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Laboratory tests for assessing adaptability and stickiness of dental composites

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ABSTRACT

Objective. Handling (stickiness, adaptability) of a dental composite does strongly influence quality and success of a dental restoration. The purpose was to develop an in vitro test, which allows for evaluating adaptability and stickiness.

Methods. 15 dentists were asked for providing individual assessment (school scores 1–6) of five dental composites addressing adaptability and stickiness. Composites were applied with a dental plugger ($d = 1.8$ mm) in a class I cavity (human tooth 17). The tooth was fixed on a force gauge for simultaneous determination of application forces with varying storage (6/25 °C) and application temperatures (6/25 °C). On basis of these data tensile tests were performed with a dental plugger (application force 1 N/2 N; $v = 35$ mm/min) on PMMA- or human tooth plates. Composite was dosed onto the tip of the plugger and applied. Application and unplugging was performed once and unplugging forces (UF) and length of the adhesive flags (LAF) were determined at different storage (6/25 °C) and application temperatures (25/37 °C). Unplugging work (UW) was calculated from area of UF and LAF data.

Results. The individual assessment revealed significantly different temperature-dependent application forces between 0.58 N and 2.23 N. Adaptability was assessed between 2.1 and 2.8 school scores. Stickiness varied significantly between the materials (scores: 2–3.2). UW differed significantly between the materials with values between 3.20 N mm and 37.83 N mm. Between PMMA substrate or tooth slides and between 1 N or 2 N application force only small UW differences were found.

Significance. The presented in vitro unplugging work allows for an in vitro estimation of the handling parameters adaptability and stickiness.

1. Introduction

Light curing dental composites are state of the art for clinical restorations. The development of these composites is strongly orientated on clinical requirements. Therefore various materials with different viscosities, application forms and with optimized properties are available [1]. Nevertheless the clinical success of a composite is strongly influenced by handling opportunities. For example insufficient condensation may result in voids or porosities and may reduce stability, marginal integrity or wear resistance. Because handling may

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not be fully described by individual parameters like stiffness, viscosity (rheology) [2], adhesive behavior, visco-elastic behavior [3] or the filler components [4], it is practise to ask dentists for their distinct impression of unset composites. Parameters are the ease to adapt a composite in the cavity (adaptability), how the composite sticks to the cavity or instrument (stickiness) or how firm the composite appears (firmness). Often a high number of dentists is questioned, which results in high expenditure and costs. Therefore, a standardized laboratory test seems necessary, which allows for estimating handling of composites. Already performed tests are tensile tests or profilometry, examining the influence of different speed, testing temperatures or different substrate surfaces. Work for probe separation, maximum force [4] or coefficients of variation [5] were defined as parameters for characterization of composite properties, temperature influence and unplugging speed. Partly the length of the adhesive flag was determined by polymerizing the material during tensile testing [6]. But in conclusion no test seems available representing the clinical situation. Therefore, the idea was to ask a representative number of dentists for the evaluation of different composites and relate these results to in vitro tensile tests. Clinical parameters such as human tooth tissue, storage conditions or cavity temperatures should be considered. Undetermined application force should be evaluated.

The hypothesis of this investigation was that unplugging work might provide an opportunity for evaluating adaptability and stickiness of dental composites. The purpose of this study was to develop a simplified test, which allows for standardizing adaptability and stickiness.

2. Materials and methods

Five different commercially available composite materials were investigated: Admira, Arabesk Top, Grandio, Polofil Molar L (all Voco, Cuxhafen, Germany) and Tetric Evo Ceram (Ivoclar-Vivadent, Schaan, Liechtenstein).

2.1. Part 1

For a praxis-orientated estimation, 15 dentists evaluated the subjective handling properties of the composite materials (estimated power > 0.9, G*Power 3.1.3, Kiel, Germany). The dentists were asked to address to "adaptability" and "stickiness" using school grades from 1 (good/high) to 6 (bad/low). For simulating clinical conditions, the dentists applied the materials with a dental plugger (flat $d = 1.8$ mm, DE 295R, Aesculap, Melsungen, Germany) in a class I cavity (height 5 mm, diameter: 4 mm), which was prepared in a human tooth (tooth 17). Composite was applied in about 2 mm increments. Teeth and plugger were cleaned with chlorhexidine and teeth were kept in water between the tests. Materials were stored and applied at 25 °C. With a force gauge (Type 8435-6001, resolution 0.01 N, Burster, Gernsbach, Germany), which was located under the teeth, the plugging force was determined. Further on plugging forces were measured at two different storage temperatures (6 °C, 25 °C) and two application temperatures (6 °C, 25 °C). Tooth temperatures were regulated using a self-assembled heating module.

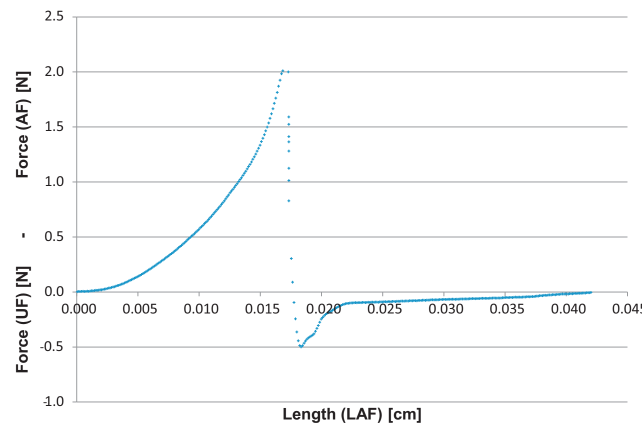

Fig. 1 – Force [N]/length [mm] diagram with application force (AF, positive) and unplugging force (UF, negative) (example, 25 °C/25 °C).

2.2. Part 2

A dental plugger was fixed to a universal testing machine (Zwick 1446, resolution 0.001 N, Zwick, Ulm, Germany), which allows applying standardized application forces (1 N or 2 N as a result of part 1) and speed (35 mm/min). After a number of pre-tests with standard cavities (tooth, PMMA) and for simplification of the testing protocol, we decided to carry out the tests on PMMA- or human tooth plates (thickness 1.5 mm). Plates were cut with an inner whole saw (SP 1600, Leica, Wetzlar, Germany) under water cooling and, in case of tooth plates, in root-crown direction. Composite was dosed (1.5 mm × 2 mm, Composite-gun tubes 1915, KerrHawe, Biggio, Switzerland) and fixed to the tip of the plugger. Application and unplugging was performed one time and the unplugging forces (UF) and the length of the adhesive flags (LAF [mm]) were determined. For detailed optical information on LAF, the tests were recorded with video (Handycam DCR-DVD450E, Sony, Tokio, Japan). Unplugging work (UW) was calculated from area of UF and LAF (integrated) data (UW [N mm] = $\int$ UF [N] × LAF [mm]). Tests were performed with two different storage temperatures (6 °C, 25 °C) and two application temperatures (25 °C, 37 °C). To hinder an uncontrolled polymerization of the applied materials, all tests were performed under yellow light (Fig. 1).

Mean and standard deviation were calculated. Statistical analysis was performed with SPSS 19 (IBM, New York, USA) using one-way ANOVA and linear uni/multi-variant comparison (Bonferroni Post Hoc). The level of significance was set to 0.05.

3. Results

3.1. Part 1

Stickiness of Arabesk and Admira were determined "3.1–3.2", whereas Grandio, Polofil and Tetric were characterized as less sticky ("2–2.5"). A comparable ranking was found for adaptability: Arabesk and Admira were evaluated 2.8, whereas Grandio, Polofil and Tetric got grades between 2.1 and 2.4 (good