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Comparability of clinical wear measurements by optical 3D laser scanning in two different centers

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ABSTRACT

Objective. The purpose of this study was to compare the use of different variables to measure the clinical wear of two denture tooth materials in two analysis centers.
Methods. Twelve edentulous patients were provided with full dentures. Two different denture tooth materials (experimental material and control) were placed randomly in accordance with the split-mouth design. For wear measurements, impressions were made after an adjustment phase of 1–2 weeks and after 6, 12, 18, and 24 months. The occlusal wear of the posterior denture teeth of 11 subjects was assessed in two study centers by use of plaster replicas and 3D laser-scanning methods. In both centers sequential scans of the occlusal surfaces were digitized and superimposed. Wear was described by use of four different variables. Statistical analysis was performed after log-transformation of the wear data by use of the Pearson and Lin correlation and by use of a mixed linear model.
Results. Mean occlusal vertical wear of the denture teeth after 24 months was between 120 μm and 212 μm, depending on wear variable and material. For three of the four variables, wear of the experimental material was statistically significantly less than that of the control. Comparison of the two study centers, however, revealed correlation of the wear variables was only moderate whereas strong correlation was observed among the different wear variables evaluated by each center.
Significance. Moderate correlation was observed for clinical wear measurements by optical 3D laser scanning in two different study centers. For the two denture tooth materials, wear measurements limited to the attrition zones led to the same qualitative assessment.

1. Introduction

Knowledge of the wear resistance of dental materials and of the likely effects of the materials on opposing natural teeth are important aspects of restorative dentistry. Although numerous wear-testing machines have been developed for preclinical study of the wear of dental materials [1–3], no method of wear simulation has yet been accepted internationally, and results from most of the methods used do not

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include clinical wear data [2,4–6]. Only recently have some research groups shown that in vitro wear tests can be clinically representative [5,7,8]. The major problem has been that all laboratory wear machines simulate only one or two of the wear mechanisms simultaneously present in the mouth. They are unable to replicate the oral environment with all its biological variations [2–4].

Clinical data on the wear behavior of dental materials are, therefore, particularly valuable, even if clinical wear measurements are methodologically difficult and require much effort. Clinical wear studies are essential, first for better assessment of the wear behavior of new dental materials and, second, to monitor the wear of natural teeth. Tooth wear with different etiology has been recognized as a major problem with increasing prevalence [9,10].

For measurement of clinical wear, either clinical categorization systems or indirect methods with study casts have been used. Some popular methods, for example the United States Public Health Service (USPHS) system [11], enable only subjective categorization of wear. With another method, the Leinfelder system [12], subjective, but at least semiquantitative, measurements of wear are possible. Most wear-evaluation systems have the disadvantage of assessing wear at restoration margins only and do not enable quantitative measurement of wear of whole restorations or tooth surfaces [3]. They are, therefore, unsuitable for measurement of the wear of denture teeth or full crowns. These methods also systematically underestimate true wear [13].

Advances in measurement techniques have led to the use of 3D laser-scanning devices which enable non-contact surface profilometry and wear measurements by superimposition of baseline and follow-up scans (occlusal matching) [14]. Nowadays, such objective quantitative procedures, rather than subjective evaluation scales, are recommended, and are adequate for studies of clinical wear. Non-contact 3D wear measurement with a laser scanner is currently regarded as the most accurate and effective technique for clinical wear analysis [10,13,15].

Several clinical studies have used 3D laser-scanning devices and occlusal matching to quantify the occlusal wear of different biomaterials [16–21]. Although these studies used the same principle of quantitative wear measurement, they differ in minor, but probably important, methodological details. They also used different variables to measure wear (volume wear versus vertical height loss) and different occlusal areas (attrition zones versus complete occlusal surfaces) to report clinical wear data. It is not yet clear to what extent wear data from different centers, obtained by use of 3D laser scanning, are comparable, or the extent to which their accuracy and precision is affected by the scanning hardware, matching software, and operator.

The purpose of this study was to compare the use of different variables for measurement of clinical wear by use of optical 3D devices in two different centers. Wear data for two different denture tooth materials from patients with complete dentures were collected by one center over a period of 24 months by use of a split-mouth design. One tooth material was a double-cross-linked polymer (DCL = control material); the other was an improved version of the first material. In a laboratory study tooth brushing resulted in less wear of the experimental material than of the DCL material [22].

Casts of the dentures were evaluated for wear in two different centers. Both centers performed non-contact 3D wear measurements with the same methodological approach but with different laser-scanner devices, different matching routines, and different variables for reporting wear data. We intended (1) to investigate the extent to which the different wear variables correlated with each other and (2) to compare statistically the performance of the two materials.

2. Materials and methods

2.1. *Subjects*

This study was part of a multi-center clinical trial (seven centers) involving the same denture tooth materials. Wear results from all the test centers have been published elsewhere [23]. The participants in this clinical trial were initially ten edentulous patients with indication for new full dentures. Two further patients were subsequently recruited because of dropouts early in the study. Exclusion criteria were subjects with allergy to the ingredients of the denture base or the denture tooth material, subjects who wear their existing dentures for fewer than 6 h per day, subjects for whom compliance could not be expected, and subjects who received their first set of full dentures less than 12 months ago. The mean age of the participants was 74.6 years (SD 10), seven were female. All participants were required to sign a consent form. The study protocol was approved by the local review board of Heidelberg University Hospital (ethical approval no. 375/2006).

2.2. *Clinical procedures*

All participants were treated in the Department of Prosthodontics of Heidelberg University Hospital, Germany, and provided with complete dentures in the maxilla and mandible. For one subject the lower denture was retained by use of four implants. The dentures were made in accordance with the usual routines of complete denture treatment. For occlusal adjustment, centric occlusion and the principle of bilateral balanced dynamic occlusion were used. All dentures were fabricated from the denture base material ProBase High Impact (Ivoclar Vivadent, Schaan, Liechtenstein) in accordance with the manufacturer's instructions for use (standard polymerization).

Two different denture tooth materials were used to manufacture the dentures. One material (control group) was a double-cross-linked polymer (DCL; Ivoclar Vivadent). The other denture tooth material (study group) was an improved version of the first material containing 20% UDMA/PMMA fillers (experimental material; Ivoclar Vivadent) (Table 1). In the latter material the polymer and the matrix were homogeneously cross-linked; this was achieved by subjecting both the pre-cross-linked polymer and the matrix to a secondary cross-linking process. The occlusal anatomy was identical for both materials and for all subjects. The posterior teeth were produced in SR Ortholingual molds and the anterior teeth in SR Vivodent molds, at Ivoclar Vivadent. Both tooth