FATIGUE BEHAVIOUR FOR PREFABRICATED COMPOSITE VENEERS:

Didier Dietschi D.M.D, PhD, Privat-docent

Senior lecturer, Department of Cariology & Endodontics
School of Dentistry, University of Geneva, Switzerland.

Adjunct Professor, Department of Comprehensive Dentistry
Case Western University, Cleveland, Ohio.

Private Practice & Edudation Center
The Geneva Smile Center, Switzerland

Address for correspondence:

Didier Dietschi
Division of Restorative Dentistry and Endodontics
School of Dentistry
University of Geneva
19, Rue Barthélémy Menn
1205 Genève
SWITZERLAND

E-mail: didier.dietschi@unige.ch

UNIVERSITÉ DE GENÈVE

INTRODUCTION

Indirect ceramic veneers have been used successfully for almost 30 years as a method to improve the smile appearance for severely decayed, non-aesthetic anterior teeth, but are unfortunately quite expensive. Due to today's weak economy and the fact that this treatment option does not address the aesthetic needs of less privileged patients, alternative solutions are needed. Direct composite veneers have been widely used as an "economical" solution for patients with discoloured teeth (which do not respond to bleaching), and for extensively decayed or eroded/abraded anterior teeth. Unfortunately, this approach is highly operator dependant and optimal aesthetic results are rarely achieved. Therefore, indirect, prefabricated veneers made of composite that is manufactured under pressure and heat, exhibit superior physical properties and appear to be a promising solution.

The aim of this in-vitro study was to test the hypothesis that the prefabricated composite veeners, cemented onto enamel and dentin, would sufficiently resist simulated occlusal fatigue loads. Attention was also given to the quality of all interfaces in order to identify the restoration's most vulnerable areas.

MATERIALS & METHODS

Specimen preparation

Fifty freshly extracted human third molars were used for this study. The inclusion criteria were absence of carious lesions and a complete root formation. The teeth were stored in a sodium azide solution (0.2%) at 4°C until the experiment was started.

For each specimen, the root length was adjusted to fit inside the test chamber of the mechanical loading device (Department of Cariology, Endodontics & Pedodontics; Laboratory of Electronics of the Medicine Faculty; University of Geneva). After the specimen was properly positioned, it was attached to a metallic holder (Baltec; Balzer, Liechtenstein) using light-cured composite; and the root base was embedded afterwards using self-curing acrylic resin to complete the stabilisation of the tooth. Minimally invasive veneer tooth preparations were prepared, with dimensions that roughly corresponded to the dimensions of the medium, upper central incisor prefabricated veneers (DIRECT VENEAR 11 M upper, REF 10151, edelweiss dentistry, Allgäustrasse 5, 6912 Hörbranz, Austria). The preparation was made about half way into the enamel and the dentin. The cavities were prepared using coarse diamond burs under profuse water spray (Cerinlay No 3080.018 FG; Intensiv, Viganello, Switzerland), and finished using fine grit burs of the same shape (Cerinlay No 3025.018 FG; Intensiv, Viganello, Switzerland).

Restorative procedures

After completion of the preparation, a multi-functional “etch & rinse” adhesive system (edelweiss Total-Etch Bond, REF 10510, edelweiss dentistry, Allgäustrasse 5, 6912 Hörbranz, Austria) was used to prepare both the enamel and dentin surfaces according to the manufacturer’s instructions. This implied etching the enamel for 30 s and the dentin for 10 s. Afterwards, the preparation was thoroughly rinsed-off with water, with excess water gently removed using suction taking great care to prevent tissue dehydration or excessive moisture. The bonding agent was polymerized using an LED light curing unit (Bluephase, Ivoclar-Vivadent, Schaan, Liechtenstein) equipped with a new bulb and a power intensity of 1200 mW/cm^2.

The internal surface of the DIRECT VENEAR was sandblasted using 27 μm aluminium-oxide powder at about 3 bars of pressure. Prior to cementation, the DIRECT VENEARs were then coated with a special primer (edelweiss DIRECT VENEAR Bond, REF 10520, edelweiss dentistry, Allgäustrasse 5, 6912 Hörbranz, Austria), and left uncured. The internal surface of the DIRECT VENEAR was covered with approximately 1 mm of light-cured composite (edelweiss Nano-Hybrid Composite, Body Intensity 3 dentin, edelweiss dentistry, Allgäustrasse 5, 6912 Hörbranz, Austria) before placing the restoration onto the prepared tooth surface. The restoration was initially cemented into place using manual pressure, and then with the assistance of a specific ultrasonic device (Cementation tip, EMS, Nyon, CH). After removal of excess composite using a probe and dry microbrush, each restoration surface was light-cured for 40 s using the same LED curing light, as previously described. Restorations were then immediately finished and polished using pear-shaped, fine diamonds burs (40 and 25 μm grit size) (Intensiv 5255, Intensiv, Viganello, Switzerland) and discs of decreasing grit size (Pop On XT, 3M, St. Paul, MN, USA).

