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A study to investigate and compare the physicomechanical properties of experimental and commercial temporary crown and bridge materials

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ABSTRACT

Objectives. To develop two experimental temporary crown and bridge materials with improved physicomechanical properties.

Methods. Commercial materials: Trim (TR, monomethacrylate, Bosworth) and Quicktemp2 (QT, dimethacrylate, Schottlander). Experimental materials: isobutyl methacrylate/poly(ethyl methacrylate) (IBMA/PEM) and n-butyl methacrylate/PEM (nBMA/PEM), both monomethacrylates. For water absorption/desorption studies rectangular samples (40 mm × 10 mm × 1 mm) of each material were prepared, immersed in deionized water (DW, control) and artificial saliva (AS), and weighed at regular time intervals. %solubility and diffusion coefficients (*D*) for uptake/loss processes were calculated and compared with theoretical predictions. Polymerization exotherm (cylindrical samples 10 mm × 18 mm) and flexural moduli were measured (three point bending; rectangular samples 80 mm × 10 mm × 4 mm, dry and after 9 days storage in DW). The data were compared statistically.

Results. QT and nBMA/PEM had lower %equilibrium uptakes/loss in DW (0.68%/0.884% and 0.64%/0.895% respectively). QT had the lowest water absorption/desorption D ($P < 0.05$) compared to the three monomethacrylates, in DW and AS. %solubility for all systems showed no differences in DW ($P > 0.05$), but a difference for QT in AS ($P < 0.05$). QT reached its maximum temperature rapidly (~2 min; 3 monomethacrylates ~7–13 min). The commercial materials exhibited high peak temperatures (~51 °C, $P < 0.05$; experimental materials ~43 °C). QT had a higher flexural modulus (~4 GPa; 3 monomethacrylates ~0.7–1 GPa) for dry and wet samples. The moduli for commercial materials reduced significantly after immersion in DW; there was no difference between the dry and wet experimental materials samples ($P > 0.05$).

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Significance. The experimental materials merit further studies since they presented with lower setting exotherms, and contained no phthalate plasticizer, thus being less of a risk to patients.

1. Introduction

Several studies have assessed the importance of provisional treatment while the fabrication of the final restoration is being carried out [1–5]. The functions of a provisional/temporary crown and bridge (TCB) material include aesthetics, comfort, speech, maintenance of healthy periodontal tissue, support or establishment of desirable occlusal relations and the creation of aesthetic guidelines for the planned definitive prosthesis. These restorations should also meet biological, mechanical, and aesthetic requirements, to ensure the desirable outcome of the provisional treatment [6].

Currently, the commercial temporary crown and bridge materials (TCBs) available on the market are either composite resin based (for example aromatic/aliphatic dimethacrylates) or polymer based (for example poly[methyl methacrylate] – PMMA or poly[ethyl methacrylate] – PEM). The type of TCBs selected by the clinicians should be based on the clinical needs. Unfortunately, however, none of these materials meet all the required aspects for provisional treatment [7].

Currently, a bis-acryl composite is the most popular provisional prosthesis material [8] because it has many desirable properties such as good aesthetics, easy to use and polish, and it also has a low exothermic temperature [9]. However, it is only used for making single interim restorations or veneers and some inlay/onlay restorations, due to its brittle structure and high cost [8,10] compared with polymer based materials. Moreover, it is better to fabricate a new bis-acryl interim restoration than to repair an old one, because it is difficult to add new layers over it [4], and because 85% of its transverse strength would have been lost after repairing an old interim restoration [11].

Alternatively, PMMA based TCBs have many advantages, for example in terms of strength, aesthetics and colour stability, marginal fit, and they can be easily fabricated, polished and repaired [8]. PMMA is an inexpensive material, and because of its good strength, it is used for making long interim bridges and for moderate-term provisional treatment. However, it has been reported to have some serious disadvantages like irritation of vital tissues, which could be due to leaching of the free monomer, high polymerization exotherm during setting, low wear resistance and high volumetric shrinkage [4,12]. Consequently, it was suggested that PMMA based resins should only be used for the indirect technique of TCB fabrication, or as PMMA shells that are fabricated in the laboratory, which are then lined in the patient's mouth with PEM/monomer system [8].

PEM based TCBs are suitable for both direct and indirect techniques, due to their minimal polymerization exotherm, low shrinkage [4] and better biocompatibility compared with PMMA. They are the most commonly used provisional materials to date due to various advantages: e.g. they are inexpensive, easily fabricated, polished, repaired, and bonded to PMMA shells, and have adequate strength, lower exothermic temperature during setting (than PMMA) [8]. PEM provisional restorations could be used directly in the patient's mouth (direct technique) [4] and they are more acceptable than PMMA [9]. However, due to PEM resins being mechanically weaker and with less colour stability than PMMA [4], their use is limited to making posterior interim prostheses, in short-term provisional treatment [8].

Most PEM based TCBs contain either the monomer isobutyl methacrylate (IBMA) or n-butyl methacrylate (nBMA). The latter was introduced as a new provisional restorative material due to having low water uptake, low polymerization exothermic reaction and low irritation to the vital tissue (compared with other commercial TCBs like Trim and PMMA based TCBs) [13]. Acceptable biological response also enabled it to be tried as novel bone cement [14]. The former commercial PEM based provisional material with IBMA monomer (e.g. Trim, Bosworth; Table 1) contains a plasticizer (di-butyl phthalate, DBP). The phthalate ester is not chemically bonded to the plastic network [10], and phthalates are considered as endocrine disruptor chemicals (EDCs) that can cause estrogenic behavior and are possible carcinogens [15]. Therefore ingesting a small amount of these elements (EDCs) may cause considerable problems to the living system [16]. Moreover, the plasticizer reduces the glass transition temperature (T_g) of polymers by weakening the links between the polymer chains and increasing their movements [17].

Since polymeric TCBs are placed, and remain, in a moist environment the water absorption behavior of the materials needs to be investigated in detail. This will give an indication of the longevity of the TCBs during the treatment period, as well as the effects of the absorbed water on the other properties. Water uptake behavior is a critical property of dental polymers. The excessive absorption of water can affect the materials dimensional stability and accuracy, reduce mechanical properties, tensile strength and fatigue life, which in turn will reduce their lifetime [18]. Moreover, water absorption can distort soft acrylics, increase the ingress of micro-organisms [19] and decrease glass transition temperature, T_g, by weakening the links between the polymer chains (plasticizer action) [20]. Since TCBs function as temporary restorations in the oral environment (wet condition), the increase in temperature during polymerization and changes in mechanical properties in an aqueous environment, compared with the dry state, need to be assessed.

In this contribution three PEM based resins (two experimental and one commercial) and one composite based material (commercial) were studied. The aims were to assess