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Fracture toughness of heat cured denture base acrylic resin modified with Chlorhexidine and Fluconazole as bioactive compounds

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ABSTRACT

Purpose: This study investigated the impact of incorporating Chlorhexidine and Fluconazole as bioactive compounds on the fracture toughness of conventional heat cured denture base acrylic resin material (PMMA).

Materials and methods: 30 single edge-notched (SEN) samples were prepared and divided into three groups. 10% (mass) Chlorhexidine and 10% (mass) Diflucan powder (4.5% mass Fluconazole) were added to heat cured PMMA respectively to create the two study groups. A third group of conventional heat cured PMMA was prepared as the control group. Fracture toughness (3-point bending test) was carried out for each sample and critical force (F_c) and critical stress intensity factor (K_{IC}) values measured. Data were subject to parametric statistical analysis using one-way ANOVA and Post hoc Bonferroni test ($p = 0.05$).

Results: Fluconazole had no significant effect on the fracture toughness of the PMMA while Chlorhexidine significantly reduced the K_{IC} and therefore affected the fracture toughness.

Conclusion: When considering addition of a bioactive material to PMMA acrylic, Chlorhexidine will result in reduced fracture toughness of the acrylic base while Fluconazole has no effect.

1. Introduction

Removable appliances have played an important role in routine prosthodontics and orthodontics for centuries. They are simple to fabricate, easy to modify, versatile, and relatively easy to maintain. Despite all the benefits, these appliances can compromise oral health[1] when not cleaned and maintained well.[2]

When appliance-related oral disease occurs, several approaches have been suggested to manage the situation. One approach would be to use polymeric systems that enable controlled release of medications.[3–5] In this approach, a prolonged therapeutic effect may be achieved by replacing high systemic doses with slow releasing lower local doses.[6] Several systems have been developed to incorporate medications into removable appliances. The simplest way is to use them within the soft liners or tissue conditioners[7–10] but the

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short-term effect and the huge maintenance requirements[7] make this system unfavourable. To overcome these problems, researchers have tried to incorporate medications into polymethylmethacrylate (PMMA)[4,11] or the cold-cured poly(-ethyl methacrylate)/tetrahydrofurfuryl methacrylate (PEM/THFM) polymer bases.[3,5,12–17] Two examples of such medications are Fluconazole and Chlorhexidine (CHX). It has been shown that once Fluconazole and CHX are incorporated into PMMA, they retain their therapeutic dose for up to 28 days.[11,13–15]

On the other hand, however, there are some uncertainties regarding the effect of these techniques on the mechanical properties of the acrylic resin. The Chlorhexidine particles may dissolve and result in porosity of the acrylic base.[18] It also has been shown that these additions can have adverse effects on the mechanical properties of cold-cured acrylic,[19] however, data with regard to high concentrations have not been reported.

In this in vitro randomized controlled trial, the effect of incorporating Chlorhexidine and Fluconazole as bioactive materials on the fracture toughness of heat-cured PMMA has been assessed. The null hypothesis was: there is no significant difference between the fracture toughness of heat-cured PMMA with, and without Chlorhexidine and Fluconazole additives (10%, mass), respectively.

2. Materials and methods

2.1. *Sample preparation*

A sample size calculation was performed by using data from a previous study by Hill and Bates.[30] Seven specimens were required in each group to detect a difference of 0.22 MN $m^{-3/2}$ with 95% power at a 5% significance level with an estimated SD of 0.11 MN $m^{-3/2}$.Ten specimens were allocated to each group in case of failure. A master model was prepared and duplicated to create further samples. To create the master model, a block of self-cured acrylic was formed and trimmed to the required specific dimensions of 40 mm × 8 mm × 4 mm using a 600M-grit abrasive paper (Abrasives Industries AG, Fraumenfeld, Switzerland) and measured digitally (Economical Digital Calliper Model DC-515, EZTECK, New Jersey, USA). A negative master mould was made from the master model in silicon putty impression material (Putty Vinyl Polysiloxane, Provil™ Novo Putty, Heraeus-Kulzer, Germany) which was then used to prepare 30 samples in wax (Baseplate Wax, Hi-Tec Baseplate Wax, Hi-Tec Dental Products, Greenback, TN, USA). Care was taken when pouring the mould in wax to avoid voids. A clean glass microscope slide was used on top of the mould to ensure a flat surface.

