ivoclar

Scientific Report

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English

Tetric® plus

Simplified Universal Composite

Making People Smile

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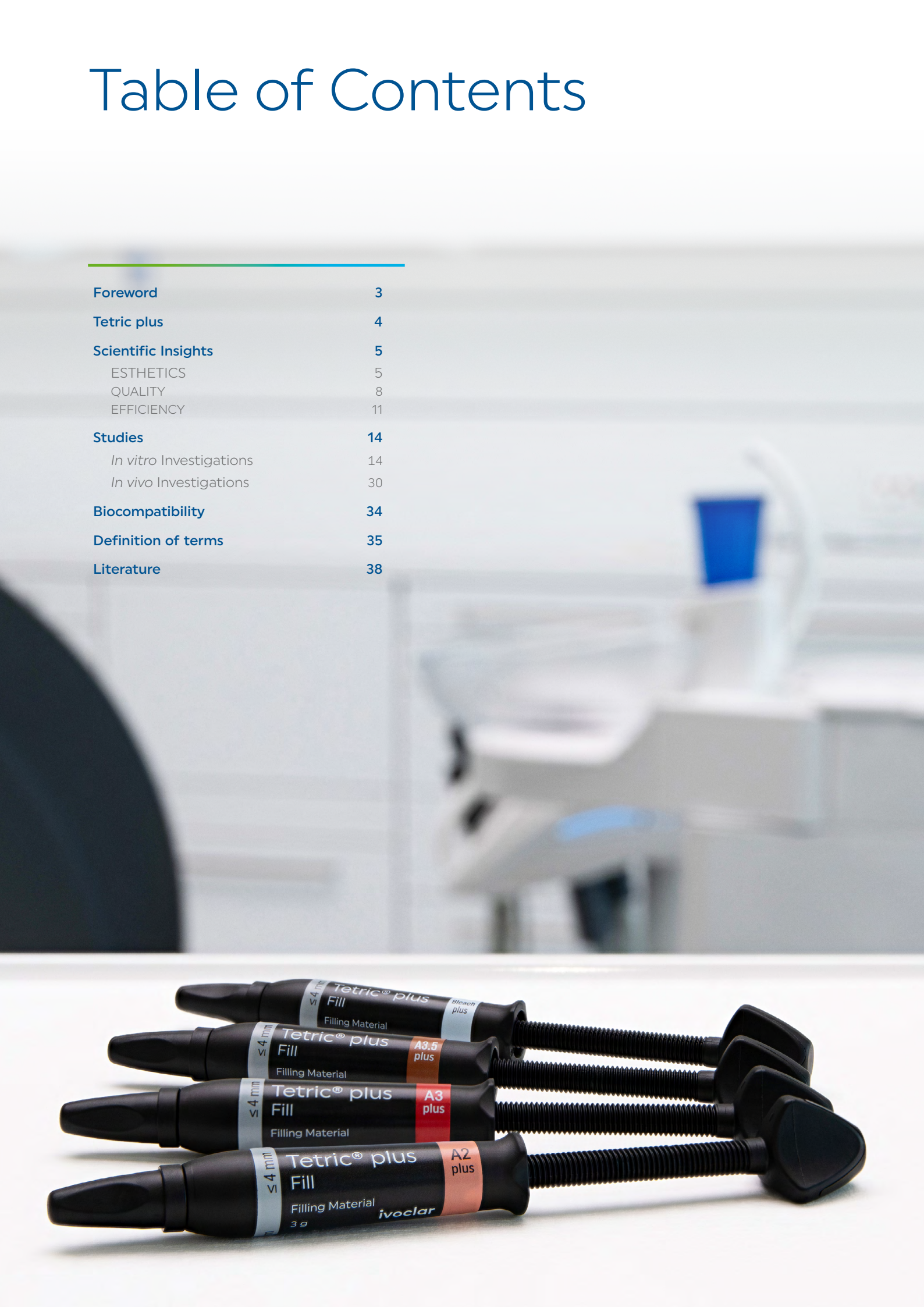

Foreword

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Since their introduction in the 1960s, dental filling materials have undergone continuous advancement, driven by ongoing technological innovation. These developments have led to a variety of materials. From the increasingly user-friendly, durable, and efficient to those that satisfy the highest specialized demands of modern dental needs and esthetics.

High-efficiency materials of limited colour-range, such as Tetric PowerFill and Tetric PowerFlow, are designed for posterior restorations, enabling rapid application with up to 4-mm layers and curing times as short as 3 seconds. On the other hand, materials like IPS Empress Direct offer a broad spectrum of shades, translucencies and effects, allowing for highly esthetic restorations that closely replicate natural teeth. In between these options, conventional, universal composites like Tetric Prime and Tetric EvoFlow provide versatile, reliable solutions for around 80% of routine dental procedures – delivering an optimal balance of esthetics, and quality.

In recent years, the demand for simpler and more efficient solutions in direct restorative treatments has surged, largely due to increasing economic pressures on dental practices. In response, Ivoclar has introduced Tetric plus. Building on the esthetic qualities and proven reliability of the conventional, universal Tetric Line composites, Tetric plus also enhances efficiency with the ability to apply 4-mm layers that can be cured in 3 seconds. This advancement was made possible by developing an innovative shading system of "plus" shades, combined with carefully optimized optical properties in both sculptable and flowable form – ensuring outstanding esthetics, high depth of cure, rapid curing, and consistent quality.

The first part of this scientific report provides an in-depth exploration of the technologies underpinning Tetric plus Fill and Tetric plus Flow. The in vitro section offers a comprehensive summary of investigations carried out during the development phase of the materials, and this is followed by initial results from ongoing clinical studies.

Tetric plus is a versatile, dependable solution that addresses a broad spectrum of challenges in daily clinical practice – seamlessly combining quality, esthetics and efficiency.

Tetric® plus

Tetric plus is the new simplified universal composite from Ivoclar - available in both sculptable and flowable form. The materials are intended for standard day-to-day use, can be applied in layers of up to 4 mm and are suitable for both rapid and conventional curing.

Tetric plus Fill: The sculptable material is used to create restorations in both permanent and deciduous teeth, including the replacement of individual cusps in posterior teeth. Tetric plus Fill is also suitable for reconstructive build ups, composite/ceramic repairs, direct veneers and the sealing of implant screw channels.

Tetric plus Flow: The flowable material can be used in permanent and deciduous teeth as an initial composite layer in Class I and II restorations and for small direct restorations that are non-occlusion-bearing. For occlusion bearing fillings a final layer of a sculptable composite such as Tetric plus Fill is used. Tetric plus Flow is also suitable for extended fissure sealing, Class V restorations, composite/ceramic repairs and the sealing of implant screw channels.