Mechanical loading

After cementation, the samples were stored in saline for 24 hours before the stress test was performed. All specimens were submitted to 1'000'000 cycles using 100 N of occlusal loading force applied to the occlusal margin of the restoration. The axial force was exerted at a frequency of 1.5 Hz, following a one-half sine wave curve. These conditions simulate approximately 4 years of clinical service (Krejci, Heinzmann et al. 1990; Krejci, Reich et al. 1990). The restored teeth were in contact with antagonist artificial cusps made of stainless steel with a hardness that was similar to natural enamel (Vickers hardness: enamel = 320-325; steel = 315). The diameter of the cusps was 4 mm. By having the specimen holder mounted onto a hard rubber disc, a sliding movement of the tooth was produced between the first contact on an inclined plane and the central fossa (Fig.1B). The function of this experimental device was similar to the machine developed by Krejci and his co-workers (Krejci, Reich et al. 1990).

Specimen evaluation

SEM evaluation of marginal and internal adaptation

Before fatigue testing, as well as after completion of each loading phase, the margins of the restoration were cleaned using a brush and fine pumice. Gold sputtered epoxy resin replicas (Epofix, Struers, Rødrove, Denmark) were made using polyvinylsiloxane impression material (President light, Coltène/Whaledent). The following segments were observed: enamel margins on the occlusal and proximal sides, and dentin margins on proximal side below the cementum-enamel junction. The tooth-restoration interface was analyzed semi-quantitatively using scan electron microscopy (SEM) (Digital SEM XL20, Philips, Eindhoven, Netherlands) by employing an established evaluation method. The restoration margins were observed at a standard 200x magnification; or whenever necessary, higher magnifications up to 1000x were used for assessment accuracy. The following evaluation criteria were tentatively considered: perfect adaptation (continuity), over-filling, under-filling, marginal opening, marginal restoration or tooth fracture.

After completion of mechanical loading and sample replication, the teeth were embedded into a slow, self-curing epoxy resin (Epofix, Struers, Rødrove, Denmark), and sectioned in the middle using a slow, rotating saw (Isomet 11-1180,

Buehlers, Lake Bluff, USA), (Fig.5). Both sections were successively polished using 200, 400 and 600 grit SiC paper. Impressions of the two external surfaces that were used to fabricate the gold-sputtered resin replicas were then made. In order to avoid observation artifacts, special care was taken to avoid dehydration of the samples prior to taking the impression using a “moisture tolerant” material (President light, Coltene/Whaledent). The internal adaptation of the restoration was assessed semi-quantitatively on the gold-sputtered replicas using an SEM magnification of 200x; or whenever necessary, higher magnifications up to 1000x were used for assessment accuracy. The internal adaption of the restoration was judged based on the following criteria: continuity and interfacial opening. Results were expressed as a percentage of “perfect adaptation" (defect free) for occlusal, axial and cervical dentin segments.
A single and trained evaluator performed all SEM observations.

RESULTS

In general, SEM evaluation of marginal and internal adaptation demonstrated excellent performance of the restorations under simulated functional loading. Almost no defects were observed either before or after loading, at both the enamel and dentin margins. The most relevant demonstration of satisfactory behaviour for the tested prefabricated DIRECT VENEARs, was obtained from the evaluation of the internal adaptation of the restoration. No defects were discovered at the interface of the enamel or in-between the composite cement and the DIRECT VENEAR. These results confirm the excellent bond strength at both the composite-enamel or composite-composite interfaces. At the dentin level, minor defects were observed, but which all together, accounted for an insignificant proportion of the overall dentin-composite cement interface. A few voids were observed within the composite cement, but had virtually no impact on the overall quality of the restoration or the adaptation, as demonstrated by the absence of other interfacial defects nearby.

FIGURES

Internal adaptation observations

Figure 1

Full section of a molar restored with a prefabricated composite DIRECT VENEAR (see right side), in which half of the surface was bonded to enamel and the other half to dentin.

