Dissolution & mechanical properties of bioresorbable glass fibres for use in Paediatric stents

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INTRODUCTION
Stents provide biological support in body conduits and are useful for counteracting stenosis (constriction) in cardiovascular, gastrointestinal, urethral and airway passages1. However, the current widespread use of permanent metal stents that remain throughout the lifespan of a patient, threaten restenosis, thrombosis, or physical irritation if not surgically removed. In infants the clinical requirement is for a stent that retains structural integrity for periods of several weeks up to many months in vivo during host tissue restoration2 and from a materials perspective this requires an implant with appropriate mechanical and degradation characteristics. Bioresorbable phosphate glass fibres have shown enormous potential for temporary implants and tissue repair, owing to their mechanical properties and solubility in aqueous media which can be modified by addition of various oxide compounds3,4. Further, when combined with degradable polymers the resulting glass fibre polymer composites (GFRP) become ductile allowing them to be forged into supporting scaffolds with suitable mechanical and dissolution properties. To date however, their use for stenting applications has not been investigated possibly due to major difficulties of processing these compositions into fibre form. In this study, two phosphate glass fibre compositions containing SiO2 (silica) and B2O3 (Boron) were fabricated to test the hypothesis that B2O3 containing phosphate glass fibres present enhanced mechanical and dissolution behaviour for use as a degradable stent.

EXPERIMENTAL METHODS
Glass fibres: GF330 (Silica based) and GF331 (Boron) continuous fibre with target diameters ranging from 10-20µm were obtained (Giltech Ayrshire, UK).

Fibre dissolution and pH study: 200mg fibre bundles for each fibre formulation were immersed in 10ml glass vials containing phosphate buffered saline (Sigma Aldrich UK). Each sample (n=6 per formulation) was weighed (Denver Instrument) and the dissolution media pH recorded (Accument Basic AB15) before and after 3 and 7 days of incubation at 37°C. Before weighing, samples were dried in an air circulating oven at 60°C for 4 hours.

Tensile tests: Individual fibre filaments were placed on a paper frame (fig 2) with a gauge length of 25mm and the ends of each fibre attached to the frame using cyanoacrylate adhesive. Glass fibre diameters (n=20) were measured using optical microscopy (Zeiss Axiovert). Samples were mounted onto the specimen grips of a test machine (Instron 8841) fitted with a 10N load cell and tested at room temperature at 1mm/min. Tensile modulus and strength were calculated and Student’s t-test were performed using Prism v.5

RESULTS AND DISCUSSION

Degradation media of the boron based GF331 displayed a more dramatic decline in pH after 7 days 4.09±0.76 compared with GF330 6.20±0.23 (fig1), however a greater quantity of fibre mass was lost in the Silica based composition after 7 days of immersion in PBS. On average boron containing glass fibres demonstrated a statistically significantly higher tensile strength and tensile modulus than silica based fibres (p<0.05) and this maybe attributed to increased cross link density in glass fibres containing B2O3 additions5.

CONCLUSIONS
Despite creating a noticeably higher acidic environment B2O3 fibres retain greater mass after days of immersion in PBS and are likely to perform with longer mechanical integrity in vivo than SiO2 based fibres when used as part of a GFRP composite stent material.

REFERENCES

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