4-shades: Both Tetric plus materials are offered in 4 "plus" shades that cover 16 classic VITA* shades and bleach colours. Each shade blends in seamlessly with several natural tooth shades:

Tetric plus				
VITA* classical shades	A1, A2, B2, C1, D2	A3, C2, C3, D3, D4	A3.5, A4, B3, B4, C4	B1, Bleach

Tetric plus is an esthetic, convenient solution for both posterior and anterior direct restorations.

* Not a registered trademark of Ivoclar Vivadent AG

Scientific Insights

Tetric plus is a simplified universal composite offering esthetics, quality and efficiency.

ESTHETICS	QUALITY	EFFICIENCY

This part of the Scientific Report explains how Tetric plus achieves all three without compromise.

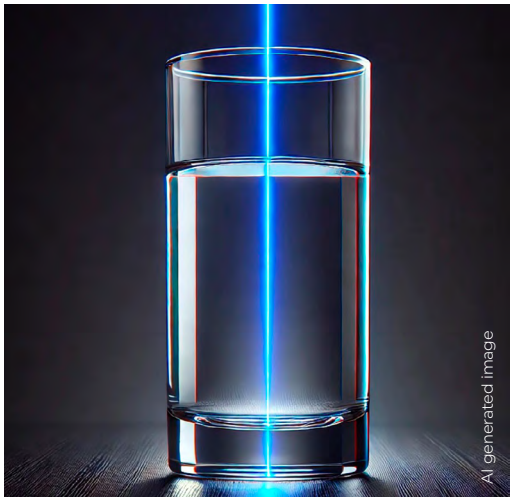
ESTHETICS

The core challenge in the development of Tetric plus was delivering a material that could match the esthetics of a conventional universal composite but also be cured quickly in up to 4-mm layers.

Translucency Shift

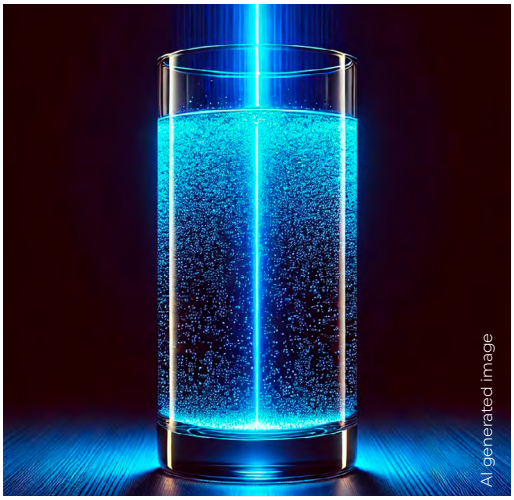
The key technology here lies within the translucency shift – an effect utilised by both Tetric plus Fill and Tetric plus Flow. In their uncured state, the materials exhibit high translucency, allowing an elevated level of light penetration. This is crucial for a high degree of conversion and reliable curing of a material in layers up to 4 mm, as light clearly travels more easily through a transparent material. During polymerization however the density of the organic material increases and the translucency decreases, shifting towards a final, tooth like, esthetic opacity. The translucency shift is realized via the careful matching of the refractive indices (n_D) of the composite monomer formulation and inorganic fillers. This principle is illustrated below:

n_D Monomer = n_D Filler



Minor refraction: Light penetration

n_D Monomer ≠ n_D Filler

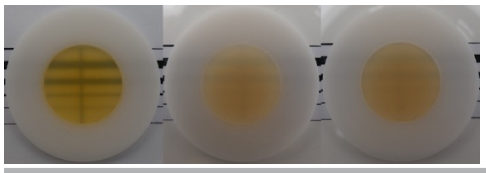
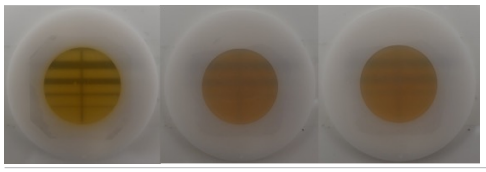


Multiple refraction: Light scattering

The refractive index influences the extent to which light waves are bent (refracted) and scattered when they pass through or encounter particles in a medium.

Low differences in the refractive indices of particles and the surrounding medium lead to less scattering when light passes through a material. The reverse is true with large differences in refractive indices. In Tetric plus, matching the the refractive indices of the monomer and fillers is decisive.

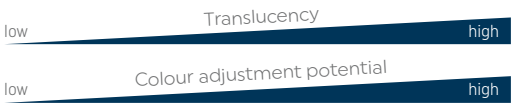
The translucency shift is easily visualized. The disc specimens below of Tetric plus Fill and Tetric plus Flow, show that prior to polymerization, translucency is relatively high in both materials at ca. 36% and 38% respectively. Following polymerization and water storage at 37°C, translucency decreases, and an opaquer esthetic colour is established, because the final polymer and filler of the restoration now have different refractive indices and light is scattered.

Tetric plus Fill (A3 plus)			Translucency [%]
	Left	Unpolymerized	36
	Middle	Polymerized	14
	Right	After 24h / 37°C	13
Tetric plus Flow (A3 plus)			**Translucency [%]**
	Left	Unpolymerized	38
	Middle	Polymerized	16
	Right	After 24h / 37°C	14

Due to post-polymerization (of remaining radicals), final translucency is reached 24h after curing. A 4-mm depth of cure however is reached after 3s irradiation at 3000mW/cm^2.

Colour-adjustment potential

Another key to achieving materials with good esthetic properties and high depth of cure is the colour-adjustment potential (chameleon effect) of the formulation.



In general it can be said that the higher the translucency of a material, the higher the potential for colour adjustment.

The formulation of many bulk materials is designed to be translucent in order to facilitate light penetration and polymerization at depth. One-shade materials such as Omnichroma/ Tokuyama Dental or Venus One/Kulzer focus on this feature. Numerous bulk materials however retain considerable translucency post-polymerization and do not undergo the pronounced translucency shift of Tetric plus materials. Retaining translucency post-polymerization serves a bulk composite well to the extent that it may aid the colour-adjustment potential. However, this is really only the case if there is considerable tooth structure surrounding a cavity (e.g. Class I, V or small Class IIs) that can transport and reflect its natural appearance within a restoration. Should less surrounding tooth structure be available, (e.g. large Class II, III or IVs), the optical properties of the restorative material itself are far more important.

Composites with diffused light transmission (less translucent) properties were found to possess better colour adjustment potential (Ismail et al 2022). Clearly the best design and composition is a balancing-act. Tetric plus utilizes the reliable 4-filler (Tetric) technology with adapted filler sizes, shapes and compositions for optimized, diffuse light transmission in the polymerized material. The 4 final shades also all feature minimal pigmentation, which further facilitates colour adjustment. As a result, Tetric plus is suitable for use in all sizes and type of cavity – anterior and posterior.