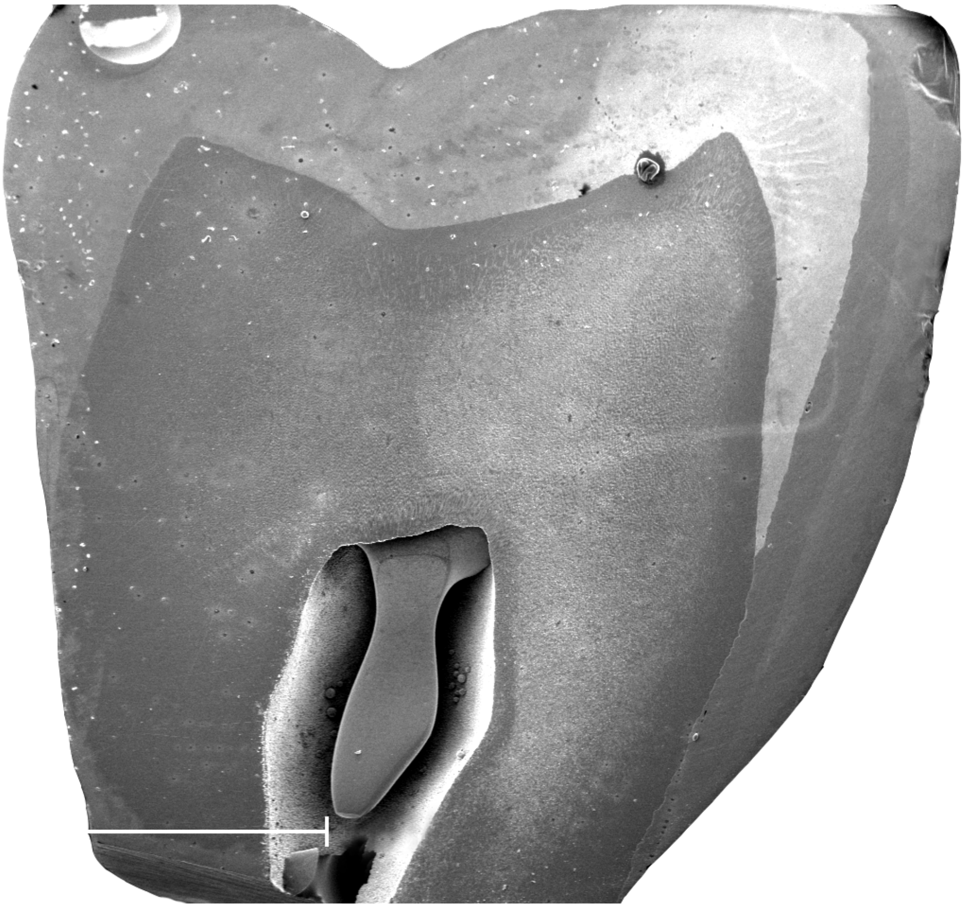


Figure 2

View of the interface area between the enamel and dentin. The composite-composite interface is also visible and shows that this interface was stable and resistant to occlusal loading.

