

**The abrasion resistance of VITA MRP materials using the example of
VITA PHYSIODENS® as a critical factor for functional
and esthetic long-term success**

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The results are based on a wear test with 8 different lines of teeth from different manufacturers at the University of Regensburg.

Abstracts

The abrasion resistance of ready-to-use teeth has a significant influence on the esthetic and functional long-term success of a prosthetic restoration. From a functional view, this involves increased abrasion with a lowering of the bite, which has negative effects on all anatomical structures of the stomatognathic system. The patient's chewing capacity is reduced in the case of an abraded protuberance fissure relief. Particularly in the anterior tooth area, grinding facets lead to morphological deficits which have a negative effect on the overall esthetic image. For this reason, the University of Regensburg investigated and compared the abrasion behavior of 8 different lines of teeth from different manufacturers. VITA PHYSIODENS made of VITA MRP materials demonstrated the lowest abrasion values in this investigation.

The problem

An In-vitro wear test under standardized laboratory conditions can show whether there are actually significant differences in the abrasion behavior of ready-to-use acrylic teeth and which tooth lines are particularly resistant. Meaningful results can provide the practitioner with the tools needed to make decisions on which tooth line is the best for long-term prosthetic success.

Level of technology

Ready-to-use acrylic teeth have consisted of acrylic polymers since the 1950s, mostly of polymethyl acrylate (PMMA) [1]. The smallest single molecular building block of PMMA, the monomer, is the liquid methylmethacrylate (MMA) [2]. When manufacturing teeth, PMMA, available in the form of small beads, and MMA are mixed together homogeneously with pigments, cross-linking monomers, stabilizers and initiators [3][4]. This mass, still plastically deformable, is then hardened into tooth shapes under increased temperature and high pressure [5]. In the beginning, the polymer beads consisted of linear, non-cross-linked PMMA. Later, these PMMA beads were modified to positively influence the material properties. This was implemented by the use of pre-cross-linked prepolymers. The mechanical durability was slightly increased through the more even distribution of the cross-linking sites [6]. PMMA beads, chain lengths and the internal molecular cross-linking of the polymers have an influence on the physical properties of an acrylic tooth, including its abrasion resistance. Modern acrylic teeth also possess an inorganic phase of filling material which positively influences the material properties [7] [8]. Ground glasses or synthetically obtained oxides such as amorphous silicon dioxide are used, for example, as an inorganic filling material [9]. The type of filling material and its particle size, the filling material content and the distribution and binding to the organic matrix, determine the clinical abrasion behavior [10]. A natural play of shade and light can be enabled by the inlay of dentine, enamel and cervical materials with varying translucencies in the press forms [11]. A balanced pressure and temperature management during polymerization provides for a controlled chemical hardening [12].

Materials and methods

In a Pin-on-Block (POB) wear test at the Poliklinik für Zahnärztliche Prothetik of the University of Regensburg (Report Number: 280_2/Project Number: 280. 09 Nov. 2015), 8 ready-to-use prosthetic teeth were tested in a chewing simulator. The following tooth lines were used: Genios A (DENTSPLY), VITA PHYSIODENS as an example of the VITA MRP material (VITA Zahnfabrik), SR Phonares II (Ivoclar Vivadent), PhysioStar NFC+ (CANDULOR), Mondial 6 (Heraeus Kulzer), Premium 6 (Heraeus Kulzer), Bioplus (DENTSPLY) and Veracia SA (Shofu). For the wear test, anterior teeth of all manufacturers were embedded in a sample holder and carefully ground. Before the investigation, the roughness of the samples was determined with a stepwise process.

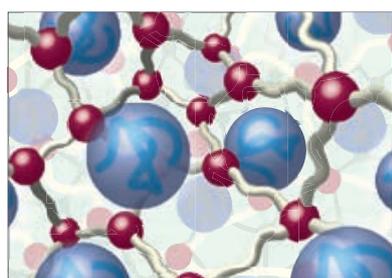
To do this, the surface of the sample was scanned with a point and documented. The samples were then mounted, one after the other, in the chewing simulator. A steatite ball was used as an enamel-like antagonist. This was done with each sample in 120,000 cycles with a force of 50 N and a pulse of 1.2 Hz. The lateral movement of the chewing simulator was set to 1 mm. The vertical travel of the antagonists was also 1 mm, which created the impact momentum on the samples. In one 2-minute cycle, a temperature changed between +5 °C and +55 °C was added with distilled water. This fluctuation simulated the temperature difference during food intake. At the end of the chewing simulation, the wearing surfaces of all samples were examined and measured in a 3-D laser microscope.