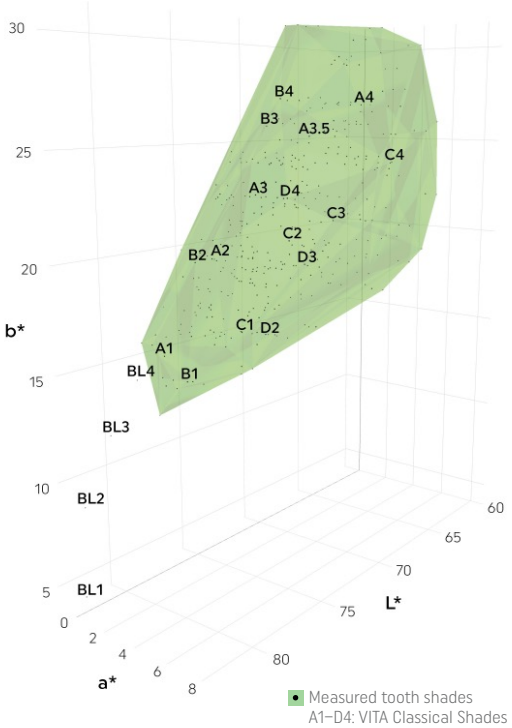
Shade clusters / Colour clouds

The last key to the esthetic story of Tetric plus is the shade cluster concept – resulting in 4 Tetric plus shades, able to cover the full range of VITA shades and some bleach colours.

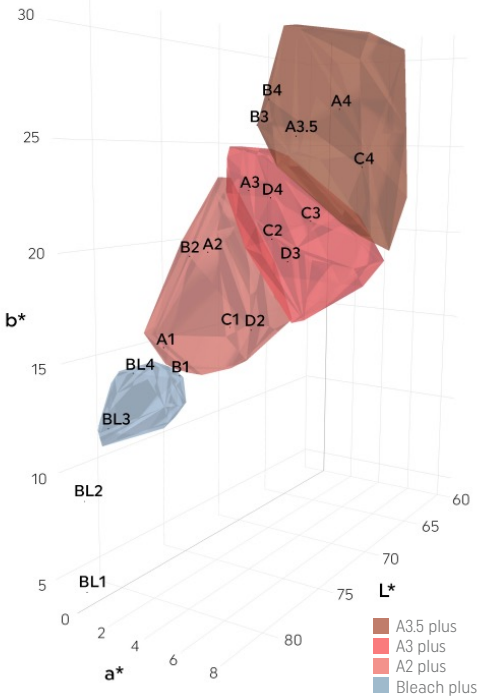
The "colour cloud" concept was borne from investigations carried out on natural human teeth. The colour of 368 anterior teeth (#21, #22 and #23) from approximately 120 male and female adult patients was examined via spectrometer.

The colour values of all the teeth were analysed and mapped using the CIEL*a*b colour space method. This distinguishes colour differences with precise accuracy using three values. The L axis refers to brightness from black (low=0) to white (high=100), whereas a* and b* refer to the chromaticity i.e. hue and chroma with positive and negative values from red to green (a+ to a-) and yellow to blue (b+ to b-).

The shades of the individual teeth are shown in the CIEL*a*b map as mini individual dots. The area covered by these dots is delineated by the green "cloud" area. This cloud or cluster visually depicts the colour space of the natural teeth. The standard A-D VITA shades were then also mapped alongside the natural shades (dots). The natural shades all fell in and around the A-D VITA shades but did not extend to bleach shades. It is clear that the individual VITA shades are also not equally represented amongst natural teeth.



CIEL*a*b map of anterior teeth and VITA shades



4 final shade clusters / colour clouds

The number of composite shades was not "reduced" at random. Following extensive market research and consultation with dentists, the shades A2, A3 and A3.5 were established as the most commonly used for standard practice purposes. The shade cluster (green) with the generated tooth-colour values was therefore divided into three separate clusters (pink, red and brown areas), whereby A2, A3 and A3.5 were representative of each area/cluster. These plus the centre values of each cluster were the starting points for shade design.

Although none of the natural teeth assessed fell within the bleach range, in order to fulfil the demands of modern dentistry, an additional cluster (blue area) was calculated, and the respective shading developed. Final shading was tested in Class III cavities of extracted human anterior teeth and the four cluster-based shades named A2 plus, A3 plus, A3.5 plus and Bleach plus resulted – able to cover 16 VITA shades and several bleach shades. To ensure the 4 plus shades really do cover the entire cloud area, borderline colours were also tested for a good fit.

Esthetic results: The result of all the esthetic technologies (translucency shift result + colour adjustment + shade cluster concept) is illustrated perfectly below. Tetric plus Fill in shade A2 plus, which is designed to cover the five classic VITA shades: A1, A2, B2, C1, and D2 , is able to blend seamlessly into the respectively shaded tooth models below.

Natural shade matching with Tetric plus Fill (A2 plus) in five differently shaded tooth models

Unfilled cavity | A1 | A2 | B2 | C1 | D2

Tetric plus is a simplified universal composite whose shade system is based on the many shades of natural teeth.

QUALITY

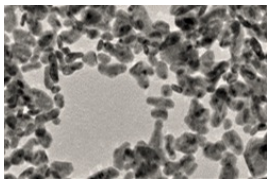
Tetric 4-Filler technology

The first Tetric composites, whose name was derived from the Greek prefix for the number four, were launched in the 1990s, with the line continuing to evolve thereafter. Tetric Ceram was based on the 4 fillers: barium glass, ytterbium fluoride, high dispersed silica and mixed oxide. Tetric EvoCeram was based on combining 4 pillars of quality: excellent handling properties, pre-polymer technology, low shrinkage and low abrasion. Each technology having been fine-tuned via the development of various predecessor products.

Tetric plus includes innovations in just about every part of its formulation and remains truer than ever to these "pillars" due to the next generation of 4-Filler technology, involving:

- ✓ **Nano-ytterbium trifluoride** (nano-YbF_3) facilitating enamel-like radiopacity (≥ 200% Al) in combination with a high translucency shift and superior thixotropic handling properties
- ✓ **Glass filler** assuring the mechanical properties of the material and due to matched refractive indices facilitating the distinct translucency shift during light curing
- ✓ **Optimized mixed oxide** supporting the translucency shift along with quick polishability and superior handling properties
- ✓ **Spherical IFP composite filler** a pre-polymer type filler prepared using an in-flight polymerization (IFP) technique. Its spherical structure supports smooth handling properties, the translucency shift, and quick polishability.

