Tetric® CAD

Scientific Documentation

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1. Introduction

1.1 Dental composites

As the name suggests, dental "composites" are a combination of at least two different materials. In most cases, the components are inorganic or organic fillers embedded in an organic resin matrix with initiators, stabilizers, pigments and optical brightening agents (1). The balance between the monomers and the fillers determines the material.

Composite materials became available in dentistry in the 1960s, when Bowen introduced a Bis-GMA formulation to the market in 1962 (2). Initially, dentists employed composites primarily in the anterior region where amalgam fillings were deemed unesthetic. By the 1990s, they had begun to substitute amalgam as a more universal filling material. These direct composites (applied and cured directly in the patient's mouth) along with innovative bonding agents, heralded a new minimally invasive era in dentistry. Direct composites however were always somewhat limited with regard to large posterior restorations due to accelerated wear and polymerisation shrinkage issues. In the 1980s therefore, the first generation of indirect composites was introduced, followed by a second generation in the 1990s.

2. Indirect Composites

Whereas direct composites are applied, modelled and cured by dentists intra-orally, indirect composites are traditionally designed, modelled and cured extra-orally by dental technicians at a dental laboratory. As such, they are often referred to as lab composites. Indirect composites can be cured in units capable of delivering higher intensities of light and/or heat than is either possible with hand held units or would be practically possible intra-orally.

2.1 Laboratory composites

First Generation
First generation indirect composite resins were introduced in an effort to address disadvantages that could arise from the use of direct resin composites – this included technique sensitivity, anatomic form, polymerisation shrinkage, excessive wear and sub-optimal interproximal contacts.

Touati (3) and Mörmann (4) were the first to introduce a technique for using the first generation of lab composites. Products included SR Isosit/Ivoclar Vivadent and Visio-Gem/ESPE. In general, the materials suffered from low flexural strength, low modulus of elasticity, discoloration and unacceptable wear and abrasion due to a low homogenous filler load and a high matrix load.

Second Generation
Second generation indirect composites were introduced in the mid-1990s. Often termed micro-hybrids they utilize small-diameter mineral fillers of less than 1µm with the percentage/ratio of the shape, size and distribution of the fillers varying according to the type of composite material. A higher filler content improved mechanical characteristics and a lower organic matrix content reduced polymerisation shrinkage (5).

2.2 CAD/CAM Composite Blocks

Due to huge advances in intra-oral imaging and manufacturing technology, there has been a dramatic increase in the use of computer-aided design and manufacturing (CAD/CAM) materials in dentistry (6) both labside and chairside. The delivery of a ceramic restoration in a single appointment became a reality in 1985 with the first chairside CAD/CAM system (7). Although ceramics account for the majority of CAD/CAM materials, there has been considerable progress in the field of resin composite block materials for indirect dental restorations.

Launched in 2000 (7), the first commercial composite block for permanent restorations was Paradigm MZ100/3M Espe, a factory-polymerized version of the direct composite Z100/3M Espe (6, 7). Lava Ultimate later replaced this. Several manufacturers now offer resin-composite CAD/CAM blocks created under high temperature – high pressure (HT-HP) conditions. Such conditions have been shown to significantly increase the degree of monomer conversion in comparison to light-cured composites and to improve homogeneity i.e. decrease the presence of irregularities and pores in the material. Industrial processes also allow for the augmentation of the filler content, which is not possible with direct composites, as they need to remain mouldable during placement (8).

Advantages of CAD/CAM Composite Blocks

As an alternative to direct composite materials, CAD/CAM composite block materials exhibit superior strength and because they are pre-cured, they avoid any possible issues related to leachable monomers such as contact dermatitis.

Whereas ceramics exhibit overall superior mechanical and esthetic properties, resin-composite blocks can offer significant advantages related to machinability and intra-oral reparability of minor defects (6). Milling times for example, are shorter, Ruse et al (2014) estimated that a set of CAD/CAM burs at around 20 USD per bur could be used to fabricate 5 to 10 ceramic crowns, but well over 100 resin-composite crowns (6). Polishing and adjustment at initial placement is less time-consuming (9). Intra-oral repairs are facilitated by the fact that etching with hydrofluoric acid is not required - resin composite restorations can be repaired via sandblasting the area for repair, followed by the placement of a direct resin composite with similar mechanical and optical properties (6). CAD/CAM composites also exhibit an elasticity modulus close to dentin, which could be an advantage for implant-based crowns in terms of shock absorption (10) or patients with bruxism. Composites are considered well-suited to CAD/CAM processes as they are less brittle, exhibit higher damage tolerance, less marginal chipping (11), smoother milled margins and can be milled to reduced thicknesses (10). The absence of a firing procedure for ceramic staining or crystallization also adds to the attractiveness of CAD/CAM composite blocks for single-appointment applications.

Conclusion

CAD/CAM composite blocks blur the lines of the indirect/direct composite definitions somewhat as they are pre-cured materials (like indirect composites) but are largely milled and applied directly at the dental practice in a single-appointment.

CAD/CAM composite blocks offer a robust material with numerous efficiency advantages for the dental practice and dental laboratory.

3. Tetric CAD

Tetric CAD is an esthetic composite block for creating single-tooth restorations efficiently via the CAD/CAM technique. The material is industrially produced and secondarily milled. Tetric CAD restorations are polished extra-orally after milling, and cemented adhesively with Adhese Universal and Variolink Esthetic. They are not suitable for self-adhesive or conventional cementation.

Fig. 1: Tetric CAD blocks

Tetric CAD is the digital supplement to the direct restoratives of the Tetric Evo-Line. The blocks are available in medium translucency (MT) and high translucency (HT) - and in five and four shades respectively. The blocks are available in sizes I12 and C14.

3.1 Indication

Tetric CAD is suitable for single tooth restorations only. That is veneers, inlays, onlays (occlusal veneers or partial crowns) and anterior or posterior crowns.

Fig. 2: Tetric CAD onlay (left) and inlay (right)

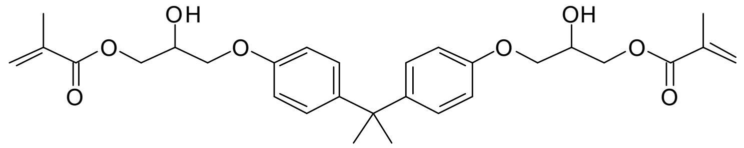
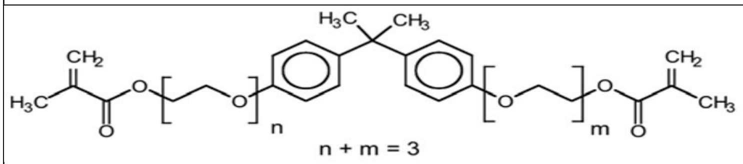
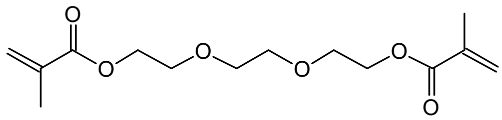
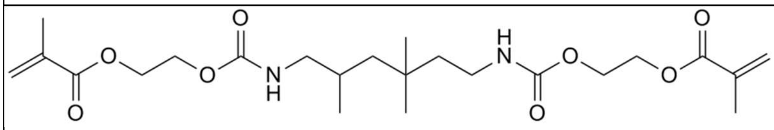
Tetric CAD restorations blend well with surrounding tooth structure due to a pronounced chameleon effect. The stability of the material allows for minimal wall thicknesses and thus minimally invasive preparation techniques. Tetric CAD restorations exhibit good polishability and can be repaired intra-orally with composites such as Tetric EvoCeram or Tetric EvoFlow.

