Occlusal Wear of Provisional Implant-Supported Restorations

Hendrik J. Santing, DDS;* Cornelis J. Kleverlaan, PhD;† Arie Werner, Ing;† Albert J. Feilzer, DDS, PhD;‡ Gerry M. Raghoebar, DDS, MD, PhD;§ Henny J. A. Meijer, DDS, PhD§¶

ABSTRACT

Background: Implant-supported provisional restorations should be resistant to occlusal wear.

Purpose: The purpose of this laboratory study was to evaluate three-body wear of three indirect laboratory composite resins, five chair side bis-acryl resin-based materials, and two chair side methacrylate-based materials used to fabricate provisional implant-supported restorations.

Material and Methods: The materials were handled and cured according to the manufacturers' instructions. The three-body wear was measured 1 day, 3 days, 7 days, 4 weeks, and 8 weeks after curing using the ACTA wear device.

Results: Wear rate decreased significantly after 8 weeks compared with the first day for all tested materials, except for Estenia C&B. The three-body wear of two indirect laboratory composite resins, that is, Estenia C&B and Solidex, was significantly less compared with all other tested materials used for fabricating provisional implant-supported restorations. Of the chair side materials, the wear rate of Protemp Crown Paste was significantly less compared with the others materials used to fabricate chair side provisional implant-supported restorations. The methacrylate-based materials, Temdent Classic and Trim, showed extreme high wear rates.

Conclusions: Based on the results of this laboratory study on long-term wear, the use of indirect composite resin is preferred over chair side methacrylate-based materials when the provisional implant-supported restoration has to be in service for a long period of time. Of the investigated materials, only Estenia C&B and Solidex showed wear rate comparable with posterior resin composites.

KEY WORDS: composite resin, dental implants, dental materials, provisional restoration, wear

INTRODUCTION

Implant-supported restorations are nowadays considered the viable treatment option for replacing missing or failing maxillary anterior teeth, with predictable documented results.[1–3] Although implant dentistry in case of single missing teeth has become routine, restoring anterior teeth with implant-supported restorations that mimic adjacent natural teeth in a well-balanced and harmonized soft tissue is still a difficult task.[4]

Good aesthetic results are becoming important criteria for the definition of success. This involves the establishment of a soft tissue contour that is harmonious with the gingiva of the adjacent teeth and a crown in balance with the adjacent dentition.[2,5–7] An anatomical provisional restoration is used to achieve harmonious peri-implant soft tissue.[6–8] Provisional implant-supported restorations are particularly important during long-term anterior temporization. They represent an important step in deciding the shape and

*Assistant professor, Department of Oral and Maxillofacial Surgery, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands; †associate professor, Department of Dental Materials Science, Academic Centre for Dentistry Amsterdam (ACTA), Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, The Netherlands; ‡professor, Department of Dental Materials Science, Academic Centre for Dentistry Amsterdam (ACTA), Universiteit van Amsterdam and Vrije Universiteit, Amsterdam, The Netherlands; §professor, Department of Oral and Maxillofacial Surgery, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands; ¶professor, Department of Fixed and Removable Prosthodontics, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

Reprint requests: Prof. Dr. Henny J. A. Meijer, Department of Fixed and Removable Prosthodontics/Department of Oral Maxillofacial Surgery, University Medical Center Groningen, PO Box 30.001, 9700 RB Groningen, The Netherlands; e-mail: h.j.a.meijer@umcg.nl

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contour of the final restoration, mainly dependent on the maturation of the peri-implant soft tissues.[9] The provisional restoration is usually in function for 3 months, but this period can be prolonged if an extended evaluation period is required.[10]

Different approaches have been suggested to fabricate implant-supported provisional restorations.[11] They can be fabricated either chair side or at the dental laboratory.[8,11–16] Chair side provisional restorative materials can be divided into two major resin groups: methacrylates (methyl methacrylate and ethyl methacrylate) and bis-acryl composites.[17] If the provisional restoration is made in the dental laboratory, indirect laboratory composite resins are used.[18,19]

