Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/jmbbm

Research paper

Interface shear strength and fracture behaviour of porous glass-fibre-reinforced composite implant and bone model material

Sara Nganga, Anne Ylä-Soininmäki, Lippo V.J. Lassila, Pekka K. Vallittu*

Department of Biomaterials Science, University of Turku, Turku, Finland
Biocity Turku, Biomaterials Research Program, Turku Clinical Biomaterial Centre - TCBC, Turku, Finland

ARTICLE INFO

Article history:
Received 6 March 2011
Received in revised form
18 May 2011
Accepted 28 May 2011
Published online 6 June 2011

Keywords:
Porous fibre-reinforced composite
Push-out test
Bone substitute material

ABSTRACT

Glass-fibre-reinforced composites (FRCs) are under current investigation to serve as durable bone substitute materials in load-bearing orthopaedic implants and bone implants in the head and neck area. The present form of biocompatible FRCs consist of non-woven E-glass-fibre tissues impregnated with varying amounts of a non-resorbable photopolymerisable bifunctional polymer resin with equal portions of both bis-phenyl-A-glycidyl dimethacrylate (BisGMA) and triethyleneglycol dimethacrylate (TEGDMA). FRCs with a total porosity of 10–70 vol% were prepared, more than 90 vol% of which being functional (open pores), and the rest closed. The pore sizes were greater than 100 μm.

In the present study, the push-out test was chosen to analyse the shear strength of the interface between mechanically interlocked gypsum and a porous FRC implant structure. Gypsum was used as a substitute material for natural bone. The simulative *in vitro* experiments revealed a significant rise of push-out forces to the twofold level of 1147 ± 271 N for an increase in total FRC porosity of 43%. Pins, intended to model the initial mechanical implant fixation, did not affect the measured shear strength of the gypsum–FRC interface, but led to slightly more cohesive fracture modes. Fractures always occurred inside the gypsum, it having lower compressive strength than the porous FRC structures. Therefore, the largest loads were restricted by the brittleness of the gypsum. Increases of the FRC implant porosity tended to lead to more cohesive fracture modes and higher interfacial fracture toughness. Statistical differences were confirmed using the Kruskal–Wallis test. The differences between the modelled configuration showing gypsum penetration into all open pores and the real clinical situation with gradual bone ingrowth has to be considered.

1. Introduction

Durable biostable fibre-reinforced composites (FRCs), which were originally developed for applications in dentistry, are a potential alternative implant material for orthopaedic and craniofacial bone reconstructions (Tuusa et al., 2007a; Vallittu, 1999). Dominant advantages of FRCs are their high resistance to fatigue failure as well as their structural stiffness and

* *Corresponding address:* Turku Clinical Biomaterials Centre - TCBC, Itäinen Pitkäkatu 4 B, FI-20520 Turku, Finland. Tel.: +358 2 333 8527; fax: +358 2 333 8356.
E-mail address: sarsch@utu.fi (S. Nganga).

1751-6161/$ - see front matter
doi:10.1016/j.jmbbm.2011.05.037