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Fracture strength of temporary fixed partial dentures: CAD/CAM *versus* directly fabricated restorations

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ABSTRACT

Objectives. This study aimed at investigating the influence of fabrication method, storage condition and material on the fracture strength of temporary 3-unit fixed partial dentures (FPDs).

Methods. A CrCo-alloy master model with a 3-unit FPD (abutment teeth 25 and 27) was manufactured. The master model was scanned and the data set transferred to a CAD/CAM unit (Cercon Brain Expert, Degudent, Hanau, Germany). Temporary 3-unit bridges were produced either by milling from pre-fabricated blanks (Trim, Luxatemp AM Plus, Cercon Base PMMA) or by direct fabrication (Trim, Luxatemp AM Plus). 10 FPDs per experimental group were subjected either to water storage at 37 °C for 24 h and 3 months, respectively, or thermocycled (TC, 5000×, 5–55 °C, 1 week). Maximum force at fracture (Fmax) was determined in a 3-point bending test at 200 mm/min. Data was analyzed using parametric statistics ($\alpha = 5\%$).

Results. Fmax values ranged from 138.5 to 1115.5 N. FPDs, which were CAD/CAM fabricated, showed a significant higher Fmax compared to the directly fabricated bridges ($p < 0.05$). TC significantly affected Fmax for Luxatemp ($p < 0.05$) but not for the PMMA based materials ($p > 0.05$). CAD/CAM milled FPDs made of Luxatemp showed significantly higher Fmax values compared to Trim and Cercon Base PMMA ($p < 0.05$).

Significance. CAD/CAM fabricated FPDs exhibit a higher mechanical strength compared to directly fabricated FPDs, when manufactured of the same material. Composite based materials seem to offer clear advantages *versus* PMMA based materials and should, therefore, be considered for CAD/CAM fabricated temporary restorations.

1. Introduction

Computer aided design/manufacturing (CAD/CAM) technologies have gained popularity in recent years for fixed restorative and prosthodontic treatment procedures. Among others, this process is driven by the growing demand for placing high esthetic all-ceramic restorations [1,2]. At the same time, due to improvement in physical properties of *e.g.* zirconia and other ceramics, these materials can be successfully used also in stress bearing areas [3]. Apart from the Cerec System, most CAD/CAM supported technologies still use labside

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Table 1 – Temporary c&b materials under investigation.

Product	Manufacturer	MR[a]	Shade	Batch	Composition
Luxatemp AM Plus	DMG, Hamburg, Germany	10:1	A2	605703, 910935	Urethane diacrylate, aromatic diacrylate, glycol methacrylate, pigments, additives, stabilizer, silica, glass filler (44 wt.%)
Cercon Base PMMA	Degudent, Hanau, Germany	n.a.	B2	005366122220	Highly cross-linked methyl methacrylate, pigments, benzoyl peroxide (<1 wt.%)
Trim	Bosworth, Skokie, Ilinois, USA	1:2.3	Light	P: 0708-475 L: 0612-600	P: ethyl methacrylate prepolymers, benzoyl peroxide, pigments, TiO_2; L: isobutyl methacrylate, di-butyl phthlate, dimethyl-p-toluidine

P, powder; L, liquid. All data reflect information provided by the various manufacturers.
[a] Mixing ratio dimethacrylates base: catalyst [by volume]; mixing ratio mono-methacrylate liquid: powder [volume:mass].

procedures during the manufacturing process (*e.g.* veneering of zirconia frames/substructures) [4] and in consequence require temporary restorations to be fabricated on the prepared abutment teeth until the final fixed partial denture (FPD) is placed *in situ*.

The temporary restorations in turn fulfill a wide range of functions comprising protection of the prepared tooth structure, pulp and the surrounding periodontal tissues as well as to maintain oral functions (mastication, phonetics) and esthetics [5,6]. Most of these restorations are fabricated chairside using an over impression technique in combination with resin based temporary crown and FPD materials (t-c&bs) [7,8]. As the timeframe between preparation of a tooth and luting of the final restoration might exceed a couple of weeks, the t-c&bs used to fabricate temporary crowns or FPDs have to meet several requirements [5,9].

Among others, the mechanical strength of a t-c&b is of particular importance as this factor might influence the integrity of the temporary restoration during clinical service, when it is exposed to functional loads [10–13]. Hence, determination of mechanical properties of t-c&bs was the subject of several studies [9,10,14–19].

The chairside fabrication of temporary restorations is associated with a couple of short-comings, affecting the mechanical strength as well as its surface texture and precise fit [12,20,21]. *e.g.* mixing procedures and filling the over impression might lead to an incorporation of voids, compromising the mechanical strength [20]. In addition, studies have indicated that flexural strength is very low directly after fabricating these restorations [12].

CAD/CAM technologies – used to fabricate temporary restorations – may solve some of these issues. *i.e.* using resin based blanks cured under optimal conditions exhibit increased mechanical strength and prevent porosities within the restorations [2]. In addition, CAD/CAM fabricated temporaries reportedly reduce the chairside time and produce superior results [22].

Therefore, it was the aim of this study to compare the mechanical strength of directly fabricated temporary 3-unit FPDs *versus* identically CAD/CAM fabricated FPDs, milled of blanks, which were produced under optimal conditions using the same materials in a semi-clinical setup.

The null-hypothesis tested was three-fold: the mechanical strength of temporary 3-unit FPDs is independent of (1) the manufacturing process, (2) the t-c&b material used and (3) the storage condition after fabrication.

2. Materials and methods

The mechanical properties of the different materials and manufacturing techniques were tested using a semi clinical setup on a metal master-model with a 3-unit FPD. SEM analysis of the fractured surfaces was carried out on representative samples. Table 1 gives an overview of the materials tested including their composition. All materials were used according to the manufacturers' recommendations. The tests were carried out at ambient laboratory conditions (23 ± 1 °C, 50 ± 5% rel. humidity).

2.1. *Master model*

Two resin teeth (no. 25 and 27, frasaco, Tettnang, Germany) were prepared with a shoulder preparation (angle of convergence 6°) for treatment with full crowns. Following this, the roots of the two teeth were completed with wax to simulate a natural root (root length 16 mm). The teeth were duplicated and cast using CrCo-alloy (Brealloy C + B 270, Bredent, Germany). A base corpus, representing an alveolar ridge, was manufactured (CrCo-alloy), containing two sockets for mounting the two teeth in a distance of 12 mm (gap between the socket and the root: 1 mm). The teeth were fixed inside the socket with a vinyl-polysiloxane (Monopren Transfer, Kettenbach, Eschenburg, Germany) (Fig. 1A) [15,23]. This material had shown to sufficiently simulate the natural tooth movement under the test conditions, as confirmed by results obtained from a Periotest device (Medizintechnik Gulden, Modautal, Germany). Finally, a jig was fabricated to record the precise position of the abutment teeth within the sockets.

A 3-unit master FPD was fabricated (Fig. 1B), cast (Brealloy C + B 270, Bredent, Germany) and fitted on the abutment teeth featuring an optimal marginal adaptation (Fig. 1C). The connection area between the abutment teeth and the pontic was 4.0 mm × 3.25 mm (pontic height: 6.3 mm). The occlusal surface of the pontic was shaped to allow unequivocal positioning of a stainless steel spheric in the center of the FPD. The master FPD was digitized using a 3-Shape scanner (Wieland, Pforzheim, Germany) and the STL data set was saved