3.2 Composition

Similar to restorations made of the Tetric Evo Line of direct composites, Tetric CAD restorations are the result of a coordinated, optimized mixture of cross-linked dimethacrylates and inorganic fillers.

Monomers

The monomers compose the matrix of a composite material. Tetric CAD includes the commonly used dental monomers listed below.

	**Bis-GMA** Bisphenol A-diglycidyl dimethacrylate
	**Bis-EMA** Ethoxylated bisphenol A dimethacrylate
	**TEGDMA** Triethylene glycol dimethacrylate
	**UDMA** Urethane dimethacrylate

Tab. 1: Table illustrating the structural formulae of monomers used in Tetric CAD

Bis-GMA (bisphenol-A-diglycidyl-dimethacrylate) was synthesized and introduced in the 1960s (1) and is one of the most frequently used monomers. UDMA (urethane dimethacrylate and TEGDMA (triethylene glycol dimethacrylate) are also commonly used monomers. Bis-EMA is structurally analogous to Bis-GMA, but without the two pendant hydroxyl groups responsible for the high viscosity and water affinity of Bis-GMA (12).

Fillers

Fillers comprise the largest portion of composite materials, their function being to reinforce the resin matrix, provide the correct degree of translucency and to control volumetric shrinkage during polymerization (13). Glass fillers result in low wear and favourable polishing properties i.e. low surface roughness and high gloss. Tetric CAD utilizes barium aluminium silicate glass with a mean particle size of < 1 µm and silicon dioxide with an average particle size of < 20 nm.

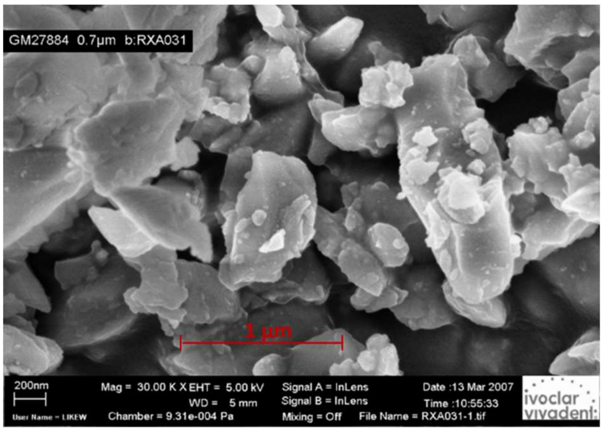


Fig. 3: SEM image of barium aluminium silicate glass filler with mean particle size of 0.7µm

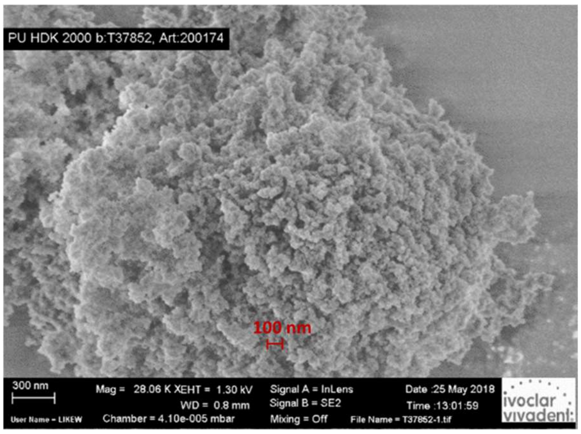


Fig. 4: SEM image of silicon dioxide microfillers with mean particle size of < 20 nm

Sakaguchi and Powers (13) define the different types of filler (according to particle size) that have evolved with composite restorations as follows:

Filler Type/Class	Particle size
Macrofill	20-30 µm
Hybrid	2-4 µm (fine particles) PLUS 0.04 – 0.2 µm (microfine particles)
Microhybrid	0.04 – 0.2 µm (fine particles) PLUS (microfine particles/silica)
Nanofill	1-100 nm (size particles throughout matrix)
Nanohybrid	0.4 - 5 µm (micro size particles) AND 1-100 nm (nano size particles)

Tab. 2: Composite filler classes according to particle size. Source: Ronald L. Sakaguchi, John M Powers. Craig's Restorative Dental Materials. 13th Ed. Elsevier 2012 (13)

Tetric CAD can therefore be described as a nano-hybrid CAD/CAM composite block with barium glass (< 1 µm) und silicon dioxide fillers (<20 nm).

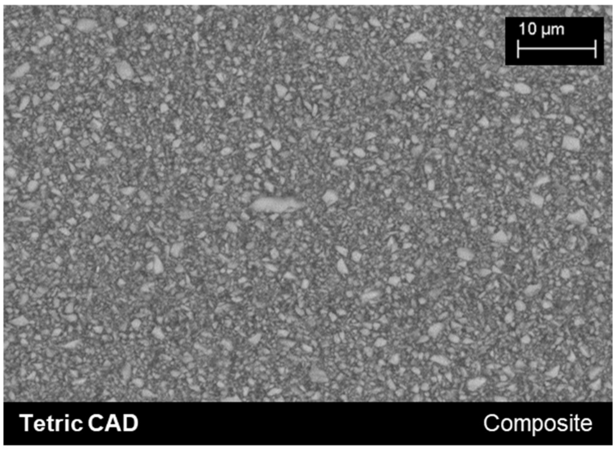


Fig. 5: SEM image of Tetric CAD
R&D Ivoclar Vivadent Schaan,
December 2017

3.3 Tetric CAD application issues

After intra-oral shade determination, the CAD/CAM process is carried out with intra-oral imaging and milling. No extra firing is required and the milled restoration is then polished extra-orally to a high gloss with e.g. OptraPol.

The restoration is tried-in with glycerine gel and adjusted as necessary.

Conditioning, to create mechanical retention is carried out via sandblasting the bonding surface with 50-100 µm aluminium oxide at a pressure of 1-1.5 bar (see Section 5.5.1: Shear bond strengths with and without sandblasting). Neither hydrofluoric nor phosphoric acid are suitable for creating a retentive surface on composite materials.

After cleaning, the restoration is conditioned with Adhese Universal, which is left uncured to avoid any problems with fit. The monomers contained in Adhese Universal are able to permeate the bonding surface of the restoration such that they swell slightly and when the adhesive and luting composite (Variolink Esthetic) are finally polymerized together after restoration-placement, a good bond between the restoration and the luting material results. Neither of the silanization agents Monobond Plus or Monobond Etch & Prime are suitable for conditioning Tetric CAD. Their monomer composition is optimized for bonding glass ceramics, oxide ceramics and metals, but is unsuitable for creating any surface expansion (swelling) of the Tetric CAD material and as such cannot generate a sufficient bond.

The tooth receiving the Tetric CAD restoration, is prepared with phosphoric acid such as Total Etch, rinsed and treated with Adhese Universal – which is cured. A selective etch or self-etch protocol is also possible.

Variolink Esthetic is applied to the restoration and the restoration is seated. Excess luting material is removed via light curing in the standard fashion and finally the adhesive on the Tetric CAD restoration and the luting composite are polymerized together.

Occlusion and articulation are adjusted as necessary with grinding instruments and the restoration is polished intra-orally with e.g. OptraPol.