A long stainless steel metal band (Narrow Siqveland Band, Astek Innovations Ltd, UK) was then used to create notches in the samples in compliance with the fracture toughness testing standards. To do so the band was cut into 30 pieces, 6 mm × 4 mm × 0.1 mm each in dimension. Each metal piece was then inserted 3 mm deep into a wax sample at the midpoint, leaving 1 mm outside the surface. To ensure accurate positioning of the notch, orientation marks were sketched over the wax at the required dimensions. The metal pieces were held between two fixed glass microscope slides with 1 mm thickness, leaving only the required 3 mm of metal protruding outside. The exposed 3 mm of the metal band was pushed fully into the wax sample. This process was repeated 30 times and the wax samples flasked for processing.

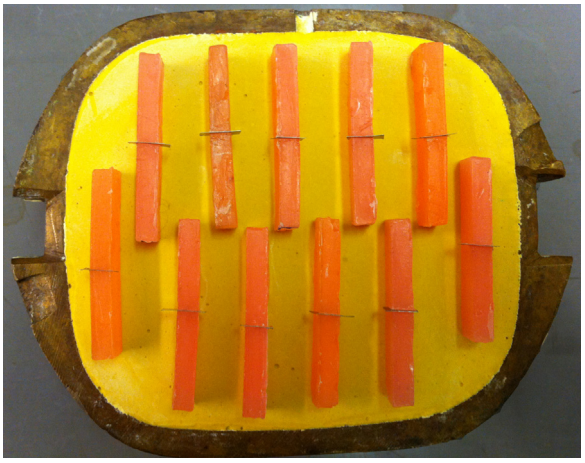

Fig. 1 – Arrangement of the samples within the flask, ready for the second pour.

Three metal flasks, one for each group, were used. Dental stone (Labstone, DENTSPLY Ltd, Surrey, UK) was poured and left to set, leaving a flat surface. All the samples were arranged in the same way with the metal band being on top (Fig. 1). To avoid dislodgement of the samples during the second pour, a drop of molten wax was used to stick them to the base. A thin layer of separator (petroleum jelly) was applied using a micro brush over the exposed surface of the stone and around the samples. No separator was applied over the metal bands to ensure firm fixation of the bands inside the stone.

To facilitate the final samples retrieval, the second pour was prepared by mixing plaster of Paris (Lab Plaster, DENTSPLY Ltd, Surrey, UK) and dental stone at 1:1 ratio. The second pour was done under vibration and left for one hour to set. Using a boiling-out machine (Labormat SD, Dreve-Dentamid GMBH, Germany) the wax was boiled out over two cycles of 10 min, one with closed flasks and the second with opened flasks. Any residual wax was then manually removed using the hand shower of the same machine. This produced the final moulds required to fabricate the working samples.

Each flask represented a single sample group. A thin layer of separator (petroleum jelly) was carefully painted over the stone of both flask halves. Materials were mixed according to the manufacturers' recommendations. Using a precise digital scale (My Weight iBalance 201, Digital Scales Company, Holywell, UK), every effort was made to ensure that the powder to liquid ratio remains at 2.5:1 by mass. The material for the control group (group A) was prepare by mixing 35 g of heat cured PMMA powder (Minacryl Universal powder, Minerva Dental Limited, Cardiff, UK) with 14 g of MMA monomer (Minacryl Universal monomer). The mix was left for 10 min to reach the dough stage before packing into the flask. The flask was then loaded to 100 N using a hydraulic press machine (Hydraulic Press P400, SIRIO Dental SRL, Meldola, Italy).