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Provisional crown and fixed partial denture materials: Mechanical properties and degree of conversion

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ABSTRACT

Objectives. This study aimed to investigate the flexural strength (FS) and flexural modulus (FM) of temporary crown and bridge materials (t-c&b) at different storage times and to identify possible correlations between the mechanical properties and the degree of conversion (DC).

Methods. FS and FM of four proprietary di-methacrylate-based t-c&bs were tested in a 3-point bending test according to EN ISO 4049:2000 at various storage times after mixing (37 °C dry/water) including thermocycling (5000×, 5–55 °C). DC was determined by calculating the percentage of reacted C=C double bonds using FTIR analysis (baseline method). Mean values of all measurements were calculated and subjected to the Games–Howell test for statistical analysis ($p = 0.05$) as well as a logarithmic regression analysis.

Results. FS and FM were very low 10 min after mixing for all materials tested (FS: 14.5–24.5 MPa; FM: 96.1–211.2 MPa). A very high correlation was observed between FS and FM on the one hand and storage time on the other. The DC was on a high level already 10 min after mixing (57.7–69.8%) for all materials except for Structur Premium (42.2%). Structur Premium showed a significantly higher FS and FM ($p < 0.05$) compared to all other materials tested though a significantly lower DC ($p < 0.05$).

Significance. FS and FM of t-c&bs significantly depend on the time after mixing. Dentists should be aware of the fact that the mechanical stability of temporary crowns is comparably low in the first hours after fabrication. The DC does not allow drawing conclusions about the mechanical stability of a t-c&b.

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1. Introduction

Temporary crown and bridge materials (t-c&b) are essential for treatment procedures with fixed prosthetic restorations, *i.e.* crowns and bridges [1]. They have to fulfil a couple of important functions within the timeframe between preparation of a tooth and until fitting, respectively, luting of the final metal or ceramic restoration [1–3]. As a consequence, the t-c&bs used to fabricate temporary crowns or bridges have to meet several biological, esthetical and mechanical requirements [2,4].

Two major groups of t-c&bs are available to fabricate temporary restorations: Methacrylate resins (powder/liquid, hand mixed) and composite-based materials (paste/paste, mainly automixed) [2]. In recent years, the composite-based t-c&bs have gained popularity among dental practitioners. Besides advantages regarding the handling *versus* traditional

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Table 1 – Temporary c&b materials under investigation

Material	Manufacturer	Mixing ratio[a]	Shade, lot	Filler load[b] (wt.%)	Setting time[b] (min)
CronMix tembridge	Merz, Lütjenburg, Germany	4:1	Universal, 7407189	42	4–6
Protemp 3 Garant	3M ESPE, St. Paul, USA	10:1	A1, B209088/C205204	40	5
Structur Premium	VOCO, Cuxhaven, Germany	1:1	A2, 511650	43	3.5
Systemp. c&b	Ivoclar Vivadent, Schaan, Liechtenstein	4:1	140/A2, H11311	47	7

[a] Base: catalyst (by volume).
[b] Manufacturers' information.

powder/liquid systems, superior mechanical properties [5–8] might be an explanation for this market trend.

The mechanical strength of a t-c&b is of particular importance as this factor might influence the integrity of the temporary restoration during its time in situ when it is exposed to functional loads [4,7,9,10]. Hence, the determination of mechanical properties of t-c&bs was subject of several studies [5–8,11–14]. Most of these studies investigated the mechanical properties at progressed points in time after setting. This brought valuable information regarding the mechanical strength of t-c&bs to light when the polymerization is more or less complete. However, as temporary restorations are fitted and luted directly after fabrication (*i.e.* 10–20 min after mixing), the authors saw the necessity to investigate the mechanical properties at a very early stage after mixing and curing, respectively. In addition, the degree of conversion of the double bonds inside the resin matrix was determined using FTIR analysis since this parameter is regarded to be critical important on both, the mechanical properties and the longevity of the restoration [15,16].

The Null-hypothesis tested was two-fold: first, the mechanical properties of t-c&bs are independent from the time after mixing and second, are reflected by the degree of conversion.

2. Materials and methods

Four different proprietary di-methacrylate-based t-c&bs with mixing ratios between 1:1 and 10:1 were tested (Table 1). All materials were delivered in automixing cartridges and used according to their respective manufacturers' instructions.

2.1. *Specimen preparation and storage*

Prior to sample preparation, a small amount of material was dispensed on a mixing pad without the automixing tip in position to ensure, that both orifices were open. Subsequently, the mixing tip was fixed and the material dispensed into the moulds for the respective test. The time interval between the start of mixing and the end of dispensing into the mould was identical for all materials (60 s) and was defined as end of mixing (EoM).

Subsequently, the moulds were placed into an incubator for 10 min at 37 °C (Ehret, Emmendingen, Germany). After setting, specimens were removed from the mould and subjected to different storage conditions (Table 2) prior to determination of flexural strength (FS), flexural modulus (FM) and degree of conversion (DC). All experiments were carried out at ambient laboratory atmosphere (23 ± 1 °C, 50% rel. humidity).

2.2. *Mechanical properties testing*

A stainless steel mould was used to prepare 2 mm × 2 mm × 25 mm bar-shaped specimens ($n = 10$ per material and storage condition) according to EN ISO 4049:2000 [17]. The mould was allowed to adapt to room temperature prior to injection of the t-c&b. After injection, the mould was covered with a transparent polyethylene strip (Hostaphan, Pfütz, Taunusstein, Germany) and a glass plate was attached tightly to the stainless steel mould's surface using a clamp. Excess material was removed and the mould placed in an incubator as previously described. Subsequently, specimens were removed from the mould and subjected to testing (group 1) or further storage prior to testing (group 2–9). Meticulous attention was paid regarding exact storage times.

Table 2 – Storage times and conditions after mixing and prior to testing

Test group	Incubator	Water storage[a]	Mechanical properties	FTIR analysis
10 min	10 min, 37 °C	/	X	X
1 h	10 min, 37 °C	1 h, 37 °C	X	n.a.[b]
2 h	10 min, 37 °C	2 h, 37 °C	X	n.a.
4 h	10 min, 37 °C	4 h, 37 °C	X	X
8 h	10 min, 37 °C	8 h 37 °C	X	n.a.
16 h	10 min, 37 °C	16 h, 37 °C	X	n.a.
24 h	10 min, 37 °C	24 h, 37 °C	X	X
3 days	10 min, 37 °C	3 days, 37 °C	X	n.a.
TC	10 min, 37 °C	7 days, thermocycling (5000 cycles; 5–55 °C; 45 s dwell time)	X	X

[a] Deionized water.
[b] Not analyzed.

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