In contrast to ceramic materials, CAD/CAM composites need to be luted adhesively – that is, an adhesive is applied between the restoration and the luting material and between the luting material and the natural tooth substance. Depending on the indication and given wall thickness of the restoration either Variolink DC or LC may be suitable. Variolink Esthetic LC can be used if the restoration exhibits wall thicknesses of < 2mm and sufficient translucency for light penetration (Tetric CAD HT). Self-adhesive cements such as SpeedCEM are not suitable for use with Tetric CAD.

4. Technical Data for Tetric CAD

Composition

Component	% Weight
Barium glass filler*	64.0
Silicon dioxide*	7.1
Dimethacrylates	28.4
Additives & Pigments	0.5

* Total filler volume: ca. 51 vol-%

Physical properties

Property	Example Value	Specification	Standard
Flexural strength (MPa)	273.8	≥ 100	ISO 6872:2015
Water sorption (µg/mm³)	22.5	≤ 40	ISO 10477:2004
Solubility (µg/mm³)	0.0	≤ 7.5	ISO 10477:2004

5. Materials Science Investigations / In Vitro

In vitro investigations form the basis for all material tests during the development phase of a dental product. Though not capable of predicting clinical success entirely, they can be useful indicators and are an efficient way of comparing similar products. In the development of dental restoratives, common materials science measurements include the flexural strength of the material, its elasticity, wear resistance and polishability. The results of various tests conducted internally at Ivoclar Vivadent (R&D Schaan) and externally are presented below.

5.1 Flexural strength

The biaxial flexural strength of Tetric CAD and seven further competitor composite blocks: Lava Ultimate/3M Espe, Shofu Block HC/Shofu, Vita Enamic/VITA, BRILLIANT Crios/Coltène, CERASMART/GC, LuxaCam Composite/DMG, Grandio blocs/VOCO was tested. Sample discs
(Ø = 12-16 mm, h = 1.2mm) of each of the composite blocks were prepared and loaded until breakage occurred. Specimens were stored in dry conditions until testing.

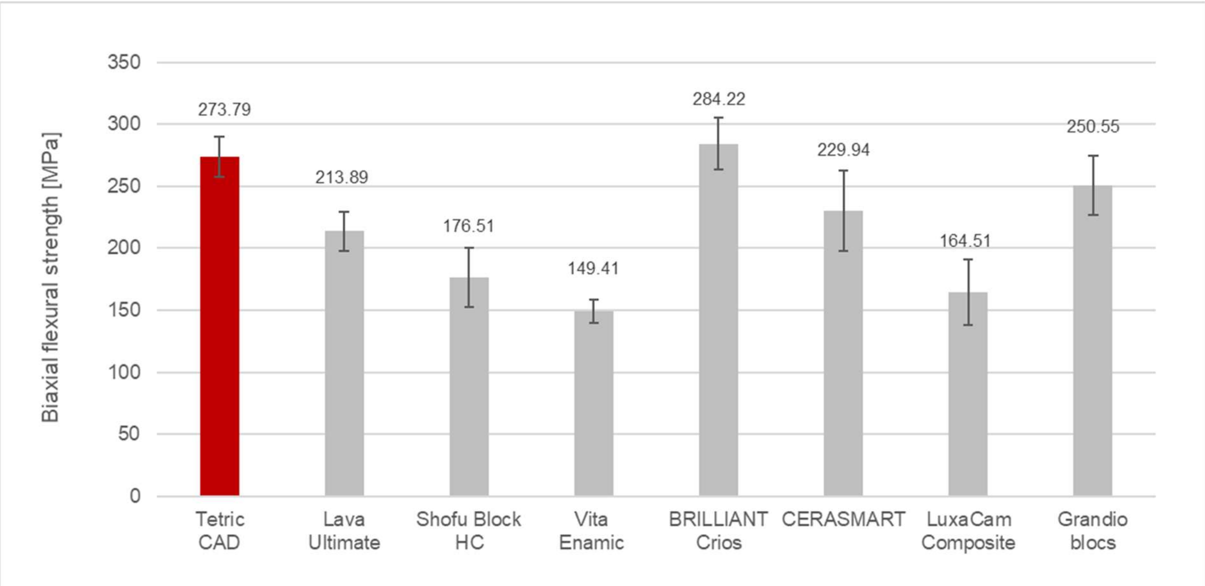


Fig. 6: Comparison of the biaxial flexural strength of Tetric CAD and various composite CAD/CAM block materials. R&D Ivoclar Vivadent Schaan. April 2018

Tetric CAD exhibited a high flexural strength of approximately 274 MPa. The hybrid ceramic Vita Enamic exhibited the lowest flexural strength in this investigation.

5.2 Modulus of elasticity

The modulus of elasticity (E-Modulus) was also calculated for the same products mentioned above in section 5.1. The elastic modulus is a measure of the stiffness of a solid material or in other words, its resistance to being deformed when a load is applied. High E-modulus values indicate a high resistance to deformation i.e. a stiff material and low values indicate a low resistance to deformation i.e. a flexible material.

Specimens of each material with plane parallel sides and a height of at least 2mm were prepared. The E modulus was calculated based on the results of Vickers hardness tests, utilizing a diamond pyramid shaped indenter with a standard force of 49.03N. Five indentations per specimen were made. The elastic modulus is the ratio of stress to strain and is related in megapascals (MPa = N/mm^2) or gigapascals (GPa = kN/mm^2).

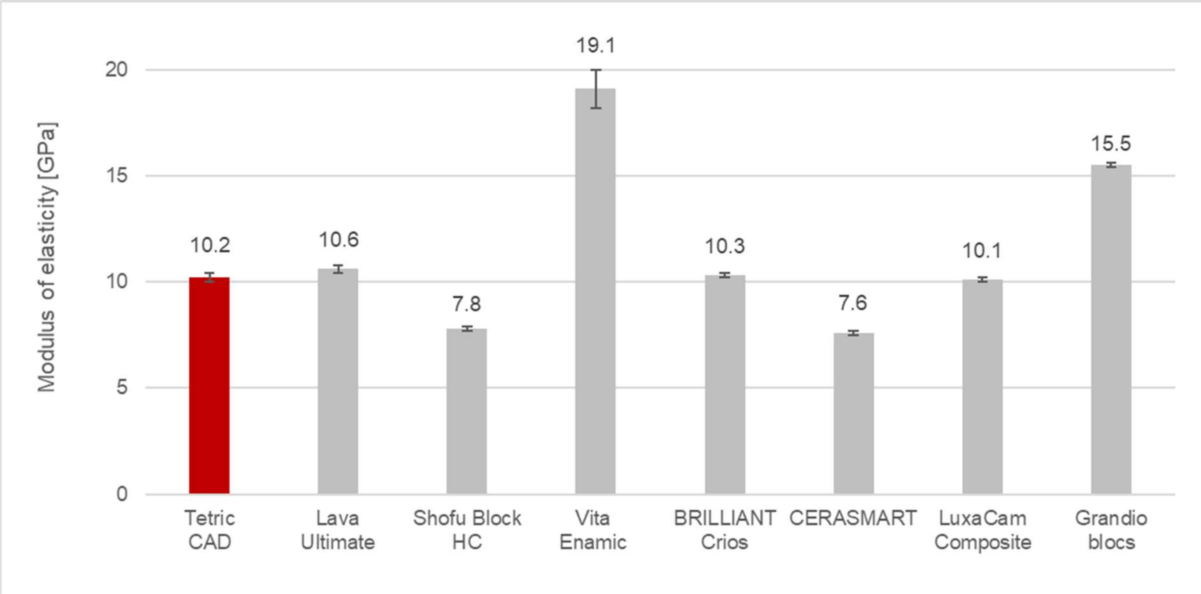


Fig. 7: Comparison of the modulus of elasticity of Tetric CAD and various composite CAD/CAM block materials. R&D Ivoclar Vivadent Schaan. April 2018

The modulus of elasticity of Tetric CAD was similar to the majority of the other composite block materials. At 10 GPa, the value is slightly lower than that of natural dentin - at approximately 15 GPa. The hybrid ceramic material Vita Enamic unsurprisingly exhibited a higher modulus i.e. greater stiffness than the composite block materials.