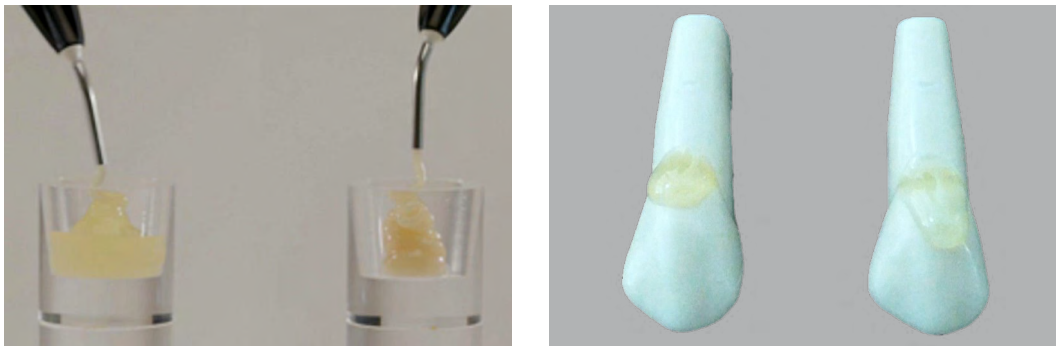
Nano-ytterbium trifluoride (nano-YbF_3)



Ytterbium trifluoride is an essential component for achieving adequate radiopacity in dental restorative materials. Its refractive index however does not match the refractive index of a standard (dental composite) monomer/filler composition.

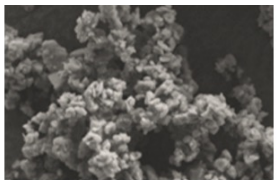
As described earlier, an initial mismatch in refractive indices would interfere with the pronounced translucency shift needed to achieve both high depth of cure and an esthetic final appearance. To overcome this limitation, Tetric plus uses very small YbF_3 particles that neither interfere with visible light, nor compromise the translucency shift. These YbF_3 nanoparticles also enable innovative (seemingly contradictory) handling properties. Both the stability of the sculptable material, (which can also be formed as required by applying shear force with moulding instruments) and the pronounced thixotropic behaviour of the flowable material are based on this innovative solution.

Tetric plus Flow **Tetric EvoFlow** **Tetric plus Flow** **Tetric PowerFlow**



When Tetric plus Flow is applied with pressure in large amounts e.g. for posterior 4-mm restorations, a very flowable consistency results that self-levels and is easy to adapt. As shown in the picture (left), this effect is more pronounced than with Tetric EvoFlow but similar to Tetric PowerFlow. On the other hand, when Tetric plus Flow is applied with low pressure in small amounts e.g. for anterior Class III or V restorations (right), the material remains more viscous than Tetric PowerFlow, holding the desired shape and not running off the tooth surface.

Glass filler



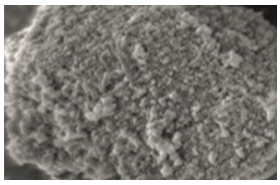
The glass filler is the heart of every composite formulation and primarily determines the mechanical properties of the material. The glass filler in Tetric plus is comparable to the filler used in current Tetric Line products and provides for stable flexural strength values whether cured for e.g. 3s or 10s. (See *In vitro* Investigations: QUALITY).

The filler also contributes to the resulting flexural modulus values of the products at approximately 10 GPa for the sculptable material and a remarkable (for a flowable) 8 GPa, for the flowable material. (See *In vitro* Investigations: QUALITY). This high value for Tetric plus Flow, in combination with the overall esthetic filler composition allows for its use without a capping layer in anterior and posterior cavities (without occlusal load). The small particle size of the glass filler at approximately 0.7 µm also facilitates excellent polishing and thus surface qualities. (See *In vitro* Investigations: QUALITY).

The main optimization of the filler however concerns the refractive index, which is perfectly matched with the monomer mixture, allowing the distinct translucency shift described earlier. (See *In vitro* Investigations: ESTHETICS).

The pronounced translucency shift in combination with the innovative shade concept is the basis for the esthetic life-like appearance of Tetric plus in combination with a depth of cure of 4 mm.

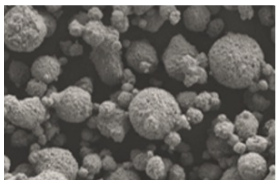
Optimized mixed oxide



The mixed oxide (silicon dioxide/zirconium dioxide) provides for fast polishability performance, good mechanical properties and handling. The mixed oxide consists of small round primary particles ("bobbles" visible on surface of SEM) of approx. 20 nm that are advantageous for surface qualities and quick high gloss polishing results. (See *In vitro* Investigations: QUALITY).

These primary particles are however also (via sintering during their production) part of secondary larger structures (overall cluster in SEM) of approx. 3.5–7 µm. These clusters in turn provide the mechanical stability of larger particles and lower the overall filler-surface-area. This lessens the thickening effect of a large quantity of "loose" filler – aiding the resultant soft, creamy, consistency of Tetric plus.

Spherical IFP composite filler



The spherical composite filler is a mix of filler and monomer that is added to the composite mix as a pre-polymerized filler in its own right – similar in principle to standard pre-polymers/ isofillers. IFP refers to the highly innovative technique of in-flight polymerization.

IFP technology involves spraying the composite-filler in a special blue light-curing cabin, whereby it is cured "in-flight" leading to the formation of polymerized spheres. These spherical particles greatly support the handling properties of the material. Spherical particles allow uniform distribution within the matrix and improve the flow properties of the material - tending to reduce viscosity and improve handling. This is because whereas irregular particles easily interlock, creating a certain stiffness, spherical particles slide or slip past each other more easily. Also as the IFP filler is cured similarly to the final product (surrounding composite), it results in a material with similarly-matched degree of conversion values and wear characteristics. Care was also taken to adapt the refractive index of the IFP filler to the monomer matrix in further support of the necessary translucency shift. (See *In vitro* Investigations: ESTHETICS).

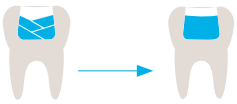
"4 Filler" shapes and sizes

Shape: Tetric plus is composed of spherical (spherical IFP composite filler and the primary particles of the mixed oxide filler) and irregularly shaped fillers (glass filler and the secondary cluster-particles of the optimized mixed oxide). This mix combines the advantages of both particle shapes: Spherical particles allow uniform distribution within the matrix; they slide past each other easily and can improve the flow properties of a material. Irregular non-spherical fillers however enable stronger mechanical interlocking within the matrix. A balance of solid material-feedback and creamy optimal handling characteristics is achieved when the right balance of filler type, size and shape is achieved. Spherical fillers also usually allow light to pass through more easily than irregular shaped fillers. The filler shapes of Tetric plus are therefore delicately balanced – not just from a handling perspective but also regarding esthetics and final opacity.