To achieve predictability, provisional materials should possess a number of ideal mechanical and physical properties, such as a high flexural strength, increased resistance to occlusal wear, high fracture strength, dimensional stability, minimal marginal gap formation, and increased resistance to staining and discoloration.[20,21] Failure of provisional restorations has been observed. After prolonged use, a tendency for occlusal wear and fracture has been described, what eventually leads to unnecessary repair.[17] In a previous study by Santing and colleagues, occlusal wear has been analyzed.[22]

A sensitive way to study differences in the structural integrity of a provisional restoration is by determination of the three-body wear.[23–26] This type of wear, which is believed to form the main portion of occlusal wear, results from the abrasive activity of the solid particles in a food bolus when it is pressed onto and sheared across the occlusal surfaces of opposing teeth during mastication.

The purpose of this laboratory study was to evaluate the three-body wear of three indirect laboratory composites, five chair side bis-acryl resin-based materials and two chair side methacrylate-based materials for provisional restorations. The null hypothesis of the current study was that no differences would exist between the 10 materials in three-body wear rate.

MATERIALS AND METHODS

The materials used in the study, their manufacturers, and batch numbers are shown in Table 1. Three-body wear was evaluated with a wear machine developed by the Academic Centre for Dentistry Amsterdam (ACTA).[25,26] In short, this device consists of two motor-driven cylindrical wheels rolling over each other with a surface slip of 15%, inside a bowl containing a third body medium, consisting of a slurry of rice and millet seed shells (pH = 7). One wheel accommodated 10 test specimens; the other wheel, of stainless steel, was pressed against the specimen wheel at a spring force of 15 N. A test run consisted of 200,000 cycles ($55^1/_2$ h) of the specimen wheel at a rotational speed of 1 Hz. All restorations materials were handled and cured according to the manufacturers' instructions, and after setting, the materials were kept at 37°C and stored in water at all times throughout a period of 8 weeks.

The specimens were not subjected to additional fatigue experiments like thermocycling because provisional implant-supported restorations do not have to function in the mouth for a prolonged period of time.

A number of wear runs were performed, the first starting 1 day after preparation of the specimen and subsequently after 3 days, 7 days, 4 weeks, and 8 weeks. After each run, 10 tracings were taken at fixed positions on the worn surface of each pair of specimens (PRK profilometer no. 20702, Perthen GmbH, Hannover, Germany) to determine the loss of material in mm and averaged. The experiments were carried out in duplo (n = 20 tracings per material).

Two-way analysis of variance (ANOVA) and Tukey post hoc test were used to test differences in wear rate. The software used was Sigma Stat 3.1 (SPSS Inc., Chicago, IL, USA).

RESULTS

The wear rates are summarized in Table 2 and graphically depicted in Figure 1. Two-way ANOVA statistical test showed that the type of material ($F = 8293.5$; $p < .001$) and time ($F = 698.7$; $p < .001$) had a significant effect on the wear rate. Tukey's post hoc test ($p < .05$) showed that wear rate decreased significantly after 8 weeks compared with the first day for all tested materials, except for Estenia C&B. For the latter indirect composite resin, no significant difference in wear rate could be observed between the first day and 8 weeks. The three-body wear of two indirect laboratory composite resins, that is, Estenia C&B (Kuraray Dental, Tokyo, Japan) and Solidex (Shofu Inc., Kyoto, Japan), was significantly less compared with all other tested materials used for fabricating provisional implant-supported restorations. Of the chair side materials, the wear rate of Protemp Crown Paste (3M ESPE, Seefeld, Germany) was significantly less compared with the others materials