5.3 Water sorption

The water sorption of Tetric CAD and various composite block materials was also tested according to the standard ISO 10477:2004. Specimens were first desiccated then stored in water for 7 days and re-desiccated/dried. The water sorption is calculated by subtracting the mass of the desiccated specimen (at the end of the experiment) from the larger mass value obtained after water storage, divided by the volume (mm^3) of the specimen.

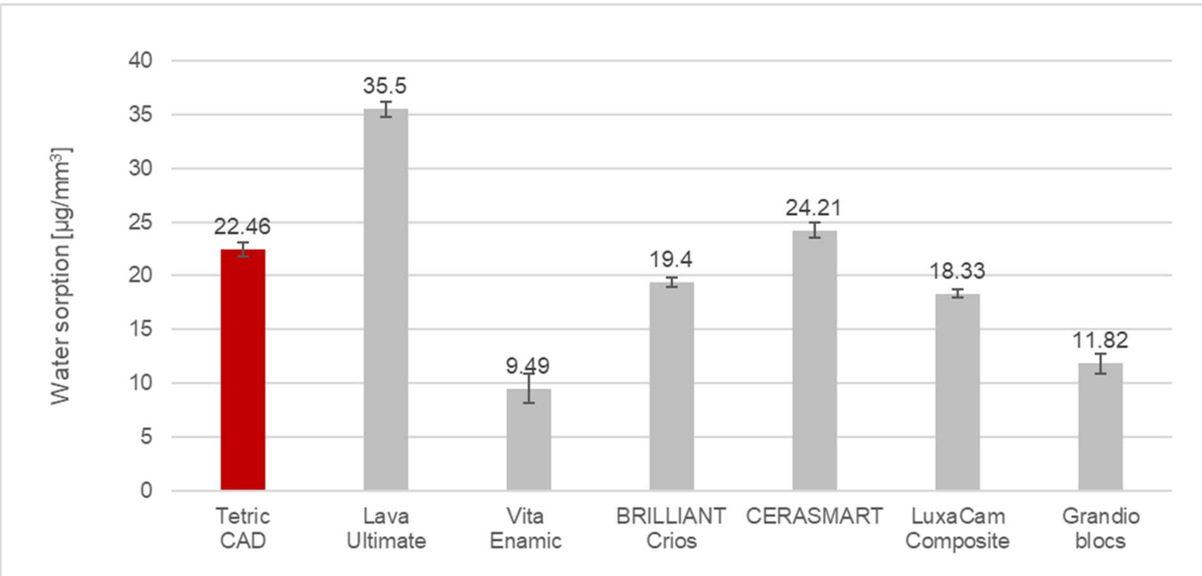


Fig. 8: Comparison of water sorption with Tetric CAD and various composite CAD/CAM block materials. R&D Ivoclar Vivadent Schaan. April 2018

Water sorption was well below the level specified by the standard (< 40 µg/mm³), for most of the composite block materials – including Tetric CAD. Lava Ultimate exhibited the highest water sorption levels in this experiment.

5.4 Wear resistance

Wear tests attempt to simulate the clinical wear of a material in the laboratory. Two-body wear refers to wear resulting predominantly from non-masticatory forces such as bruxism, i.e. the physiological wearing away of tooth structure due to tooth to tooth contact. Three-body wear involves an additional component i.e. an intervening slurry of abrasive particles. Three-body wear simulators attempt to mimic the oral environment whereby the slurry represents the role of food during mastication (14).

Ivoclar Vivadent measures wear using a long established two-body wear test without an abrasive medium. Wear tests are conducted in a chewing simulator. Flat test samples are subjected to 120,000 chewing cycles in the Willytec machine with a frequency of 1.67 Hz and a load of 50 N.

Fig. 9: Willytec chewing simulator

An artificial tooth cusp made of IPS Empress ceramic material is used as the antagonist. Once the antagonist comes into contact with the test sample, it slides horizontally over the sample for 0.7mm - thus simulating wear. The samples are simultaneously subjected to thermocycling between 5 °C and 55 °C. The volumetric and vertical substance loss is quantified using a 3D laser scanner.

With regard to material wear, if there is less than 200 µm of vertical substance loss, this is considered low wear, 200-300 µm substance loss is considered medium wear and over 300 µm loss is considered high wear.

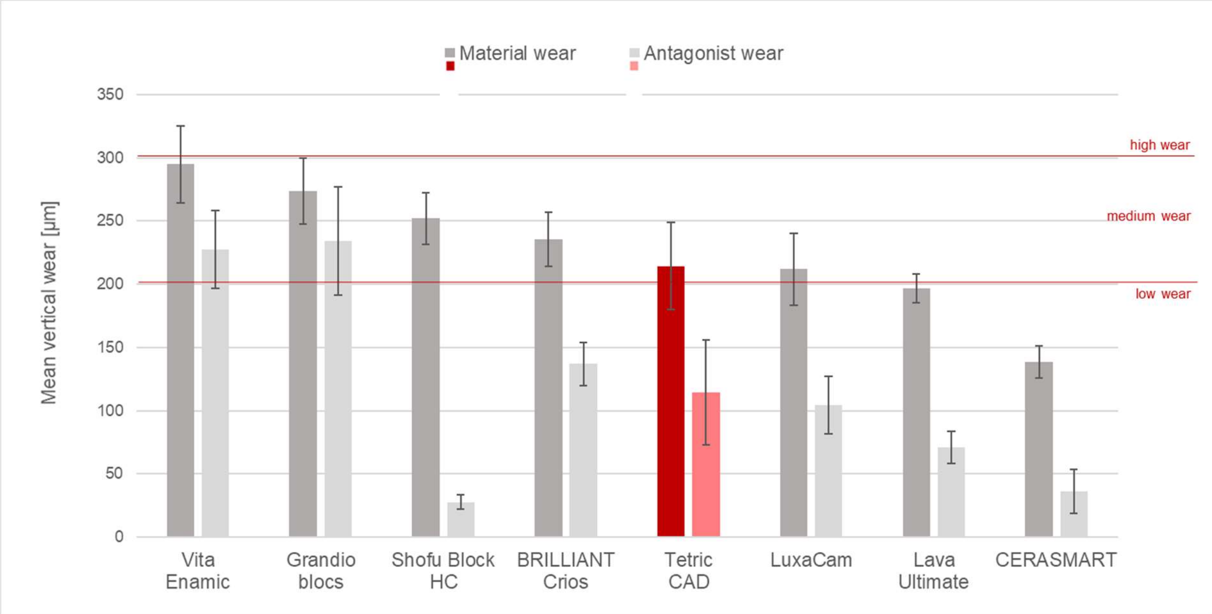


Fig. 10: Comparison of wear resistance (Willytec Method) of various composite block materials. R&D Ivoclar Vivadent. Schaan, March 2018

The graph above shows that Tetric CAD exhibits low/medium material wear with 215 µm substance loss of the material. The hybrid ceramic Vita Enamic/VITA exhibited the highest levels of material wear in this investigation and also comparatively high antagonist wear.

