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# Indirect restorations for severe tooth wear: Fracture risk and layer thickness

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ABSTRACT

*Objectives:* This in vitro study investigated static failure risk related to restoration layer thickness for different indirect materials and compare them to direct composites.

*Methods:* Two ceramics (IPS e-max CAD, EmpressCAD (Ivoclar Vivadent)), two indirect composites (Estenia (Kuraray), Sinfony (3M)) and two direct composites (Clearfil AP-X (Kuraray), Tetric EvoCeram (Ivoclar Vivadent)) were chosen. Of each material, 25 discs varying in thickness (0.5–3.0 mm) were prepared and cemented to bovine dentine. For measuring compressive strength, samples were placed in a universal testing device. Each sample was uniaxially loaded until failure occurred. For each material a regression model based on the Weibull distribution was used to estimate the relation between restoration layer thickness and failure. Using these models, the chance of failure, standard error and 95% confidence interval for that chance is estimated. Groups of materials were compared as well.

*Results:* Except for Tetric Evoceram, all materials show a significant positive association between layer-thickness and compressive strength, with an increased strength of increased thickness. ProCAD performed significantly worse than all other materials, especially when compared to the other ceramic material (IPS e-max CAD) ($p = 0.001$).

*Conclusion:* For most tested materials, a thicker layer offers more strength, however, this property seems to be material/brand specific.

*Clinical relevance:* As direct composites showed the best results within the limitations of this in vitro study, dentists should consider these materials as a good choice for restoring severe tooth wear, and may offer superior performance compared to indirect composites and ceramics. For some brands of materials thicker layers result in a stronger restoration.

## 1. Introduction

Severe tooth wear is mainly caused by erosion, bruxism or a combination of these factors[1] and results often in loss of vertical dimension. In order to gain sufficient space for restoring worn down teeth, an increase of this occlusal vertical dimension is often required. It is still unclear which materials are the best for treating this specific patient group. Recent literature shows that fracture of restorations is the

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most important reason for failure[2,3] for restorations placed in severe tooth wear cases which is explainable from bruxism as an important aetiology.[2] Therefore, it is expected that for patients with severe tooth wear restorations are exposed to considerable forces, especially when the vertical dimension is increased and all occlusal forces are supported by the restorative material. Restorative materials should therefore be able to withstand these occlusal forces when bonded to the tooth. As the anatomical shape of worn teeth is preferably restored in a minimally invasive way, this results in restorations with various thicknesses, depending on the loss of tooth substance and the increase in vertical dimension. In these situations this results in restorations of various thickness, even within different sites of the restoration itself. Therefore, the most desirable material for restoring severe tooth wear, would offer strength in every thickness applied. In a recent study four restorative direct composites in different layer thicknesses were tested in an in vitro study, showing different variations in fracture strength when applied in various thickness. It showed that for some materials the strength is more thickness dependant then for other materials. Also the type of material and its filler volume has its influence on physical properties of composite resin restorations.[5,6] As in severely worn dentitions, restorations have to be made in various thickness that are exposed to heavy loading, it is important which materials, either direct or indirect, either resin based or ceramic based offer the best fracture resistance in these circumstances. The first hypothesis tested was that compressive strength of restorative materials bonded to dentine are dependant from the thickness of the layer. The second hypothesis tested is that compressive strength is dependant from the used material. The aim of this study was to investigate static failure risk related to restoration layer thickness for different indirect materials and compare them to direct composites.

## 2. Materials and methods

For this study, four indirect materials were chosen, two indirect composite resins and two ceramic materials. As indirect composite materials, Estenia (Kuraray, Osaka, Japan) a highly filled hybrid indirect composite and Sinfony (3M, St. Paul, MN, USA), a hybrid indirect resin composite material, were selected. As ceramic materials a lithium disilicate type (e-max CAD, Ivoclar Vivadent, Schaan, Lichtenstein) and a leucite material (EmpressCAD Ivoclar Vivadent, Schaan, Lichtenstein) were selected. As control groups, two direct composite materials from a recent study were used: the material that showed to result in the highest fracture resistance (Clearfil AP-X Kuraray, Osaka, Japan) and the material with the most thickness independent performance (Tetric EvoCeram Ivoclar Vivadent, Schaan, Lichtenstein), the material properties are described in Table 1.

Of each material, 25 discs varying in thickness were prepared and cemented in a standardized way to bovine dentine prior to measuring static failure load.

Bovine front teeth were ground at the buccal surface until dentine was exposed. Subsequently, these teeth were embedded into a mould with PMMA to give all samples a standardized form. For the indirect composites teflon square plates of 0.5–3.0 mm height with an open circle of 5 mm

**Table 1 – Materials specification.**

| Material | Type | Manufacturer | Resin matrix | Filler | Content (w/v) | FS (Mpa) | E (GPa) | Filler particle size |
|---|---|---|---|---|---|---|---|---|
| Clearfil AP-X | Hybrid | Kuraray | BisGMA, TEGDMA, di-camphorquinone | Silanated barium glass, silanated colloidal sillica, silanated sillica | 86/70 | 204 | 16.6 | 0.2–17 μm |
| Tetric Evo Ceram | Nano-hybrid | Ivoclar-Vivadent | BisGma, UDMA, DMDMA | Ba glass, $YbF_3$, MO, PPF | 76/55 | 120 | 7.6 | ~550 nm |
| E-max CAD | Lithium disilicate | Ivoclar-Vivadent | $SiO_2$ | $LiO_2$, $K_2O$, MgO, $Al_2O_3$, $P_2O_5$ and other | [a] | 360 | 95 | 0.2–1.0 μm |
| Empress CAD | Leucite-reinforced ceramic | Ivoclar-Vivadent | $SiO_2$ | $Al_2O_3$, $K_2O$, $Na_2O$, other oxides and pigments | [a] | 160 | 62 | 1–5 μm |
| Estenia | Hybrid | Kuraray | Polyurethane methacrylmonomer and methacrylic acid series monomer | Glass powder and aluminium micro filler | 92/82 | [a] | 23.1 | 2.0 nm–2.0 μm |
| Sinfony | Hybrid | 3M | Mathacrylic acid series monomer | Glass, $SiO_2$, GIC, Silane | /50 | 105 | 3.1 | 0.5–0.7 μm + microfiller |

FS, flexural strength; FM, flexural modulus; and E, E-modulus.
[a] Unknown.