TABLE 1 Materials Properties According to Manufacturers' Data

Code	Material*		Matrix†	Filler‡	Manufacturer§	Batch Nr
EAD	Estenia C&B	InC	Bis-GMA, UDMA, decandiol dimethacrylate 2 µm, surface treated alumina, silinated glass ceramics	92	Kuraray Dental	LOT 00025C
SLDX	Solidex	InC	Bis-GMA, TEGDMA 1 µm, silicon dioxide, aluminum oxide	53	Shofu Inc	LOT 060862
SFY	Sinfony	InC	UDMA, Bis-EMA 0.5–0.7 µm, borosilicate glass, pyrogenic silica	45	3 M ESPE	LOT 358942
PTCP	Protemp Crown Paste	CsC	Bis-GMA, TEGDMA, Dimethacrylate 0.6 µm, silanized zirconia silica, fumed silica	78	3 M ESPE	LOT PSLMFG290L088B33
PTP4	Protemp 4	CsC	Bis-GMA, UDMA, TEGDMA, Bis-EMA 50 nm silanized amorphous silica	35	3 M ESPE	LOT B358012 C 357173
STP	Structure Premium	CsC	UDMA ethoxylated Bis-GMA 0.7 µm glass ceramics, aerosil	40	VOCO	LOT 670385
ITGY	Integrity	CsC	Multifunctional methacrylates, Glycol methacrylate Barium glass, fumed silica	44	Densply deTrey	LOT 060719
LXTP	Luxatemp	CsC	UDMA, aromatic dimethacrylate, glycol methacrylates 0.02–2.5 µm glass	44	DMG	LOT 569570
TDTC	Temdent Classic	CsM	PMMA	–	Schütz Dental	LOT P 2008006642 L 2008005994
TRIM	Trim II	CsM	PMMA	–	Bosworth	LOT P:0606-306

*Indication: InC = indirect lab composite, ScC = chair side composite, CsM = chair side methacrylate.
†Bis-GMA, bis-phenyl glycidylmethacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; Bis-EMA, ethoxylated bis-phenol-A-dimethacrylate; EBPADMA, ethoxylated bis-phenol-A-dimethacrylate; PMMA, polymethyl methacrylate.
‡In weight%.
§Kuraray Dental, Tokyo, Japan; Shofu Inc, Kyoto, Japan; 3M ESPE, Seefeld, Germany; VOCO GmbH, Cuxhaven, Germany, Densply deTrey, Konstanz, Germany; DMG, Hamburg, Germany; Schütz Dental GmbH, Friedberg, Germany; Bosworth Company, Skokie, IL, USA.

used to fabricate chair side provisional implant-supported restorations. The methacrylate-based materials, Temdent Classic (Schütz Dental GmbH, Friedberg, Germany) and Trim (Bosworth Company, Skokie, IL, USA), showed extreme high wear rates. Figure 2 shows the correlation between the wear rate and the filler content. The correlation coefficient was $R^2 = 0.816$ and 0.842 ($p < .001$) at the first day and 8 weeks, respectively.

DISCUSSION

The three-body wear of the tested restoration materials that can be used for fabricating provisional implant-supported restorations was between 23.6 and 237.3 µm/200,000 cycles and showed a dependence on the filler load. The null hypothesis that the 10 materials would not be significantly different from each other could be rejected. The wear rates of two indirect laboratory composites, that is, Estenia C&B (EAD) and Solidex (SLDX) were significantly lower compared with the other tested materials. Of the latter materials, the wear rate of Sinfony (SFY) and Protemp Crown Paste (PTCP) did not significantly differ from each other. It is hypothesized that due to the high filler load of PTCP (78 wt%), the wear rate is similar to the wear rate of indirect composite resin SFY. The materials Structure Premium (STP), Integrity (ITGY), Luxatemp (LXTP), and Protemp 4 (PTP4) had similar wear rates, probably due to the fact that the matrix and the filler load are comparable. The methacrylate-based materials, Temdent Classic (TDTC) and Trim II (TRIM), showed extreme high wear rates, which is most probably due to the lack of filler.

