G Model
JPOR 441 No. of Pages 6

ARTICLE IN PRESS

journal of prosthodontic research xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Prosthodontic Research

journal homepage: www.elsevier.com/locate/jpor

Original article

Contact wear of artificial denture teeth

Verena Preis*, Sebastian Hahnel, Michael Behr, Martin Rosentritt

Department of Prosthetic Dentistry, University Medical Center Regensburg, Germany

ARTICLE INFO

Article history:
Received 7 August 2017
Received in revised form 2 November 2017
Accepted 13 November 2017
Available online xxx

Keywords:
Chewing simulation
Composite teeth
Denture teeth
Resin-based teeth
Wear resistance

ABSTRACT

Purpose: High wear resistance of denture teeth preserves good occlusal relationship and sufficient parafunctional stability. This in-vitro investigation aimed to determine and compare the wear performance of different artificial denture teeth.

Methods: Denture teeth of fifteen commercial products ($n = 8$/group) were loaded in a pin-on-block design using steatite antagonists (d = 3 mm). Cyclic loading (50 N) was applied for 120,000 loadings ($f = 1.2$ Hz) with simultaneous thermal cycling (distilled water, 5 °C/55 °C, 2 min/cycle). A loading cycle consisted of a vertical 1 mm impact and a subsequent lateral 1 mm sliding movement. Worn areas were digitalized (3-D-laser-scanning-microscope). Maximum and mean wear depth and surface roughness were determined and statistically compared (one-way Anova, Tukey-HSD test, $\alpha = 0.05$). Worn surfaces and cut specimens were investigated with scanning electron microscopy (SEM).

Results: Maximum wear varied between 475.1 μm and 1232.2 μm. Mean wear was between 241.1 μm and 753.6 μm with significant differences ($p < 0.001$) between individual materials. Mean and maximum wear showed a significant correlation (Pearson's correlation coefficient: 0.942). Surface roughness increased between unworn to worn surface by 1.2 μm (Ra, $p = 0.387$) and by 41.7 μm (Rz, $p = 0.000$). All materials provided round or drop-shaped wear traces. Superficial analysis showed no cracks, chipping or fractures in the worn areas. Detailed evaluation of cut specimens with SEM exposed cracks on the bottom of the wear traces.

Conclusions: Denture teeth showed significantly different in-vitro wear performance and increased roughness in the wear trace. Differences may be attributed to the composition of the materials, regarding both filler and polymer structure. The selection of teeth might contribute to enhanced in-vivo performance of the denture.

1. Introduction

Denture teeth have to replace natural human teeth. They have to resist individual standard and parafunctional movements and maintain a proper occlusal relationship. Artificial denture teeth differ by their polymer matrix systems that are based on polymethylmethacrylate (PMMA) or methacrylate variations like urethane dimethacrylate (UDMA). Higher stability and better performance may be achieved by adding organic filler components that may be simply cross-linked or even highly cross-linked together with the polymer matrix [1]. New generation denture teeth have been modified using cross-linking agents, improved monomers, or new fillers [2].

Modern denture teeth are fabricated in commercially optimized processes such as robotic insertion of the material into the mold, injection molding, milling, transfer molding, or spray casting [3]. These procedures influence the quality of the denture teeth as do the material composition, individual layers, or the final adaptation and polishing during the fabrication of the prostheses.

The main requirements on denture teeth are a good bonding between tooth and denture base [4] and a sufficient stability of the teeth to withstand chewing forces [5]. Therefore, the teeth have to provide individual layers, which are firmly fixed together forming a high-strength tooth complex, assuring high wear resistance on the occlusal side and good monomer-penetration for sufficient bonding to the ridge lap portion of the tooth [3]. The design and the occlusal concepts may contribute to the clinical performance of the teeth [6]: teeth with flat and rounded cusps are able to withstand higher chewing forces, because they show a more homogenous and centric force distribution [5]. In contrast, steeper cusps are prone to chipping and accentuated fissures are

* Corresponding author at: UKR University Medical Center Regensburg, Department of Prosthetic Dentistry, 93042 Regensburg, Germany.
E-mail address: verena.preis@ukr.de (V. Preis).

https://doi.org/10.1016/j.jpor.2017.11.001
1883-1958/

predisposed to fracture. The antagonistic material contributes to the individual wear performance [7]. Indications for dentures vary between mucosa-retained and implant-retained dentures, requiring higher stability for implant-retained dentures, because they are supposed to be exposed to higher maximum bite forces. Susceptibility to fracture or chipping may even be influenced by fatigue mechanisms or superficial defects that can be initiated during fabrication of the prostheses or by contact wear and corrosion effects. After initiation, crack growth may be further supported by a humid environment. Vertical wear of denture teeth has been reported to be patient-specific between 0.2 to 1.0 mm in two years [6,8,9]. Clinical factors strongly influencing wear are supposed to be chewing forces and individual nutrition, besides others [8,10].

Improvements in the wear resistance may be achieved by applying inorganic filler components as done in restorative or veneering composites. But a modification of the tooth chemistry is complex, because increased strength and hardness may also influence toughness [2]. Tough and brittle materials may provide increased crack-growth, fatigue, creep, or other long-term breakdown effects [11,12]. Therefore, high-strength composite teeth may show higher wear resistance but they may be susceptible to brittle fracture, especially on implant-retained dentures.

