DENTAL MATERIALS 31 (2015) 907–915

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# Influence of restoration thickness and dental bonding surface on the fracture resistance of full-coverage occlusal veneers made from lithium disilicate ceramic

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ARTICLE INFO

*Article history:*
Received 9 September 2014
Received in revised form
4 March 2015
Accepted 28 April 2015

*Keywords:*
Fracture resistance
Ceramic thickness
Dental bonding surface
Full-coverage molar restoration
All-ceramic
Self etching primer

ABSTRACT

*Objectives.* The purpose of this in-vitro study was to evaluate the influence of ceramic thickness and type of dental bonding surface on the fracture resistance of non-retentive full-coverage adhesively retained occlusal veneers made from lithium disilicate ceramic.

*Methods.* Seventy-two extracted molars were divided into three test groups ($N = 24$) depending on the location of the occlusal veneer preparation: solely within enamel, within enamel and dentin or within enamel and an occlusal composite resin filling. For each test group, occlusal all-ceramic restorations were fabricated from lithium disilicate ceramic blocks (IPS e.max CAD) in three subgroups with different thicknesses ranging from 0.3 to 0.7 mm in the fissures and from 0.6 to 1.0 mm at the cusps. The veneers were etched (5% HF), silanated and adhesively luted using a self etching primer and a composite luting resin (Multilink Primer A/B and Multilink Automix). After water storage at 37 °C for 3 days and thermal cycling for 7500 cycles at 5–55 °C, specimens were subjected to dynamic loading in a chewing simulator with 600,000 loading cycles at 10 kg combined with thermal cycling. Unfractured specimens were loaded until fracture using a universal testing machine. Statistical analysis was performed using Kruskal–Wallis and Wilcoxon tests with Bonferroni–Holm correction for multiple testing.

*Results.* Only specimens in the group with the thickest dimension (0.7 mm in fissure, 1.0 mm at cusp) survived cyclic loading without any damage. Survival rates in the remaining subgroups ranged from 50 to 100% for surviving with some damage and from 12.5 to 75% for surviving without any damage. Medians of final fracture resistance ranged from 610 to 3390 N. In groups with smaller ceramic thickness, luting to dentin or composite provided statistically significant ($p \leq 0.05$) higher fracture resistance than luting to enamel only. The thickness of the occlual ceramic veneers had a statistically significant ($p \leq 0.05$) influence on fracture resistance.

*Significance.* The results suggest to use a thickness of 0.7–1 mm for non-retentive full-coverage adhesively retained occlusal lithium disilicate ceramic restorations.



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http://dx.doi.org/10.1016/j.dental.2015.04.017

## 1. Introduction

The prosthodontic treatment of severly abraded teeth or patients with a lateral open bite after orthodontic treatment is an important aspect in dental therapy. Modern dental ceramics such as lithium disilicate nowadays offer the option of minimally invasive replacement of lost tooth substance [1] while having a high fracture resistance [2,3]. Failures of all-ceramic restorations are mainly based on fractures of the ceramic material [3–6].

Fracture resistance of all-ceramic restorations is influenced by different factors. The adhesive technique used plays an important role in this regard since adhesively bonded all-ceramic restorations show a higher fracture resistance than conventionally cemented restorations [7–14]. Today resin cements based on the Bisphenol A glycidylmethacrylate compound are being used primarily. In order to bond to the surfaces of the different components (tooth structure as well as restoration) they need to be conditioned specifically; since each interface quality influences the fracture resistance of the restoration [2,7].

The type of bonding surface and the type of surface conditioning affects the bond strength of the ceramic to the tooth structure. Restorations bonded to teeth using the total etch technique achieved a bond strength of up to 28 MPa [15] within the enamel and 13 to 20 MPa within the dentin (depending on the adhesive system used) [16,17]. An improved bond strength to dentin can be reached when an immediate sealing of the dentin after the preparation is done [18]. Today many manufacturers offer self-etching primers which are supposed to simplify the adhesive bonding procedure. Different bond strength values have been reported in the literature regarding these self-etching primers. The bond strength of ceramic bonded to enamel was about 26 MPa regardless of the manufacturer while the bond strength of ceramic bonded to dentin was 15 to 29 MPa depending on the adhesive system used [17,19,20]. In these studies specimens were not subjected to thermal cycling, water storage or masticatory simulation though. For example a study of Zhang et al. [21] reported a bond strength to dentin of up to 36 MPa using a self-etching primer.