TABLE 2 Mean Wear and Standard Deviation in Parentheses in Micrometers at Different Time Periods after Curing for the Investigated Materials

	EAD	SLDX	SFY	PTCP	PTP4
D1	23.6 (1.5)	55.8 (2.2)	76.3 (5.2)	84.1 (6.7)	125.5 (9.7)^{A}
D3	21.8 (1.2)	50.1 (3.1)	80.1 (3.3)^{D}	75.9 (3.3)^{D}	119.3 (6.9)^{B}
D7	20.5 (2.0)	45.6 (2.2)	75.0 (5.0)	68.2 (3.0)	116.3 (5.0)^{E}
W4	16.5 (1.7)	43.6 (3.6)	67.6 (4.3)^{H}	67.3 (5.3)^{H}	98.6 (6.0)
W8	20.2 (1.2)	48.7 (2.1)	71.0 (6.0)^{K}	67.0 (2.7)^{K}	93.0 (11.5)^{J}
	STP	**ITGY**	**LXTP**	**TDTC**	**TRIM**
D1	128.3 (4.9)^{A}	128.7 (6.8)^{A}	135.4 (3.2)	184.9 (8.4)	237.3 (5.8)
D3	105.1 (2.4)	112.3 (5.0)^{C}	115.8 (2.3)^{BC}	145.7 (5.4)	231.7 (5.1)
D7	92.4 (1.4)	109.5 (2.6)^{F}	113.0 (2.4)^{EF}	141.8 (12.2)	203.9 (12.9)
W4	89.6 (4.2)	111.0 (6.4)^{G}	110.9 (6.4)^{G}	153.4 (11.1)	197.9 (5.6)
W8	96.5 (3.5)^{J}	102.9 (4.0)^{I}	108.0 (6.1)^{I}	135.1 (5.2)	157.7 (10.4)

Means with the same letter are not within the time not significantly different ($p > .05$).

In general, the resistance to abrasive wear is likely to be determined by a combination of hardness and fracture toughness of the restoration material. Hardness is a property that is used to predict the wear resistance of a material and its ability to abrade opposing dental structures. Differences in wear between the composite resins used, might be related to the portion of filler particles and their distribution, degree of conversion, filler and matrix properties, and the bond between the matrix and the fillers.[27–30] Due to its fillers, bis-acryl composite achieves a higher resistance to wear in relation to polymethyl methacrylate (PMMA).[17] Indirect composite resins generally show the lowest wear rates due to their fillers and high rates of polymerization.[31,32] In vitro two-body wear of the composite resins used in the current study can be found in the literature. Mehl and colleagues found a significant difference in wear between Solidex (0.024 mm3 ± 0.004), Estenia (0.053 mm3 ± 0.011) and Sinfony (0.064 mm3 ± 0.014; 3M ESPE, Seefeld, Germany) after 240,000 cycles.[33] The two-body wear

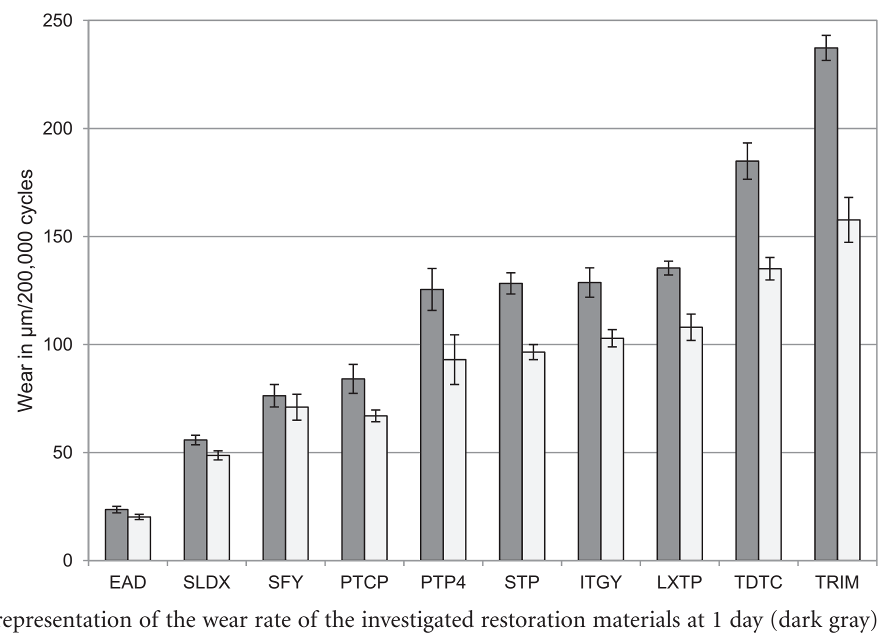

Figure 1 Graphical representation of the wear rate of the investigated restoration materials at 1 day (dark gray) and 8 weeks (light gray).