Size: A distinction is made between macro, micro and nanoparticles in fillers. In general, the larger the particles, the greater the strength of the composite. Large particles however create rough surfaces and have a negative impact on polishability. Macroparticles are therefore seldom used in modern composites. Composites consisting exclusively of nanoparticles may also exhibit disadvantages in terms of mechanical strength, wear-resistance and handling. A combination of nano- and microparticles is the key. Tetric plus is a nano-hybrid composite, with microparticles that provide sufficient strength and nanoparticles that improve surface quality and polishability. Nanoparticles also fill the gaps between larger particles and thus further contribute to increasing the density and strength of a composite.

EFFICIENCY

Fast ≤ 4-mm volume replacement



Tetric plus Fill and Tetric plus Flow are designed to be applied in ≤ 4-mm increments. Fewer layers reduce the potential for voids and a treatment protocol with reduced workflow steps necessitates fewer transitions between composite, modelling instrument and curing light. Fast volume replacement saves time.

Efficient 4-mm composites are of course not new in posterior restorations. Tetric plus (in just four shades) however is suitable for both anterior and posterior teeth and all cavity classes which also potentially reduces inventory i.e. the number of direct restorative materials required at the dental practice.

Together with the Adhese Universal and the Bluephase PowerCure curing light, every layer can be cured in 3s keeping chair time to an absolute minimum. Tetric plus combines the efficiency of bulk composites with the esthetics of conventional 2-mm composites.

Exceptionally fast curing

Tetric plus Fill and Tetric plus Flow are polymerized with the blue light of a curing device, that emits light within the 400-500nm range. The materials can be cured for varying lengths of time depending on the light intensity emitted.

Light Intensity	Curing time
500 – 900 mW/cm²	20s
1000 – 1300 mW/cm²	10s
1800 – 2200 mW/cm²	5s
2700 – 3300 mW/cm²	3s

Suitable curing times for Tetric plus Fill and Tetric plus Flow - by light intensity.
Rapid 3-5s curing is not indicated for primary teeth

Rapid curing: The 3sCure program of the Bluephase PowerCure light facilitates the rapid curing of increments in 3 seconds – using a light intensity of between 2700 and 3300mW/cm². 3s-curing is suitable under certain conditions: for light-curing posterior Tetric plus Fill or Tetric plus Flow restorations in permanent teeth, from the occlusal surface. Although all shades of both materials can be applied in layers of up to 4 mm, the darkest shade A3.5 plus should be applied in a maximum thickness of 3.5 mm when shorter curing times of 3s or 5s are planned, due to reduced light transmission in darker materials.

The initiator system of Tetric plus was specifically designed to achieve comparable performance with curing times of 3 to 10 seconds i.e. rapid or conventional curing. Evaluations of the degree of conversion showed that the "energy reciprocity" of the Tetric plus composites is given for both curing times. (See *In vitro* Investigations: EFFICIENCY and "Total Energy Concept" in Definitions of Terms)

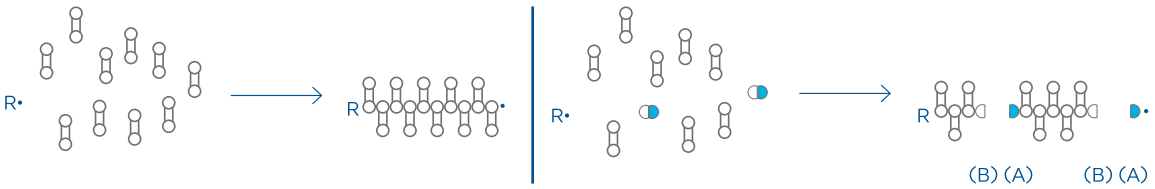
Standard curing: The 3sCure program should not be used for cases of caries profunda or restorations close to the pulp. When Tetric plus Fill is used to create reconstructive build ups – a light intensity of ≤ 1300mW/cm² is suitable and restorations in deciduous teeth should also be cured at light intensities of ≤ 1300mW/cm² , which then require a 10s curing time.

Curing rationale: The initiator system of Tetric plus Fill and Tetric plus Flow, based on developments made with Tetric EvoCeram Bulk Fill and Tetric EvoFlow Bulk Fill and Tetric PowerFill and Tetric PowerFlow, utilizes both conventional initiator technology with a camphorquinone/amine system and the newer Ivoclar-patented initiator Ivocerin® that is more efficient at absorbing and utilizing photons than standard initiators. In combination with further additives, this facilitates both exceptionally fast curing and comparably long working times. (See *In vitro* Investigations: QUALITY)

Optimal polymerization in 3s with AFCT

The composition of Tetric plus was further optimized by including an Ivoclar-patented (β-allyl sulfone) Addition Fragmentation Chain Transfer (AFCT) agent.

As with all composites, the Tetric plus materials are converted to a cross-linked polymer matrix during curing. Standard polymerization involves radical chain growth whereby excited photoinitiators create radicals that attack the double bonds of monomers resulting in methacrylate-addition and long chain formation (left part of diagram). Uncontrolled rapid long chain growth can result in an early gel point and an inhomogeneous, rigid network architecture limiting matrix-flexibility and resulting in high shrinkage stress. These effects were noted by Gorsche et al (2015), who showed that the addition of an AFCT reagent to monomer formulations improved double bond conversion by promoting a more homogenous polymer network.



The AFCT agent, (depicted by the white/blue shapes on the right of the diagram) acts as a chain controller by breaking up growing polymer chains. They initially add to growing chains but then fragment (schematic separation of white/blue shape (B)/(A)), creating a new radical fragment that starts a new short chain. Successive uniform short chain development (without the loss of radicals), creates more homogeneity, translating to reduced shrinkage stress at the adhesive interface, increased conversion and greater toughness (Gorsche et al 2025).

As the Tetric plus composites can be cured in just 3 seconds, the time available for full-polymerization is by definition reduced, the inclusion of the AFCT agent enables optimal polymerization with short curing times, by adjusting the thermal and mechanical properties of dimethacrylate networks leading to increased double bond conversion. (See *In vitro* Investigations: EFFICIENCY)

Efficient shade selection

The colour concept with 4 "plus" shades allows for easy and straightforward shade selection, using the Tetric plus shade guide or VITA shade scale. Dentists can quickly match, select and create posterior or anterior monochromatic restorations with esthetics comparable to conventional 2-mm "Tetric" composites.

