Effect of Collagen type-I on the rate of osseointegration of Ca-containing biodegradable Mg-Zr based alloys

D Mushahary[1], C Wen[2], JM Kumar[3], N Harishankar[4], G Pande[3], P Hodgson[1], Y Li[1]

[1] Institute for Frontier Materials, Deakin University, Victoria, Australia [2] Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Victoria. Australia [3] CSIR-Centre for Cellular and Molecular Biology, Hyderabad, India [4] National Institute of Nutrition (ICMR), Hyderabad, India

INTRODUCTION: Mg-Zr based biodegradable implants alloyed with Ca were investigated to assess their biocompatibility and efficacy in bone formation and osseointegration. Bare alloys, containing Ca, exhibited low surface energy, poor corrosion-resistance, reduced osteoinduction and bone integration activity [1, 2]. Upon coating with Collagen type-I, these alloys demonstrated enhanced performance as an implant material that are suitable for rapid and efficient new bone tissue induction with optimal mineral content and cellular properties.

METHODS: Collagen type-I was extracted from rat tail [3] and was characterized by FT-IR spectroscopy using a control sample. Alloys were dip-coated with Collagen type-I and the thickness of the coated protein was measured by profilometer. Coated alloys were characterized using X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). The free surface energy and wettability of the coated alloys were determined from the contact angles of polar solvents on the surface of the alloys. *In vivo* bone formation around the implants in rabbit femur was investigated by measuring the Bone Mineral Content/Density (BMC/BMD) of the implanted region using Dual-Energy X-Ray Absorptiometry (DXA) and new bone mineralization was visualized by histological and immuno-histochemical analysis.

RESULTS: Results show that Mg-Zr-Ca alloys, when coated with Collagen-I have a tendency to form superior trabecular bone structure, with better osteoinduction around the implants, as compared to the control and uncoated ones. Further, surface modification improved the surface energy of these alloys and the mineral content of the implanted region of femur bone in experimental animals. Both the uncoated [2] and surface modified Mg-Zr based alloys integrated with the host tissue and did not cause any undesirable side effects. Fig. 1 shows Hematoxylin and Eosin stained newly formed bone tissue around Mg-Zr-Ca alloy after 3 months and 1 month implantation for the uncoated and coated implants, respectively.

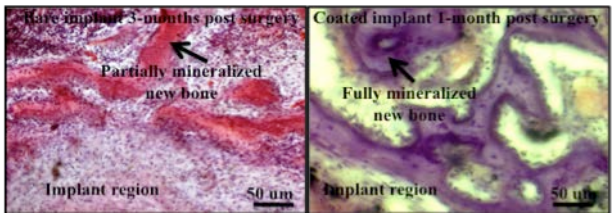

Fig. 1: Hematoxylin and Eosin stained newly formed bone tissue around Mg-Zr-Ca alloy 3 months and 1 month post-implantation respectively, in rabbit femur. The coated implant shows more rigid and mineralized trabecular bone formation (right) as compared to the bare implant (left) that forms less mineralized new bone tissue upon implantation.

DISCUSSION & CONCLUSIONS: This study demonstrated that surface modification of Mg-Zr-Ca alloys using Collagen type-I benefit the osseointegration and the formation of a new trabecular bone structure around the implants. Further, surface modification of these alloys could osseointegrate at an even earlier implanted period compared to the bare implants. Although *in vitro* results did not indicate any improvement in the cell behaviour for the surface modified Ca-containing alloys, the *in vivo* osseointegration rate was significantly enhanced. Hence, Collagen type-I coating on Mg-Zr-Ca alloys is a promising method for expediting new bone formation *in vivo* and enhancing osseointegration in biodegradable implant applications.

REFERENCES: [1]Y. Li, C. Wen, D. Mushahary, et al (2012) *Acta Biomater* **8**:3177-88. [2]D. Mushahary, S. Ragamouni, Y. li, et al (2013) *Inter J Nanomedicine* (In press). [3]N. Rajan, J. Habermehl, M.F. Cote et al (2006) *Nat Protoc* **1**:2753-8.

ACKNOWLEDGEMENTS: The authors acknowledge the financial support from the Australia-India Strategic Research Fund (AISRF) BF030031 to CW and PH and GAP 0311 to GP.