Gallium based cements for sternal fixation

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Statement of Purpose: Sternotomy is the preferred surgical choice for reaching the thoracic cavity during cardiac valve replacement and open heart surgery [1,2]. Additional surgery is often required to stabilise the ribcage following sternotomy [3]. Glass polyalkenoate cements (GPCs) have been used in dentistry for over forty years and have potential in a range of orthopaedic applications including stabilisation of the sternum [4]. The work herein considers the suitability of a gallium (Ga) containing GPC for sternal repair.

Methods: Three glass compositions (Control, LGa-1 and LGa-2) were synthesized. Control is composed of $0.12CaO\text{-}0.40ZnO\text{-}0.48SiO_2$, while LGa-1 and LGa-2 contain 0.08 and 0.16 mol% Ga, respectively, at the expense of zinc (Zn). GPCs were prepared by mixing 1g glass with 0.375 g of poly(acrylic acid) (Sigma-Aldrich, MI, USA), Mw ~120,000, and 0.375 ml of distilled water. The nomenclature of the glasses was carried over to the GPCs made from the glasses. Net setting (T_s) and working (T_w) times were evaluated in accordance with ISO 9917 [5]. A bovine sternal model was used for evaluating the tensile strength of the cements. Fresh sternal halves were sourced, the ribs were detached and the halves were cut horizontally into 3 x 3 cm samples (n=5). The cement was then prepared and applied on the halves by spatula. Samples were submersed in distilled water containing 1% formaldehyde and then incubated for 1, 7 and 30 days. Tensile testing was performed on the samples using an Instron Universal Testing Machine (Instron Corp., MA, USA) fitted with a ±2 kN load cell.

Results: Table 1 presents T_s and T_w of the cement series; both increased with Ga concentration. Tensile strength measurements are shown in Figure 1.

Table 1: Net setting and working times of cement series

	Control	LGa-1	LGa-2
T_s (s)	113	242	254
T_w (s)	75	117	137

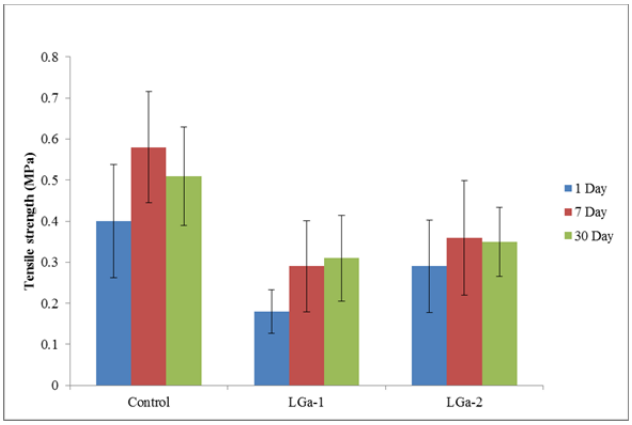

Figure 1: *Ex-vivo* tensile strength measurements.

Conclusions: The objective of this work was to evaluate, utilizing a novel *ex-vivo* study, the potential of Ga containing GPCs for sternal fixation and stabilization.

The addition of Ga to the glass phase increased both working and setting times of the resultant GPCs, and no significant effect on the strength of the bond between the sternal halves.

Zn^{2+} and Ga^{3+} are anti-bacterial and anti-inflammatory ions respectively, and their release from the cement structure, during cement maturation, may result in therapeutic potential and hence reduced post-surgical complications [6,7].

Our *ex-vivo* study does not consider osteoporosis, bleeding and bone resorption; complications regularly encountered during sternal fixation and repair. This initial study has shown that GPCs have the potential to be used for sternal fixation, but further research is required to optimise the properties of these compositions for this purpose.

References:

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