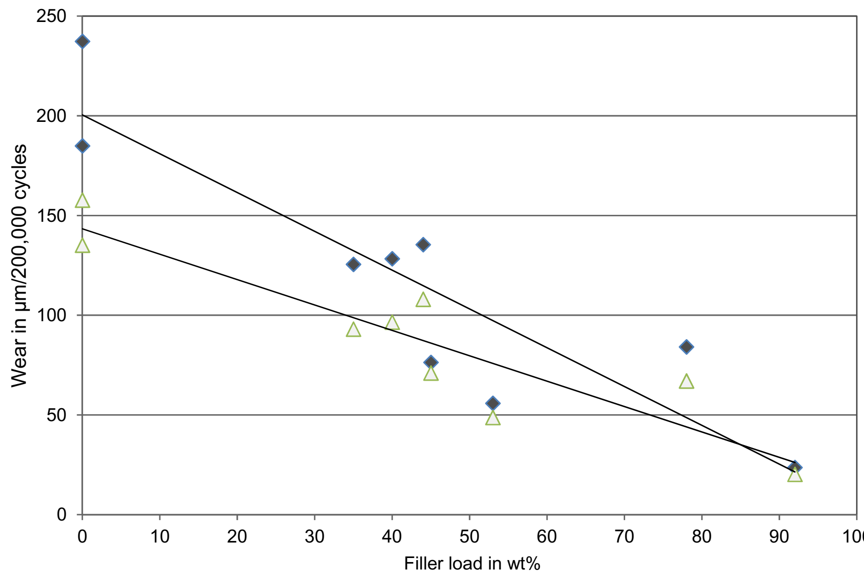

Figure 2 Graphical representation of the linear correlation between wear rate and the filler load at 1 day (dark gray) and 8 weeks (light gray).

shows a different behavior compared with the three-body wear investigated in this study. Apparently, Estenia showed a higher two-body wear compared with its three-body wear. It could be that due to the high filler load in Estenia, the material becomes brittle and in principle more susceptible to two-body wear. In this study, the wear rate of 10 restoration materials that can be used for fabricating provisional implant-supported restorations was tested in a three-body wear simulator. Abrasion occurs in a three-body wear mode and is generated by the sliding action of one material past another with force being transmitted through a layer of food that serves as a third-body medium.[34] To simulate this phenomenon in the laboratory, the current study used a slurry of rice and millet seed shells as a third body in a three-body ACTA wear testing machine.[25,26] However, a quantitative comparison between studies carried out using different chewing simulators seems to be questionable. Heintze and colleagues found in a round robin test that relative ranks of the materials tested varied tremendously between test centers (Ivoclar, Zurich, Munich, Oregon Health & Science University, and ACTA).[35] The test centers did not only use different wear simulators, but they also used different forces, different antagonistic materials, different number of cycles, with or without thermocycling, etc. Furthermore, different methods were used to determine wear. Therefore, it is difficult to compare study outcomes because of the differences in methods. The three-body ACTA wear shows a wear rate of <30 µm/200,000 cycles for ceramics, enamel, and posterior resin composites and between 30 and 60 µm/200,000 cycles for most other composites. The wear rate of glass-ionomer cement is approximately 100 µm/200,000 cycles. Due to this high wear rate, glass ionomer is clinically considered as a restoration material for temporary indications. Based on this rough estimate, Estenia C&B and Solidex can be considered as provisional materials that can be used for a longer period (3 months and more) and all other materials investigated in this study as provisional restoration material for short-term use (shorter than 3 months).

CONCLUSIONS

Within the limited scope of the current study, it was concluded that indirect laboratory resin composites Estenia C&B and Solidex exhibited significant less wear compared with materials indicated as chair side provisional restoration material and are therefore preferred when a provisional implant-supported restoration has to be in function for a longer period of time. The use of PMMA as a provisional restoration material will lead to increased wear rates and is therefore not suitable for prolonged use in the mouth.

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