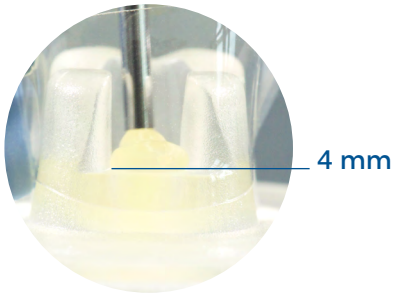
Tetric plus

ESTHETICS

4 x esthetic shades covering 16 VITA classical shades and bleach colours for true to nature results

QUALITY

4-filler technology for quality restorations and good handling



EFFICIENCY

4-mm restorations for all 4 quadrants of the mouth, curable in 3s for increased efficiency

The innovative, efficient, simplified universal composite for all daily direct restorative requirements

Studies

In vitro Investigations: ESTHETICS

Translucency shift in Tetric plus Fill & Tetric plus Flow: Part I – Light transmission

Study location: Dalhousie University, Nova Scotia, Canada
Study release: February 2024
Study author(s): R. Price

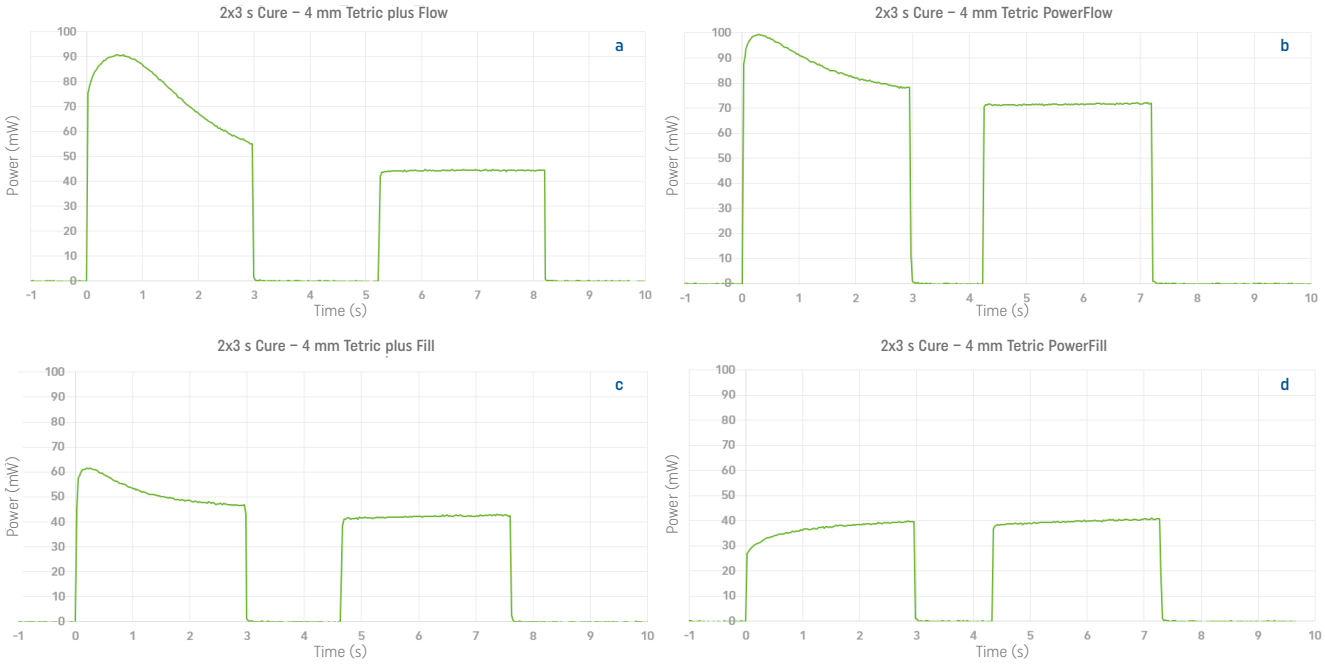
Objective:

To investigate the translucency shift during the polymerization of Tetric plus Fill and Tetric plus Flow compared to the 4-mm composites Tetric PowerFill and Tetric PowerFlow.

Method:

4-mm thick composite specimens (n=3) of each material were cured twice for 3 seconds using the Bluephase PowerCure curing light in 3s-curing mode that delivered an irradiance of approximately 3000mW/cm^2.

Results:



Translucency shift/Power transmission during 2 x 3s curing of Tetric plus Flow (a), Tetric PowerFlow (b), Tetric plus Fill (c) and Tetric PowerFill (d)

Summary:

The diagrams show the average power transmitted through the 4-mm specimens i.e. the amount of light transmission during the 3 second exposure periods. As would be expected, more light is transmitted initially through the two flowable materials. This transmission however undergoes a considerable reduction within the first 3 seconds. The reduction is most marked with Tetric plus Flow. Both Tetric plus products and Tetric Power Flow transmit more light at the beginning of light exposure and all then undergo a marked reduction in light transmission. This is not the case for Tetric PowerFill.

Conclusion:

The translucency shift in both Tetric plus materials is marked from the outset. The materials move from a translucent to a more opaque state.

In contrast, investigations comparing other composites showed that most materials became more translucent during polymerization.

Reference: Price (2024a)

Translucency shift in Tetric plus Fill & Tetric plus Flow: Part II – Beam profiles

Study location: Dalhousie University, Nova Scotia, Canada
Study release: February 2024
Study author(s): R. Price

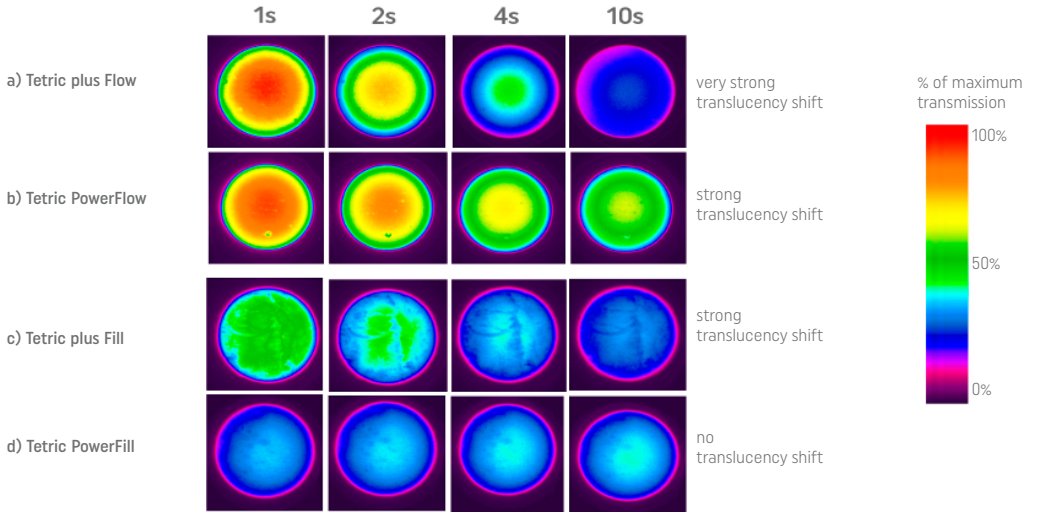
Objective:

To investigate the translucency shift during polymerization of Tetric plus Fill and Tetric plus Flow, compared to the 4-mm composites Tetric PowerFill and Tetric PowerFlow respectively.

