomechanical properties. Their propension for pitting corrosion, fast degradation with hydrogen degassing, is today rather controlled by surface treatments and coatings. As a result, a small dozen of clinical products is on the market available for clinicians in Europe, Asia, Oceania and Latino-America. Several products are today following the process of Food and Drug Administration clearance for the North American market.

Fe-based alloys are particularly attractive for the production of very thin implants, including stents, mainly due to their outstanding mechanical properties. One of the bottlenecks limiting their development is their low degradation. Several strategies have been deployed over the last decade for designing alloys with outstanding mechanical properties, including very high ductility and mechanical resistance, or designing surface processes leading to coating susceptible to accelerate the degradation.

Zn-based alloys, despite a very exciting beginning, are still under evaluation, and although their potential their development is still limited. Others potential alloys, such as tungsten and molybdenum have recently been reported, and will face further investigations in the upcoming years.

In conclusion, this presentation will highlight the rationale behind the development of these alloys, details the main advances in the field, present the evidence for their use and implantation, and, finally, discuss their clinical relevance. In a rather personal perspective, the potential that this new family of biomaterials may, or may not, represent for the future of clinical implantology will be outlined.