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Round robin test: Wear of nine dental restorative materials in six different wear simulators – Supplement to the round robin test of 2005

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ABSTRACT

Objective. The purpose of the present study was to submit the same materials that were tested in the round robin wear test of 2002/2003 to the Alabama wear method.

Methods. Nine restorative materials, seven composites (belleGlass, Chromasit, Estenia, Heliomolar, SureFil, Targis, Tetric Ceram) an amalgam (Amalcap) and a ceramic (IPS Empress) have been submitted to the Alabama wear method for localized and generalized wear. The test centre did not know which brand they were testing. Both volumetric and vertical loss had been determined with an optical sensor. After completion of the wear test, the raw data were sent to IVOCLAR for further analysis. The statistical analysis of the data included logarithmic transformation of the data, the calculation of relative ranks of each material within each test centre, measures of agreement between methods, the discrimination power and coefficient of variation of each method as well as measures of the consistency and global performance for each material.

Results. Relative ranks of the materials varied tremendously between the test centres. When all materials were taken into account and the test methods compared with each other, only ACTA agreed reasonably well with two other methods, i.e. OHSU and ZURICH. On the other hand, MUNICH did not agree with the other methods at all. The ZURICH method showed the lowest discrimination power, ACTA, IVOCLAR and ALABAMA localized the highest. Material-wise, the best global performance was achieved by the leucite reinforced ceramic material Empress, which was clearly ahead of belleGlass, SureFil and Estenia. In contrast, Heliomolar, Tetric Ceram and especially Chromasit demonstrated a poor global performance. The best consistency was achieved by SureFil, Tetric Ceram and Chromasit, whereas the consistency of Amalcap and Heliomolar was poor. When comparing the laboratory data with clinical data, a significant agreement was found for the IVOCLAR and ALABAMA generalized wear method.

Significance. As the different wear simulator settings measure different wear mechanisms, it seems reasonable to combine at least two different wear settings to assess the wear resistance of a new material.

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1. Introduction

In 2005 the results of a round robin test on the wear of dental materials were published [1]. Ten dental materials had been tested with five laboratory wear methods. The results were quite different. When allocating relative ranks to the materials there was only little agreement between the five wear methods. One explanation was that the wear methods follow different wear generating concepts which result in a different ranking of the materials. The test centres used different wear simulators, different forces, different antagonist materials, different number of cycles, with or without thermocycling, etc. Some used abrasive mediums and different methods to evaluate the material loss. ZURICH additionally included 5 h of simulated toothbrushing between the phases as well as storage of the samples in ethanol. Furthermore, some methods showed a low discriminatory power which can be explained by the device that is used in conjunction with the method. Detailed qualification and validation protocols that show that the wear device is qualified and the wear method is validated are not available [2]; this holds true for all devices that are included in the round robin test.

The laboratory Alabama wear method that has – according to a review on wear – the highest citation frequency in the dental literature was not included in the round robin test at that time [2]. The Alabama wear method is also included in the ISO Technical Specification on the wear by two/three body contact [3]; three of the other five methods (ACTA, OHSU, Zurich) are also included in the ISO Technical Specification.

The Alabama wear method was developed by Leinfelder and Suzuki and is therefore also called Leinfelder-Suzuki wear method. The method was first published in 1989 [4] and is a modification of a device that has been originally designed by Roulet [5]. Several major modifications were made over the years. In the first publication in 1989, a polyethylene tape was used as intermediate substance, driven by a tape advancing system [4]. The tape was replaced by a slurry of PMMA beads ten years later [6]. The original force was 55 N, which was increased to 75 N ten years later. In the first publication, a stainless steel stylus with 2 mm radius hit the specimen without rotation. In the new method an additional 30° clockwise rotation was integrated as soon as the stylus hits the surface of the specimen which was then called "localized wear". Additionally, with a new specimen a flat stylus made of polyacetal is brought into contact with the flat specimen; the wear produced by this approach is called "generalized wear". The materials specimens are incorporated into extracted molars that are trimmed flat. The stylus for generalized wear is made of polyacetal, the one for localized wear is stainless steel. The original publication states that each spring is calibrated with a 200 kg load cell in conjunction with a universal testing machine prior to testing, but no data have been reported with regard to the deviations, the scattering of results and the time intervals of force measurements or the replacement frequency of the spring. Most of the early published data come from the same authors (Leinfelder and/or Suzuki [4,6,16–17]).

Later, modifications to the original methods reported by Leinfelder and Suzuki were introduced to increase the reproducibility and reliability of the overall method. In an effort to move away from placing test specimens in extracted human teeth, a standardized cavity in a stainless steel custom fixture was used for positioning the tests materials in the wear simulator. To eliminate variations due to the wear of the acetal generalized wear stylus an identically shaped flattened stainless steel was introduced [7]. For localized wear, a custom antagonist fixture was used that could accommodate a stainless steel ball bearing with a radius of 2.387 mm was used in place of the original hardened steel cone-shaped stylus. The original hardened steel localized antagonist tip surface degraded with use altering the surface finish of the stylus. Using ball bearings facilitates a cost-effective way to provide a new, standardized antagonist for each test specimen and each experiment trial [8,9].

The aim of the present study was to submit the same dental materials that were included in the round robin test published in 2005 to the Alabama wear method and to compare the results to the other five methods with the same statistical methodology. Therefore, this publication is a supplement to the 2005 publication; Section 2 as well as Section 5 are abbreviated and the reader is asked to consult the first publication.

2. Materials and methods

The selected materials were the same as in the first phase of the round robin test except for Targis 130 °C. As the oven that cured Targis specimens at a temperature of 130 °C was no longer available, this material had to be excluded. However, Targis specimens cured at 95 °C were included. Except for two materials (belleGlass and Targis) batches other than the ones used in the first phase of the round robin test (2002–2003) had to be used since the batch was not longer available or had already expired. Table 1 lists the materials with their batch numbers of the first and second phase of the round robin test.

The materials were produced in the same way as in the first phase. They were produced at Ivoclar by one operator, coded with numbers and sent to the test centre so that the centre was not aware which material they were testing.

2.1. ALABAMA wear method

The ALABAMA wear method was carried out at the Center for Oral Health Research at Creighton University (Omaha, USA) using three Leinfedler-Suzuki wear simulators that were thoroughly calibrated before testing the specimens. The materials were submitted to both generalized wear testing using a flat surface stainless steel stylus and localized wear using a stainless steel ball bearing. Specimens for both wear models were placed in a water bath with slurry of PMMA beads (average particle size 44 μm). Each generalized and localized specimen was surface scanned with the Proscan 2000 non-contact optical profilometer (Scantron Industrial Products, Ltd, Taunton, England) using a S38/3 sensor with a depth of field of 3000 μm. Proscan and ProForm software were used for quantification of material changes between the "before" and "after" surface profiles.