Method:

4-mm thick composite specimens of each material were cured using the Bluephase PowerCure curing light in 3s-curing mode which delivered an irradiance of approximately 3000mW/cm^2. Transmitted light was measured in real time and the results were reported after 1, 2, 4 and 10s of light exposure. The colours show the percentage drop in light transmission over time, with red representing the highest transmission and violet the lowest.

Results:



Changing beam profiles indicating translucency shift during polymerization from 1-10 seconds

Summary:

The beam profiles correlate with the light transmission graphs shown in Part I of this investigation. The translucency shift (red (left) to blue/green(right) colours) in the flowable materials (with a higher monomer content) is, as would be expected, more marked than in the sculptable materials. Tetric plus Flow is the composite that shows the strongest translucency shift from translucent to opaque during polymerization.

Conclusion:

The translucency shift in both Tetric plus materials (from a higher to a lower transmission of light), is marked from the outset. The materials move from a highly translucent state to a more opaque state. This technology combines high curing depths and high esthetics, as high translucency facilitates the deep penetration of light within the uncured material and final low translucency is esthetically advantageous in the cured composite material.

Reference: Price (2024b)

Tetric plus Fill: Comparison of composite translucency after curing

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

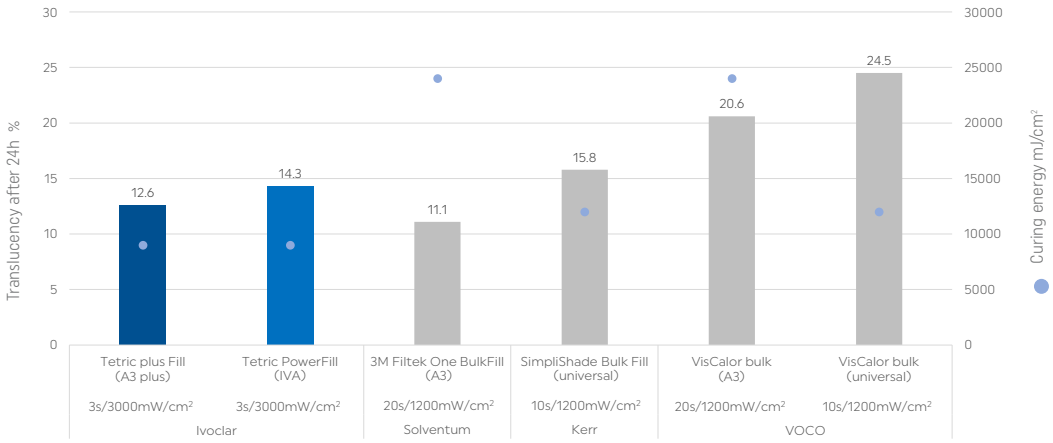
Objective:

To investigate differences in translucency between Tetric plus Fill and similar sculptable products with curing depths of up to 4 mm.

Method:

Materials were applied to round (Ø 20 mm, 1 mm high) steel moulds and cured according to their respective instructions for use. Translucency was measured using a spectrophotometer CM-5 before curing, directly after curing and following 24h water storage at 37°C. Post storage values are shown below. Tetric plus Fill and Tetric PowerFill were cured for 3s using the Bluephase PowerCure at 3000 mW/cm², illustrated via the blue dot representing total curing energy for the time cured – at 9000 mJ/cm². All curing procedures are shown in the graph.

Results:



Translucency (after 24h) of Tetric plus Fill compared to other direct restoratives with up to 4-mm curing depths

Summary:

Whereas high translucency is useful prior to curing in terms of light penetration to deeper areas, after curing the translucency should be high enough to allow chameleon effects but not so high that underlying tooth discoloration affects the final esthetics. The bulk fill sculptable materials tested showed differing levels of translucency post-polymerization and after differing curing-energy exposure. Tetric plus Fill has a relatively low translucency at 12.6% which is slightly lower than Tetric PowerFill which can also be cured in 3s. In this experiment the Ivoclar products received the lowest amount of total curing energy.

Conclusion:

In comparison to the other sculptable 4-mm materials, Tetric plus Fill was the only product that achieved a post-polymerization translucency similar to that achieved with conventional 2-mm layering composites together with short curing times and low overall curing energies (3s curing method, at a light intensity of 3000 mW/cm² :●). In contrast 3M Filtek One BulkFill Restorative/Solventum exhibited lower translucency but required far higher curing energy.

Reference: Bielec (2024a)

Translucency shift in Tetric plus Flow: Product comparison

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Schroll

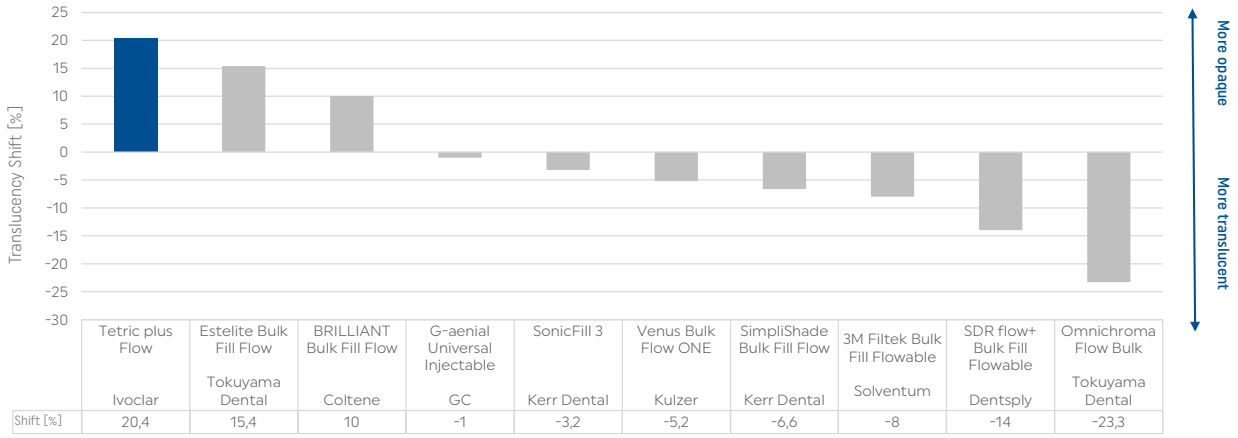
Objective:

To investigate the translucency shift after polymerization of Tetric plus Flow compared to other flowable bulk composites.

Method:

Materials were applied to round (Ø 20 mm, 1 mm high) steel moulds and cured according to their respective instructions for use. Translucency was measured using a spectrophotometer CM-5 before curing and directly after curing. All values (unpolymerized and polymerized) were measured through a glass plate. Shift values were calculated by subtracting the post polymerization translucency values from the pre-polymerization values.