5.5 Shear bond strength

Shear bond strength testing with indirect dental materials is generally carried out, as indicated in the diagram below. A prefabricated cylinder of a restorative material is bonded to a substrate (tooth or dental material) along with the adhesive and luting material to be tested. It is then sheared off parallel to the bonding surface. In the following investigation, Tetric CAD was embedded in resin and the shear bond strength was tested via shearing off a pre-cured composite cylinder that was luted to the Tetric CAD with Variolink Esthetic and Adhese Universal.

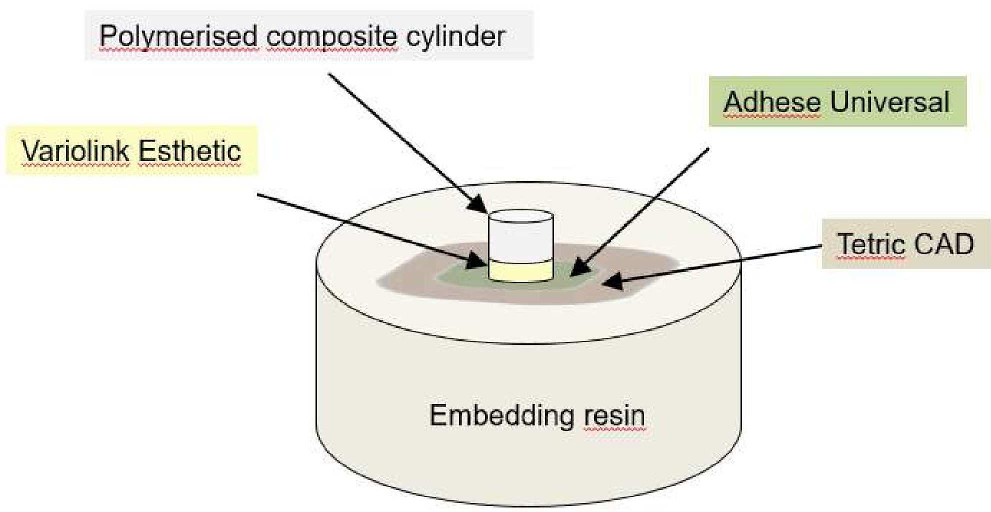


Fig. 11: Schematic representation of method for shear bond strength testing for indirect restorations

5.5.1 Shear bond strengths with and without sandblasting

As mentioned previously, neither hydrofluoric nor phosphoric acid are suitable for creating a retentive surface on composite materials. The surface of the Tetric CAD restoration should be conditioned via sandblasting in order to facilitate optimal mechanical retention. This is carried out via blasting the inner bonding surface of the restoration with 50-100µm aluminium oxide at a pressure of 1-1.5 bar. Tetric CAD is ideally bonded with Adhese Universal and Variolink Esthetic.

For ease of handling, Tetric CAD blocks were embedded in resin blocks (see diagram above). The Tetric CAD blocks were split into 2 groups. The sandblasted group were air blasted as described above and the non-sandblasted group underwent roughening with sandpaper (p400) for 10 seconds.

The sandblasted specimens were cleaned with ethanol in an ultrasonic bath for 5 minutes - then rinsed with ethanol and dried with compressed air. The non-sandblasted specimens were simply cleaned with ethanol. Adhese Universal and Variolink Esthetic were applied according to the instructions for use. Adhese Universal was applied to the surface for 20s, dried and left uncured. Pre-cured composite cylinders made of Tetric EvoCeram were then bonded to the Tetric CAD surface using Variolink Esthetic DC and cured twice for 10 seconds.

The diagram below shows the superior bond strengths achieved when the Tetric CAD surfaces were sandblasted before the luting protocol. The shear bond strengths are shown to decrease with longer water storage times (37°C) in both groups, but less so when sandblasting is carried out.

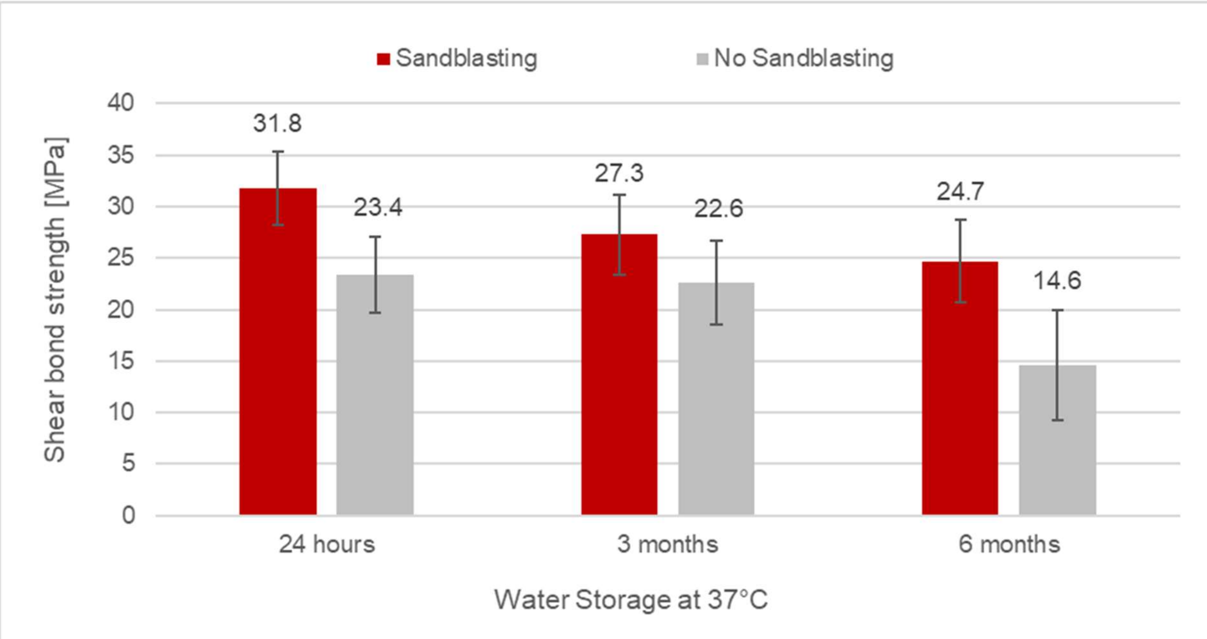


Fig. 12: Shear bond strength of Tetric CAD bonded with Adhese Universal and Variolink Esthetic DC with or without sandblasting. R&D Schaan, Ivoclar Vivadent 2018

Water storage had less effect on the bond strengths in the sandblasted group. The Ivoclar Vivadent standard lower limit of 15MPa is far exceeded over the time-period in the sandblasted group. The type of breakage also confirms the trend. Breakage in the sandblasted group was predominantly cohesive whereas in the non-sandblasted group where the shear bond strengths were lower - it was largely adhesive.

5.5.2 Shear bond strengths and water storage

Long-term bond strength of CAD/CAM composite samples and a universal adhesive

M. Barbisch, T. Bock, T. Köhler, N. Schneller, T. Milosovac. R&D Ivoclar Vivadent, Liechtenstein. Poster IADR London 2018 (15)

Objective
To evaluate the effect of water storage (as a proxy for the intraoral clinical situation) on the shear bond strength established between the CAD/CAM composite Tetric CAD and Adhese Universal with Variolink Esthetic DC.

