Scottish Executive Health Department Chief Scientist Office

FOCUS ON RESEARCH

AN INVESTIGATION OF THE FORMULATION, STRUCTURE AND PROPERTIES OF PORTLAND-TYPE CEMENTS SUITABLE FOR DENTAL RESTORATION.

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Aim
The disease dental caries remains an extremely widespread health problem in Scotland. Treatment of those affected results in the replacement of the decayed tissue with a durable material. However, existing materials are flawed. The two most commonly used materials, amalgam and composite, have median survival times of 4.6 and 6.6 years, respectively. Retreatment is wasteful of resources, and thus, an "unnecessary" burden to Scottish Health Services. This is a particular concern at present since there is an acute shortage of dentists in Scotland. Improving the performance of existing materials or the introduction of new chemistries is essential. This project was a pilot investigation to explore variations in formulation of Portland-type cement to identify the most promising compositions for dental products.

Project Outline/Methodology
This research was conducted entirely in a laboratory. Properties that are considered of primary importance for cement in this intended application were identified and investigated. These included fracture toughness, compressive strength, resistance to dissolution and acid erosion and setting expansion / contraction. The chemistry selected was calcined tricalcium silicate (recognised for producing a fast setting stable solid) with nanosize silica particles (to improve long-term strength) and fine fibres (for toughening).

Key Results
Compositions were selected to produce a thick consistency, one that could be packed into moulds within the working time to produce perfect specimens and hence valid results. Silica and fibre additions doubled fracture toughness to a value that rivals that of many glass ionomer products. Setting contraction seen as a major deficiency in composite (at 3%) is under 1% in the modified cement. Resistance to both water dissolution and acid erosion is excellent. The former matches current dental cements while the latter is an order of magnitude better.

Conclusions
The objective was achieved. The calcined tricalcium silicate / nanosize silica particle / fibre system is suitable for major development as a dental restorative material.

What does this study add to the field?
A new formulation is available for development as a dental restorative material. No significant deficiencies were uncovered and in many respects the performance is better than current materials. Since the composition is considered to have excellent biocompatibility, the discovery that physical properties are acceptable is timely since there are allegations concerning the release of substances that have adverse effects from materials that dominate the market at present. As this was a short pilot study we recognise that a clinical product may be some time away. However, it has pointed to combining nanosize silica and fibre toughening as the way forward.

Implications for Practice or Policy
At present none. However, in the longer term when the material is commercialised its adoption will result in a home sourced product which has significantly improved performance and is anticipated to be available at a low cost. Clinical trials will be required to quantify durability. As it is a simple material with low inherent cost we would envisage development as a material that is suited to the needs of the poorest nations and could become part of Scotland's contribution to development.

Where to next?
A major research programme to optimise the fibres in relation to the silica content and to accelerate setting with modifiers. Uncovering the nature of bonding in this system will continue since this is key to controlling release of beneficial substances.

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