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Low modulus novel bone substitutes for osteoporotic vertebral fracture management

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INTRODUCTION: Currently developed bone substitutes such as calcium-based bone cements have tried to overcome the clinical complications found in PMMA cement augmentation for osteoporotic spinal fracture¹. However, lack of osteointegration and mismatched mechanical properties of PMMA potentially jeopardize surgical outcomes e.g. interfere bone healing and adjacent level fracture². Hence, our group has fabricated a novel bone substitute comprised of polycaprolactone (PCL) and magnesium (Mg) with a wide range of compressive moduli and enhanced osteoblastic activity for vertebral cement augmentation. This paper aims to report the mechanical characteristics, *in-vitro* and *in-vivo* properties of the new bone substitute.

METHODS: The bone substitutes were prepared by incorporating 0.1g or 0.6g silane-treated Mg particles into 1g PCL. Their mechanical properties were evaluated by compression test, whereas the cytocompatibility and osteogenic differentiation properties were studied by direct cell culture, MTT and ALP assays, respectively. The *in-vivo* response was studied in rat model for 6 months. The animals were monitored and examined by Micro-CT at respective time points. Commercial PMMA and pure PCL were served as the controls.

RESULTS: The compressive moduli of the composites with 0.1g and 0.6g Mg were 1-fold and 3-fold higher than PCL, respectively (as shown in Figure 1). Also, they were about 5-fold and 2-fold lower than PMMA. The cell viabilities of all new composites were higher than 100% as compared to the control. The ALP activities of PMMA were significantly lower on days 3, 7 and 14 as compared to the new composites and pure PCL, whereas significantly higher ALP activities were found on day 14 of the new composites with 0.1g Mg. Figure 2 shows the percentage change of bone volume on all the samples during the implantation period. Significant more new bone formation was found on new composites with 0.1g Mg after 1 week of post-operation and up to 8 weeks as compared with the control.

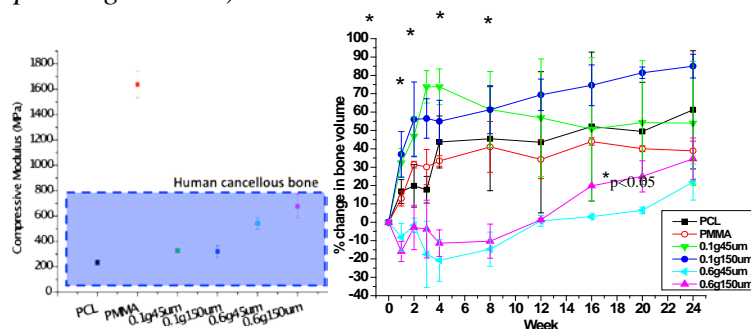


Fig. 1 (Left): Compressive moduli of the PCL-Mg composites as compared to PMMA & PCL (Blue box: range of human cancellous bone moduli). Fig. 2 (Right): The percentage change of bone volume during the implantation period.

DISCUSSION & CONCLUSIONS: The results of *in-vitro* tests suggested that the new composites were well tolerated by bone cells and osteoconductive. In *in-vivo* experiment, new bone formation found in the composite with 0.1g Mg was significantly higher than that of PMMA at the early time points. It indicated the new bone substitutes could promote fast bone healing as compared to the conventional PMMA. Additionally, various compressive moduli of the new composites can be adjusted by incorporating different amounts of Mg particles into the material matrix in which these new substitutes are mechanically similar to the cancellous bone (50-800MPa)³. Hence, they potentially help reduce the post-op complications while using PMMA. In summary, we prove that the mechanical properties of the newly developed bone substitutes can be individualized according to patient's need. Also, the new composites are radiopaque, biodegradable and injectable that benefit for clinical applications.

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