Methods
Tetric CAD blocks were sandblasted with 50 µm aluminium oxide at 1.5 bar to obtain a visibly matte surface. Adhese Universal was then applied to the surface and agitated for 20 seconds with a microbrush. The adhesive layer was thinned out and dried with compressed air (4 bar). The specimen was placed into the sample jig and Variolink Esthetic DC was applied to the bonding surface via the jig mould. The specimen was then light-cured using a Bluephase Style curing unit at 1200 mW/cm^2 through a Tetric CAD disc (3mm, MT A3.5) for 30s. Specimens were aged for 24h, 3 and 6 months at 37°C in water, before shear bond testing was carried out in a ZWICK-ROELL machine, at a crosshead speed of 1mm/s.

Results
Shear bond testing was carried out according to ISO 29022.

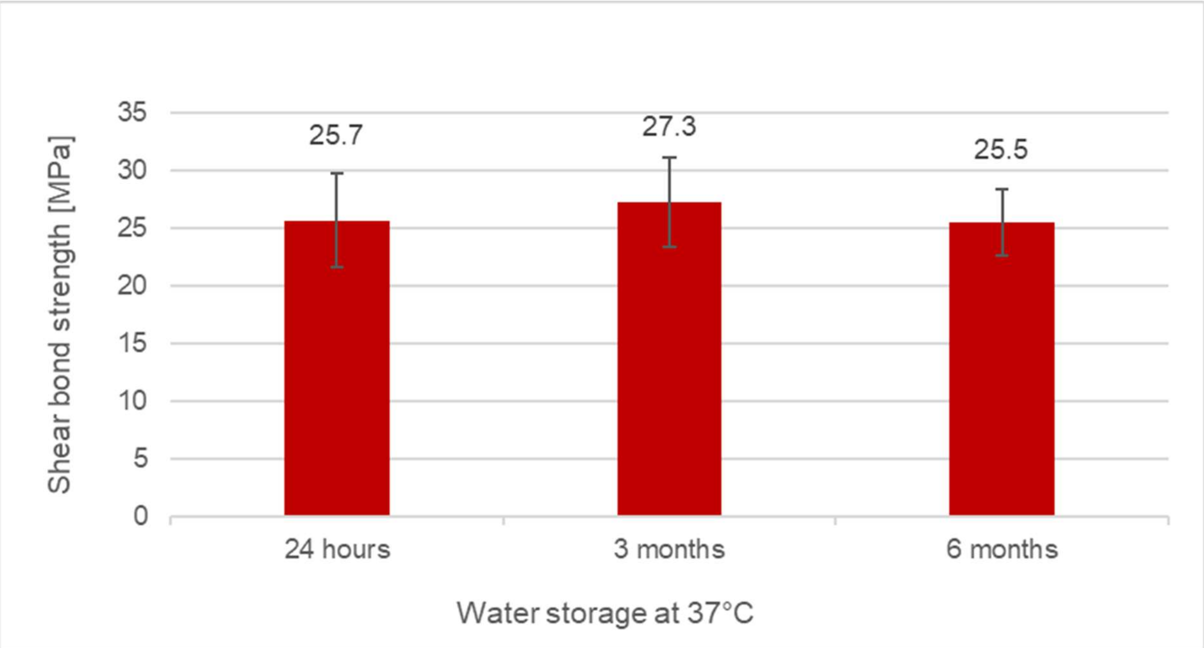


Fig. 13: Shear bond strength between Variolink Esthetic and Tetric CAD over 6 months' water storage. M. Barbisch, Poster IADR 2018 (15)

The graph below shows that Adhese Universal and Variolink Esthetic DC on sandblasted Tetric CAD provided stable high values for at least 6 months. There was no discernible influence of storage period on bond-strength performance.

Conclusion
The shear bond strengths obtained were well beyond the Ivoclar Vivadent specification limit of 15 MPa and remained high over 6 months of water storage.

5.6 Fracture resistance

CAD/CAM composite molar crowns: Fracture resistance after 90 days' storage and thermocycling/mechanical loading.

M. Rosentritt, University Clinic Regensburg, Germany, 2017 (16)

Objective:
To investigate the fracture resistance of Tetric CAD crowns affixed to human molars after artificial aging, designed to represent 5 years in the oral cavity.

Methods:
The roots of human teeth were coated with a layer of polyether impression material (1mm thickness) to simulate the elasticity of the human periodontium. The teeth were then fixed in PMMA and prepared according to two different protocols.

- Good Preparation: retentive with h = 6 - 8mm, angle = 6 - 8°, gap = 100µm.
- Worst Case: non-retentive with h = 3.5 - 4mm, angle 10 - 15°, gap 250µm

80 molar crowns (n=8: per material, per protocol) of the following materials were then prepared: Shofu Block HC/Shofu, Lava Ultimate/3M Espe, Grandio blocs/Voco and compared to Tetric CAD. The restorative materials underwent sandblasting of the bonding surface and were treated with the manufacturer's recommended adhesive luting technique. Two groups of Tetric CAD were included – one underwent sandblasting (as mentioned) the other remained untreated.

Crowns were stored in distilled water at 37°C for 90 days and then subjected to thermocycling/mechanical loading (TCML: 2 x 3000 x 5°C/55°C). Fracture force was then calculated by mechanically loading the crowns to failure in a universal testing machine. Force was applied to the centre of the restorations with a steel ball (Ø =12 mm, crosshead speed = 1mm/min).

Results:
8 crowns of the original 80 could not undergo fracture testing or statistical analysis. Four Tetric CAD crowns from the no sandblasting group debonded during water storage and four Lava Ultimate crowns from the worst case scenario group debonded during TCML.