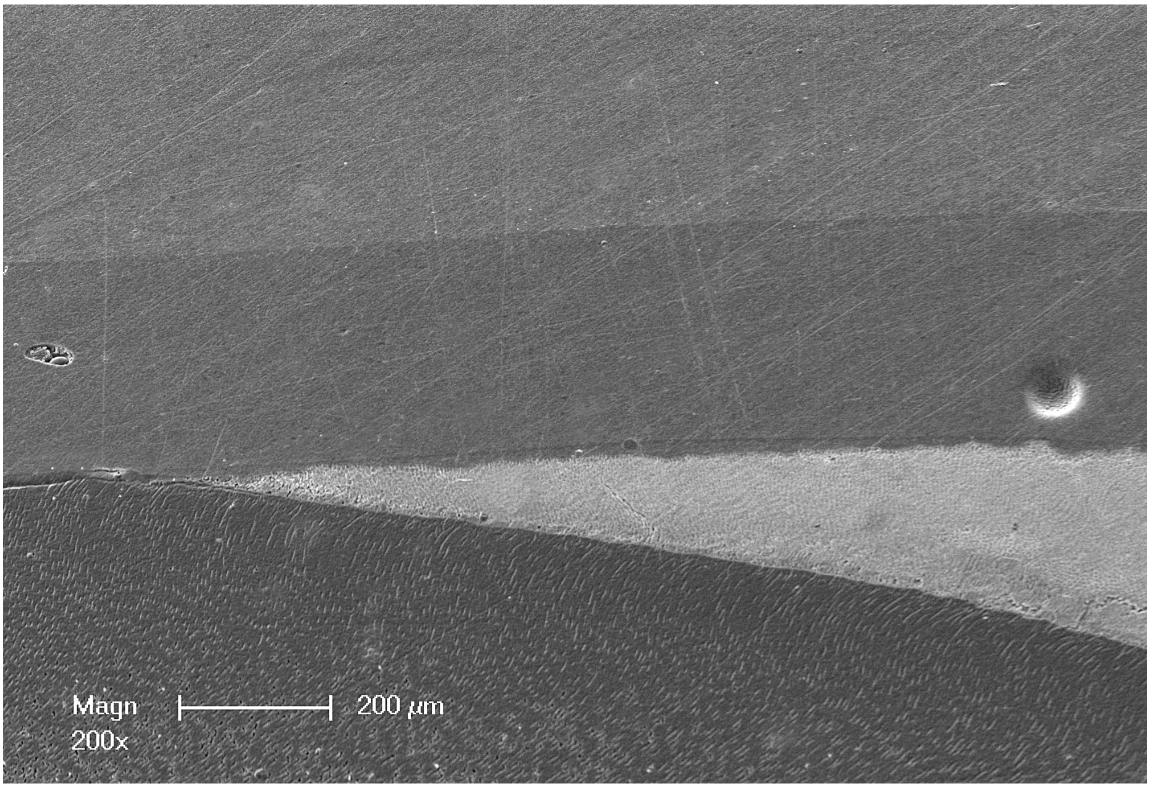
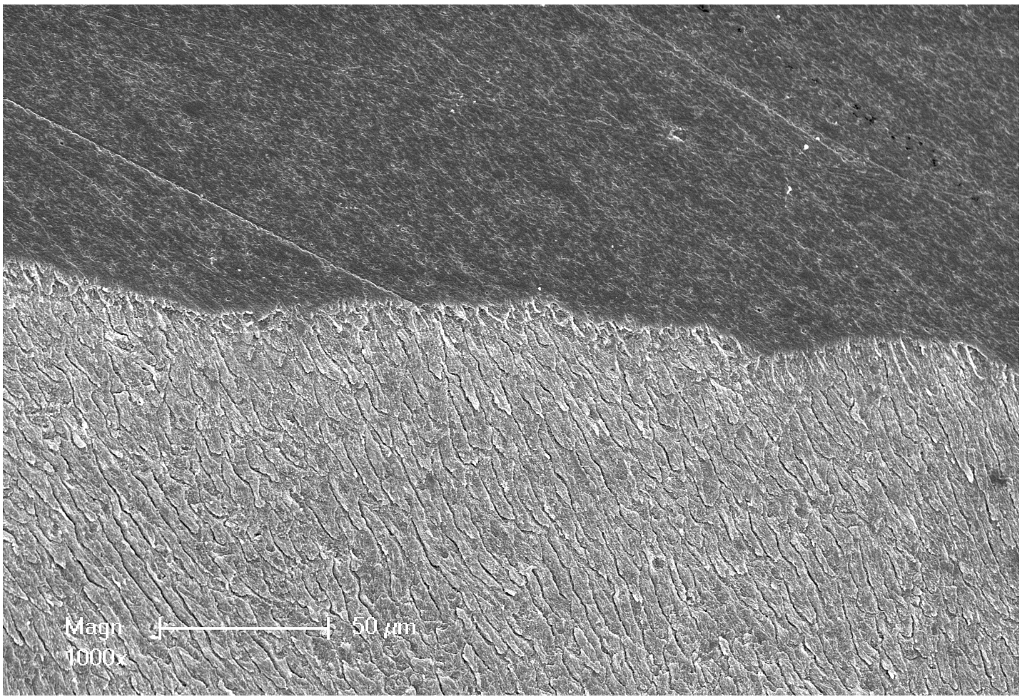


Figure 3

The interface of enamel demonstrated to be free of any defects after the loading test, as shown on the image below (A). Only a few voids were observed, but they did not affect the adaptation.