A further factor influencing the fracture resistance of all-ceramic restorations is the design of the preparation. For all-ceramic restorations the preparation has to be rounded carefully and no sharp angles should exist [4,22–25]. The thickness of the ceramic restoration is another factor influencing its fracture resistance [26]. Scientific data on the minimum thickness of lithium disilicate ceramic partial crowns or occlusal veneers is rare. In vitro studies on bonded occlusal veneers made of emax CAD showed that restorations with a thickness of 1.2–1.8 mm withstood forces of up to 1000 N and thicknesses of 0.6–1.0 mm withstood 800 N [27,28]. A study of Guess et al. [29] investigated the influence of the thickness and the extension of different premolar partial crowns made of a pressed lithium disilicate ceramic. No significant effect on the fracture resistance of pressable lithium disilicate ceramic onlay restorations was found in this study when the preparation depth was reduced down to 0.5 mm.

The success of all-ceramic restorations is related to multiple factors. The purpose of this study was to evaluate the effect of varying thicknesses of non-retentive full-coverage adhesively retained occlusal lithium disilicate ceramic restorations (further on referred to as occlusal veneers) bonded to different surfaces using a bonding system based on a self-etching primer.

## 2. Materials and methods

### 2.1. *Specimen fabrication*

Seventy two human molars without any caries or fillings were cleaned and stored in a 0.1% thymol solution. They were embedded in a technique which proved to be effective in previous studies [2,30–32]. The root portion apically of the cemento-enamel junction was coated with an artificial periodontal membrane made of gum resin (Anti-Rutsch-Lack, Wenko-Wenselaar, Hilden, Germany). The roots of the teeth were then embedded in custom made standard brass cylinders (Ø 15 mm) positioned along their long axis with autopolymerizing acrylic resin material (Technovit 4000, Heraeus Kulzer, Wehrheim, Germany). The enamel-cement junction was located 2 mm above the level of the embedded resin. The roots were retained in the resin by a thin steel bar (Ø 0.9 mm) inserted in the apical third of the root.

Specimens were divided into three groups ($n = 24$ each). In the first group the preparation was only within the enamel (group EN), in the second group the preparation was not limited to the enamel but extended into the dentin (group ED) and in the third group the preparation extended into the dentin also but the dentin core was reduced by 1.5 mm and a composite filling (Tetric EvoCeram, Ivoclar Vivadent, Schaan, Liechtenstein) was placed into the cavity (group EC) using a three-step bonding system (Optibond FL, Kerr, Charlotte, NC, USA). Finally all preparations and all composite fillings were smoothed and sharp edges were rounded. In all three groups the circumferential outline of the preparation was strictly within the enamel. An angle of 150 degrees was prepared between the cusps (Fig. 1). After tooth preparation, impressions were made using a simultaneous dual-mix technique with polyether material (Permadyne Penta H und L, 3 M ESPE, Seefeld, Germany). The impressions were cast with die stone type 4 (Hydrobase300, Dentona, Dortmund, Germany). The teeth were stored in a 0.1% thymol solution until adhesive luting.

In order to achieve a constant ceramic thickness the occlusal surface received a semi-anatomic shaping. In the CAD/CAM software the occlusal surface of the tooth was virtually elevated and then reduced again in the fissure area until the desired thickness was obtained. The master casts were sent to a commercial milling center (Biodentis, Leipzig, Germany). The unsintered ceramic occlusal veneers were then milled out of lithium disilicate blocks (IPS e.max.CAD, Ivoclar Vivadent, Schaan, Liechtenstein) in accordance to the planned design using CAD/CAM technique. They were fitted to the master casts and sintered according to the manufacturers' directions. Test groups are summarized in Table 1.