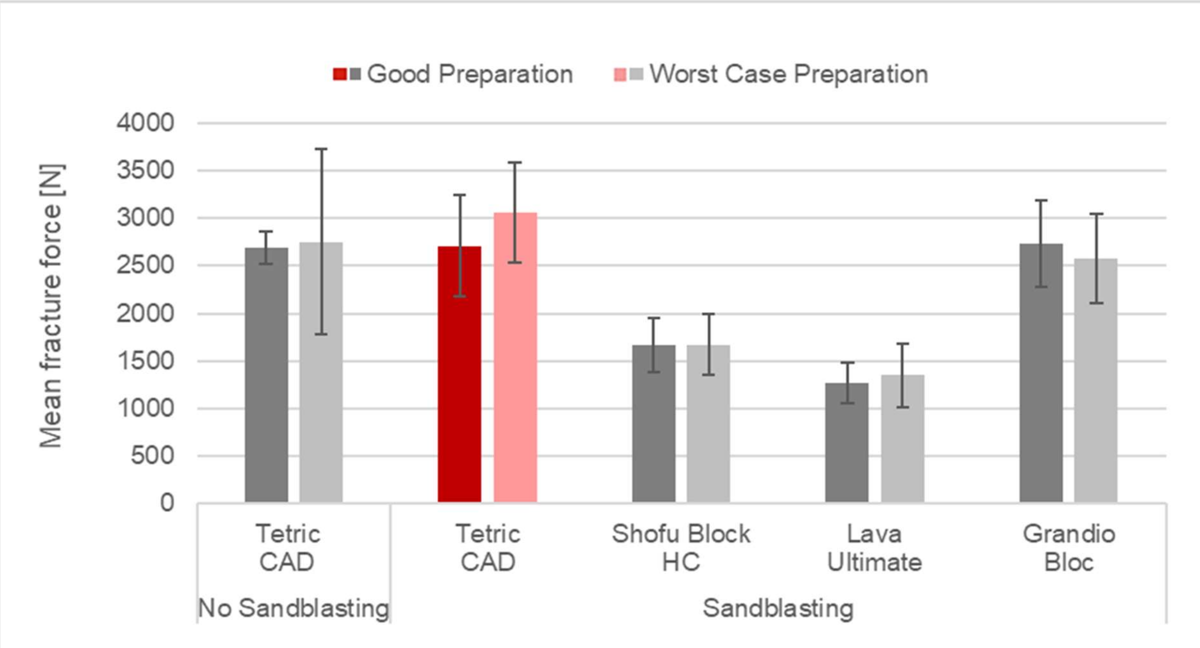


Fig. 14: Mean fracture force after water storage and thermocycling/mechanical loading for various CAD/CAM composite materials. Rosentritt 2017 (16)

There was no statistically significant difference between good or worst case tooth preparation for any product.

Tetric CAD (with or without sandblasting) and Grandio blocs crowns exhibited significantly higher fracture force values than Shofu Block HC and Lava Ultimate crowns. The fracture resistance of Tetric CAD was slightly higher in the sandblasted group than the non-sandblasted.

Conclusion:
The survival and stability of Tetric CAD seem sufficient for clinical application even with a non-retentive i.e. worst case preparation protocol. Debonding appeared to be both material and preparation dependent, occurring only in the non-sandblasted Tetric CAD group and with Lava Ultimate (with worst case preparation). Surface roughening of the materials i.e. sandblasting is therefore required.

5.7 Polishability

Polishing represents a critical step in restorative treatment. A pleasing surface gloss is decisive for the clinical success and esthetic appearance of a direct or indirect composite restoration.

Restoration surfaces that are too matte in relation to the surrounding tooth structure are unesthetic and rough surfaces are conducive to staining and plaque accretion.

Fig. 15: Tetric CAD: Unpolished, directly after milling (left) and after polishing with Optrapol (right)

To investigate the polishability of Tetric CAD quantitatively, surface gloss and surface roughness tests were carried out. Eight specimens of Tetric CAD and seven further composite-based CAD/CAM materials were prepared. The specimens were roughened with sand paper (320 grit) to achieve a defined initial surface roughness. Vita Enamic/VITA was roughened with a fine-grained diamond bur (Intensiv/Swiss Dental Products) for 10,000 rpm/wet/2N.

The specimens were then stored in a dry-storage area at 37 °C for 24 hours, whereupon their gloss was measured with a Novo-Curve Glossmeter and surface roughness was determined with an FRT MicroProf measuring device.

The specimens underwent polishing with an OptraPol polisher at a pressure of 2N at 10,000 rpm under water cooling. Specimens were polished for 30 seconds in total, with subsequent surface gloss and surface roughness (Ra) values measured at 10-second intervals.

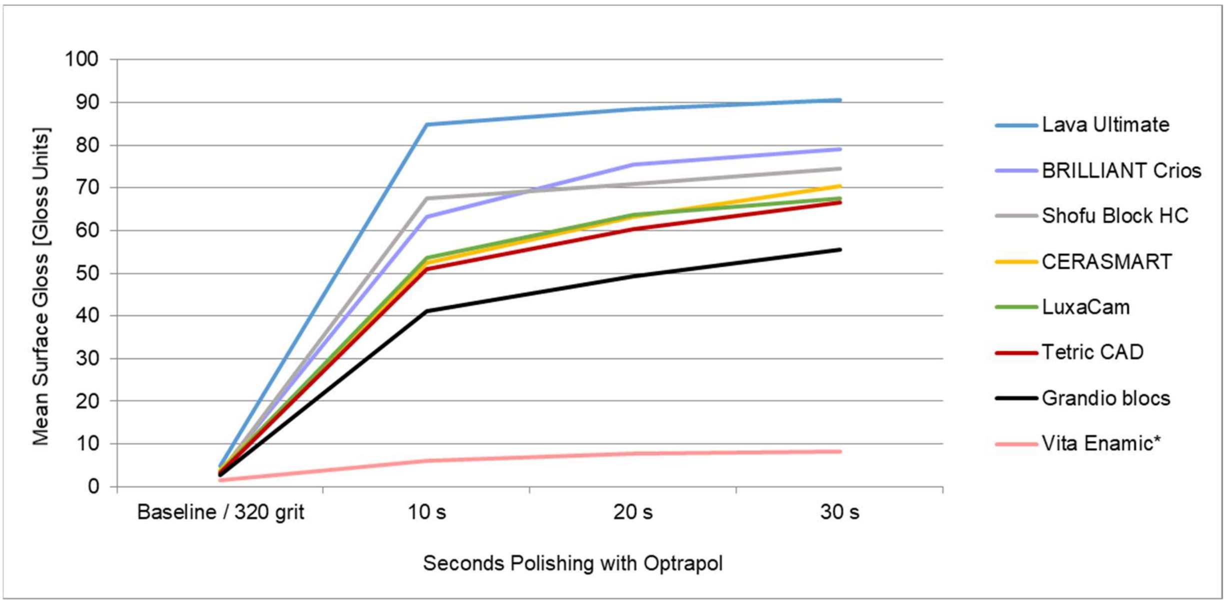


Fig. 16: Mean surface gloss of various composite-based CAD/CAM materials after polishing with OptraPol for 30 seconds. (Preclinic R&D Ivoclar Vivadent, Schaan, March 2018)

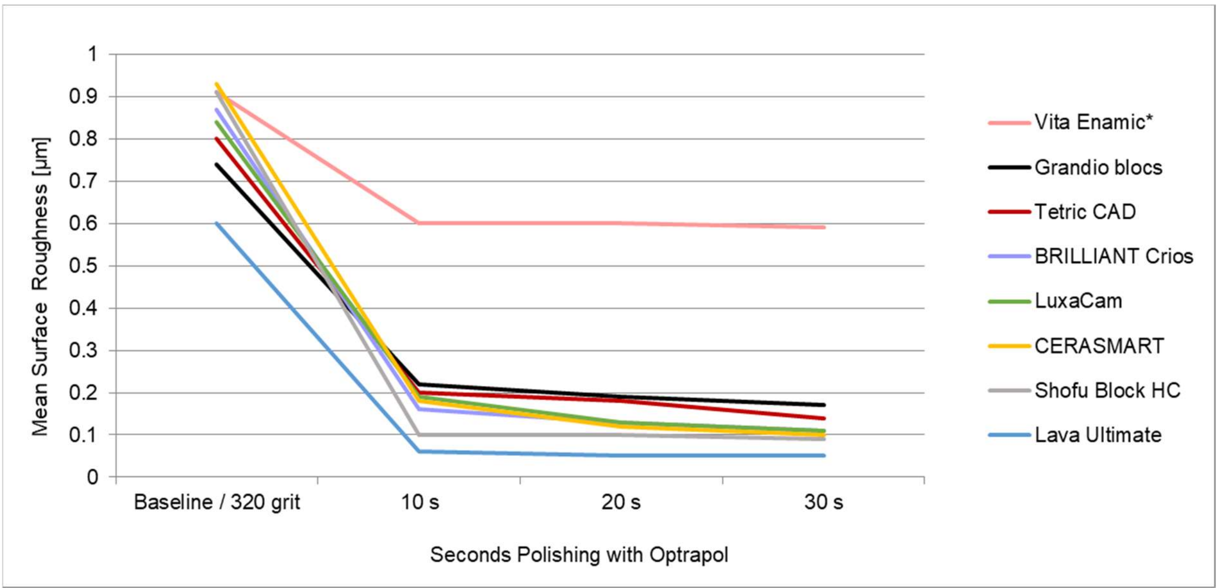


Fig. 17: Mean surface roughness of various composite-based CAD/CAM materials after polishing with OptraPol for 30 seconds. (Preclinic R&D Ivoclar Vivadent, Schaan, March 2018)