A



B

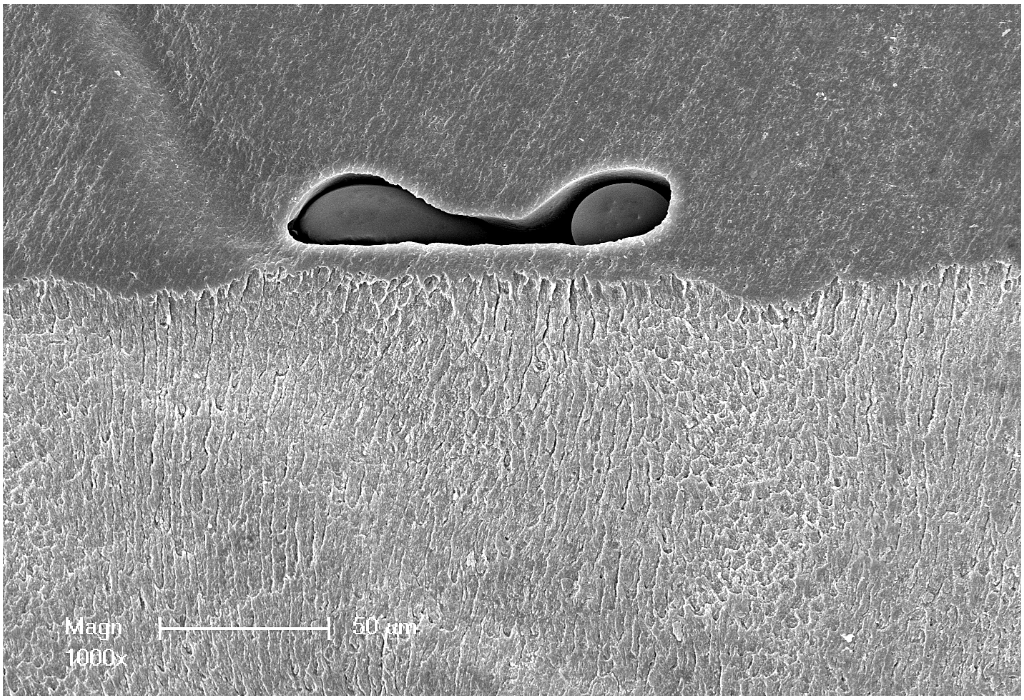
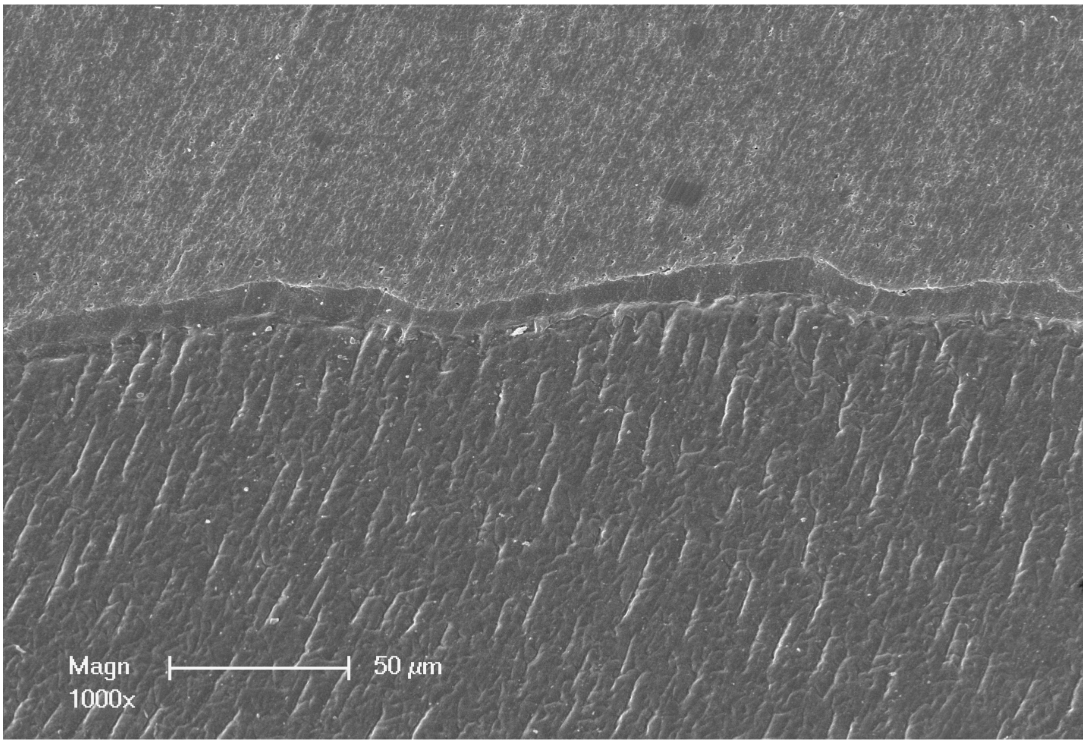


Figure 4

The adaptation to dentin was also highly satisfactory after the loading test (A). Only minor proportions of interfacial defects (gaps) were observed (B).

A



B