Results

In general, no cracks, flaking, material displacement or nicks were detected during the evaluation of evidence of wear under a 3-D laser microscope. The samples with VITA PHYSIODENS, however, showed a significantly lower maximum wear in comparison to all other tested ready-to-use teeth, as can be seen in the bar diagram on the following page.

Discussion

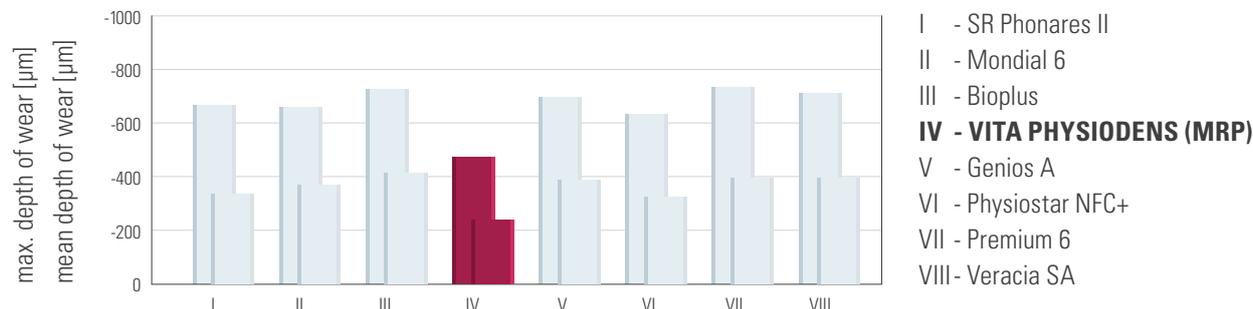
The exact formula and composition of the organic and inorganic phase, as well as the process chain during manufacturing, appears to lead to different abrasion resistances of prosthetic teeth. The VITA PHYSIODENS, like all other tooth lines of VITA Zahnfabrik (VITAPAN PLUS, VITAPAN CUSPIFORM, VITAPAN SYNOFORM and VITAPAN LINGOFORM), consists of MRP material (MRP = Microfiller Reinforced Polymer matrix). The quality of the polymer pearls in the organic matrix also plays a critical role here. The developer again used a linear, macromolecular structure of the pre-polymerized pearls in the organic matrix. The great advantage is the effective solubility. In order to also strengthen the internal bond, finely dispersed and silanated silicon dioxide (SiO_2) is mixed in as an inorganic microfiller (MRP). The silanation provides for a reliable bond in and to the organic acrylic matrix. Because of this, methylmethacrylate (MMA) can be dispensed with, which has a positive effect on the biocompatibility of the material. Only dimethacrylates (DiMA) are homogeneously mixed in here with silanated SiO_2 and PMMA pearls. Now the chemical maturation starts: The DiMA penetrates the upper layers of the PMMA pearls and causes these to swell. The result after hardening is a high-molecular weight and highly cross-linked acrylate polymer with SiO_2 -microfill material incorporated by polymerization, which is responsible for the significantly better abrasion resistance.



- PMMA pearls, swollen with monomers and incorporated in the polymer network
- cross-linked monomer
- inorganic microfiller, incorporated into the polymer network

In addition, some of the tooth lines of competitors are provided with filling elements in the upper enamel layer only. VITA PHYSIODENS and all other ready-to-use acrylic teeth of VITA Zahnfabrik contain the same proportion of microfiller in all layers. Even during grinding, the practitioner moves securely over an abrasion-resistant surface. Through the homogeneous mixing in of microfillers and a one-step polymerization of the entire MRP tooth, there is no danger of chipping between different material layers. The after-pressing procedure (VNPV) developed especially for this material by VITA Zahnfabrik polymerizes all microfiller-reinforced acrylic layers under pressure so that it becomes dense and compact in one step. The material-specific management of pressure and temperature results in a practical methylmethacrylate-free, biocompatible end product. The harmonious bond of enamel, dentine and cervical material allows for the creation of a highly esthetic and natural-appearing tooth, which provides for a sustainable, functional and esthetic long-term success, with high mechanical durability and outstanding abrasion behavior.

Lowest abrasion values for VITA PHYSIODENS® made of MRP materials



(Source: Pin-on-Block (POB) wear test, University of Regensburg, Germany, 2015)

Diagram based on the Pin-on-Block (POB) wear test at the University of Regensburg illustrated on page 2.

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