* Roughened with a fine-grained diamond bur for 10,000 rpm/wet/2N

As illustrated by the graphs above, compared to the other CAD/CAM composite materials, Tetric CAD exhibited polishability in the middle-range. A mean surface roughness of <0.1 µm indicates excellent polishability, <0.2 µm suggests good polishability, a value between 0.2 - 0.4 µm corresponds to a medium polishability and >0.4 µm means poor polishability.

Tetric CAD exhibited good polishability after 10 seconds polishing and this continued to improve over the 30-second test. Vita Enamic/VITA exhibited the poorest polishability with the lowest gloss and highest surface roughness levels, in this investigation.

5.8 Conclusion

Tetric CAD exhibits good mechanical properties with respect to flexural strength, E-Modulus, water sorption, wear and polishability. The shear bond strength investigations illustrate the importance of sandblasting the bonding surfaces of the material.

6. Clinical Case

There are currently relatively few clinical studies with resin composite block materials; however, Fasbinder et al compared the original Paradigm/3M Espe block with the porcelain block Vitablocs Mark II/VITA when used for CAD/CAM generated composite inlays. Three years after placement, the authors concluded that the resin based inlays performed equally as well as the porcelain inlays over all the USPHS categories studied. They also noted clinical advantages regarding fracture resistance and colour match (17).

The following case from the University of Munich illustrates the esthetic results possible with Tetric CAD.

Optical Evaluation of the CAD/CAM composite block Tetric CAD

J. Schweiger, D. Edelhoff. Poliklinik for Dental Prosthetics, University of Munich, Germany *(18)*

Four crown/occlusal onlay restorations for the bicuspids and molars of the third quadrant were prepared using CAD/CAM technology. Restorations were prepared for teeth 34 to 37 from Tetric CAD HT blocks in shades A2 and A3.

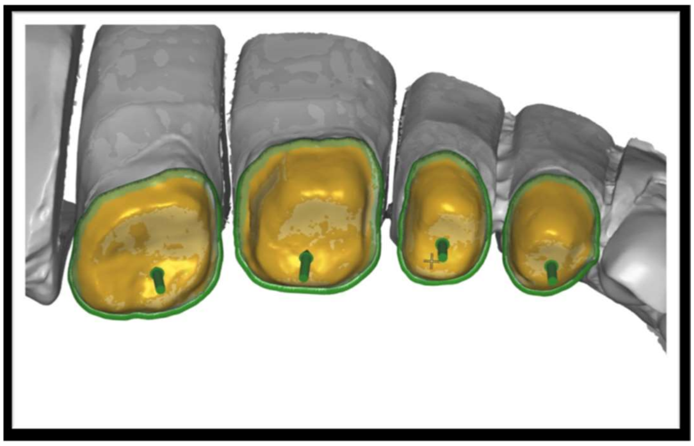


Fig. 18: CAD Design using ExoCAD Software: Inner view

Fig. 19: CAD Design using ExoCAD Software: Occlusal view

The restorations were milled using Sirona CEREC Inlab MCXL in extra fine mode. The milling result was highly satisfactory with no marginal chipping. The inner bonding surfaces were sandblasted with aluminium oxide, 50 µm at 1 bar. The polished surfaces were described as exceeding expectations – exhibiting a homogenous smooth, high-gloss surface and excellent translucency.

Fig. 20: Finished Tetric CAD restorations in transmitted light

Fig. 21: Initial clinical situation of teeth 34 to 37, indicating considerable tooth attrition and abrasion

Fig. 22: Occlusal onlay and crown preparations at try-in with Variolink Esthetic Try-in shade in "warm"

Conclusion

The overall esthetic appearance of Tetric CAD was considered very good – both in terms of gloss and translucency and illustrates the chameleon effect of the material.

7. Biocompatibility

To minimize biocompatibility risks as far as possible from the outset, care is taken to use mainly raw materials that have been used previously in dental materials and proven to be safe in vivo.

Tetric CAD is a pre-polymerized composite CAD/CAM block, that utilizes the same/similar monomers and fillers as those found in the Tetric Evo family of composites. These materials are industry standards and have been thoroughly investigated.

Various biocompatibility tests were carried out using milled discs of Tetric CAD as samples. Extractions were carried out according to the requirements of EN ISO 10993-1 2009.

7.1 Cytotoxicity

Cytotoxicity refers to the destructive action of a substance or mixture of substances on cells.

The XTT assay is used to examine whether or not a substance causes cell death or inhibits cell proliferation in a cell culture. The XTT_{50} value refers to the concentration of a substance which reduces the cell viability by half, thus the lower the XTT_{50} value, the more cytotoxic the substance. An XTT assay was carried out on extracts of Tetric CAD test specimens (in various concentrations) by an independent test facility. No cytotoxic potential was observed at any concentration and an XTT_{50} value could not be calculated. (19)

7.2 Irritation or intracutaneous reactivity

As the undiluted extract of Tetric CAD did not show any cytotoxicity, it can be assumed that the risk of Tetric CAD causing irritation is extremely low. Tetric CAD contains proven ingredients, which have been used in similar products and for Tetric CAD they are delivered in a polymerized state.

7.3 Hypersensitivity and sensitisation

Tetric CAD contains dimethacrylates which may have an irritating effect and initiate sensitisation to methacrylates, which can lead to allergic contact dermatitis. Allergic reactions are extremely rare in patients but are observed in dental personnel who handle uncured composite materials on a daily basis (20). Tetric CAD is delivered and used in a polymerized state, thus any risk of sensitization is negligible.

7.4 Genotoxicity

Mutagenicity testing is an accepted tool for evaluating the potential risk of material/substance-genotoxicity. The most established mutagenicity test is the bacterial reverse mutation test or Ames test which is usually carried out with strains of Salmonella typhimurium or Escherichia coli.

An Ames test was carried out at an independent testing facility whereby extracts of Tetric CAD were found to be non-mutagenic. That is, Tetric CAD extracts did not induce gene mutations by base pair changes or frame shifts in the genome of the strains used. (21)

7.5 Conclusion

The toxicological evaluation of Tetric CAD shows that according to current knowledge, Tetric CAD provides a high level of safety and an even higher level than highly established composite materials that are applied in a non-polymerized state. Clinical experience with composite CAD/CAM blocks dates back to 2000 and no undesired effects relating to biocompatibility issues have become apparent. According to current knowledge, if used as indicated, Tetric CAD poses no risk for the patient, user or third party, and the benefits of the product exceed any residual risk.

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Ivoclar Vivadent AG
Research and Development
Scientific Service
Bendererstrasse 2
FL - 9494 Schaan
Liechtenstein

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