Because there is a lack of information on the clinical performance, composition, and properties of artificial denture teeth, it seems important to provide comparable in-vitro data of commercial teeth allowing some estimation of their clinical behavior. Contact wear of denture teeth seems an important property because a high wear resistance maintains good aesthetics and function of a dental prosthesis. The hypothesis of this in-vitro study was that artificial denture teeth show significant differences in wear performance.

2. Materials and methods

Denture teeth of fifteen different commercial systems were investigated (Table 1). Teeth were selected to offer a wide range of commercial products. Maxillary incisors were chosen for providing a sufficient labial area for the wear test. The teeth were polymerized to sample holders using a flowable composite (Filtek Supreme flow, Elipar TriLight, 3 M Oral Care, St. Paul, MN, USA). The labial sides of the teeth were planed in a polishing machine (Metaserv Motopol 8, Buehler, Coventry, UK, 90 rpm) under permanent water cooling and standardized conditions (60 s, 3 N) using silicone carbide grinding paper (grit 1000) for providing appropriate flat surface areas of about 6 mm × 6 mm for the wear test. A total of eight specimens per group were investigated.

All specimens ($n = 8$/group) were loaded in a pin-on-block design using a spherical steatite antagonist (CeramTec, D, diameter: 3 mm) that replaced an antagonistic tooth cusp. One loading cycle consisted of a vertical 1 mm impact and a subsequent lateral 1 mm sliding movement under load. Cyclic loading of 50 N was applied for 120,000 loadings ($f = 1.2$ Hz; vertical and horizontal speed: 30 mm/s; reverse speed: 70 mm/s) in a pneumatic loading device (EGO, Regensburg, D). Simultaneous thermal cycling was performed with distilled water between 5 °C and 55 °C for 2 min each cycle. After wear testing all worn areas were digitalized and analyzed with a 3-D laser-scanning-microscope (KJ 3D, KEYENCE, J; parameters: magnification 5×, WD = 22.5 mm, 1025 × 768 pixel, effective z-range 7 mm, resolution z = 0.005 μm). Maximum wear and mean wear depth [μm] of all specimens were determined: the complete wear trace was manually marked and the mean wear depth was calculated from all data below the reference surface plane. The maximum wear depth was defined as the highest distance between the reference surface plane and the bottom of the wear trace. Linear correlation between maximum wear depth

Table 1
Materials and manufacturer.

#	Material	Batch number	Color	Manufacturer	Composition (number of layers)
	PMMA, conventional				
1	Trubyte Classic	16716	A2	Dentsply Sirona, York, PA, USA	PMMA (n.i)
2	Kenson	L5F305	A2	Myerson LCC, Chicago, IL, USA	PMMA with high molecular weight Methylmethacrylate (n.i)
	PMMA, cross-linked/IPN				
3	Kaijing	M160104	A2	Huge Dental Material Co., Shandong, China	Double cross-linked (DCL) acrylic (4)
4	Vivodent DCL	UP0705	A1/ A2	Ivoclar Vivadent AG, Schaan, Liechtenstein	Double cross-linked (DCL) PMMA (3)
5	Vita MFT	T7	A2	Vita Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany	Cross-linked PMMA (3)
6	Bioplus	06L	A3	Dentsply Sirona	IPN (4)
7	Genios A	090	A3	Dentsply Sirona	IPN, no inorganic filler (5)
8	Merz Dental Artegral BXL	45011	A3	Merz Dental GmbH, Lütjenburg, Germany	Organic-modified polymer network (OMP-N) (5)
	PMMA, cross-linked, with fillers				
9	Premium 6	B83	A3	Kulzer GmbH, Hanau, Germany	PMMA, cross-linked, organic filler, nanofillers (n.i)
10	Mondial 6	06	A3	Heraeus Kulzer, D	PMMA, cross-linked, organic filler, nanofillers (3)
	Composite				
11	Veracia SA	776	A3	Shofu inc., Kyoto, Japan	UDMA, PMMA, microfilled hybrid (MF-H) Composite + coated glass (3)
12	SR Phonares II	016279	A3	Ivoclar Vivadent inc., Amherst, NY, USA	UDMA, nanohybrid composite (NHC), PMMA-cluster; inorganic fillers (4)
13	Physiostar NFC+	06	A3	Candulor AG, Opfikon, Swiss	UDMA, nano/microfilled composite (NFC) (4)
14	Yamahachi Dental Crown PX	S535	A3	Yamahachi dental mfg., Co., Gamagori, Japan	UDMA, PMMA, silica (3)
15	Physiodens	L99	A3	Vita Zahnfabrik H. Rauter GmbH & Co. KG	Microfiller-reinforced polyacrylics (MRP): 14 weight-% silanized silica filler, cross-linked PMMA (3)

IPN: interpenetrating polymer network; PMMA: polymethylmethacrylate; UDMA: urethane dimethacrylate; data provided by manufacturers, n.i.: no information available.

Please cite this article in press as: V. Preis, et al., Contact wear of artificial denture teeth, J Prosthodont Res (2017), https://doi.org/10.1016/j.jpor.2017.11.001