Results:



	Tetric plus Flow Ivoclar	Estelite Bulk Fill Flow Tokuyama Dental	BRILLIANT Bulk Fill Flow Coltene	G-aenial Universal Injectable GC	SonicFill 3 Kerr Dental	Venus Bulk Flow ONE Kulzer	SimpliShade Bulk Fill Flow Kerr Dental	3M Filtek Bulk Fill Flowable Solventum	SDR flow+ Bulk Fill Flowable Dentsply	Omnichroma Flow Bulk Tokuyama Dental
Shift [%]	20,4	15,4	10	-1	-3,2	-5,2	-6,6	-8	-14	-23,3

Translucency shift from pre to post curing of various bulk flowable materials

Summary:

The diagram shows the translucency shift that occurs during curing, a positive value denotes a move to less translucency i.e. more opacity. A negative value denotes an increase in translucency post-curing. As with Tetric plus Fill, whereas high translucency is useful prior to curing, in terms of light penetration to deeper areas, after curing, the translucency should be high enough to allow chameleon effects but not so high that underlying tooth discoloration can affect final esthetics. The materials tested showed very different translucency shifts post polymerization.

Conclusion:

The translucency shift in Tetric plus Flow shows the most marked shift towards opacity. Only two other products of this type also increase in opacity with the others becoming more translucent post-polymerization. Increased opacity safeguards esthetics. As with Tetric plus Fill, this technology combines high curing depths and high esthetics - as high translucency facilitates the deep penetration of light within the uncured material and final low translucency is advantageous esthetically in cured material.

Reference: Schroll (2024a)

In vitro Investigations: QUALITY

Flexural strength of two fast-curing, sculptable and flowable composites: Tetric plus Fill and Tetric plus Flow

Study location: University Clinic, Ludwig Maximilians University, Munich, Germany
Study release: January 2024
Study author(s): N. Ilie

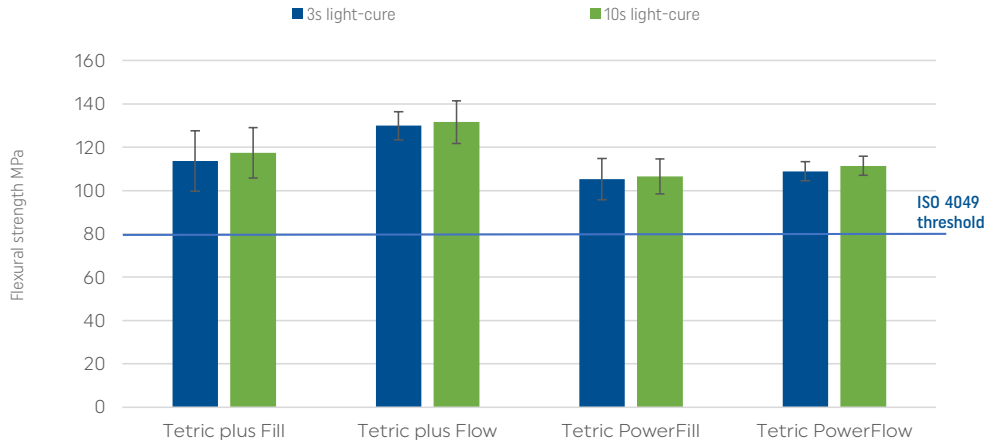
Objective:

To evaluate the flexural strength of two new fast-curing bulk-fill composites under two different curing conditions and compare these results to those with the established bulk composites, Tetric PowerFill and Tetric PowerFlow.

Method:

A three-point bending test according to ISO 4049, was carried out on 160 composite specimens divided up amongst the 4 product groups and 2 light-curing scenarios. Beams were prepared (2 mm x 2 mm x 25 mm) and cured with the Bluephase PowerCure light for either 3s in 3sCure mode or 10s in High power mode. The mean flexural strength was determined for the groups, using a universal testing machine to fracture at a crosshead speed of 0.5 mm/min.

Results:



Mean flexural strength of Tetric plus and Tetric Power composites when cured for 3 or 10 seconds

Summary:

The flexural strength of the Tetric plus products was higher than the established sculptable and flowable Tetric Power products for both curing regimens. One way ANOVA statistical testing found Tetric plus Flow had statistically significantly higher flexural strength ($p<0.001$) than all other products in both curing groups. Tetric plus Fill also had significantly higher flexural strength than the other sculptable product Tetric PowerFill.

Conclusion:

All products exhibited flexural strength values well in excess of the ISO 4049 standard minimum requirement of 80 MPa. The choice of curing mode (3s vs. 10s) showed no significant effect on flexural strength.

Reference: Ilie (2024)

Flexural modulus of Tetric plus Fill & Tetric plus Flow

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

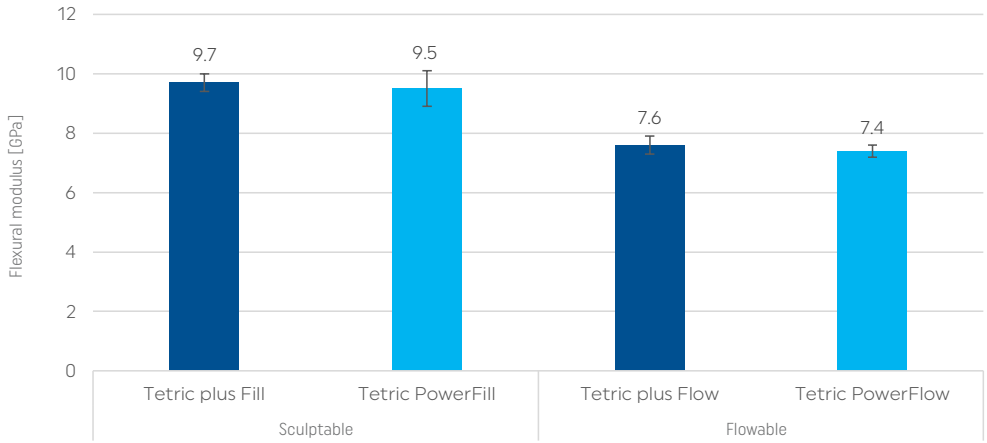
Objective:

To establish the flexural modulus of Tetric plus Fill and Tetric plus Flow in comparison to the comparable established Ivoclar bulk composites Tetric PowerFill and Tetric PowerFlow.

Method:

The mean flexural modulus was measured via 3-point flexural testing with a ZWICK universal testing machine. The materials are pressed into moulds and cured through a glass plate according to the instructions for use in 3s mode (ISO4049:2019). After water storage at 37°C for 24 hours, the flexural modulus was tested and calculated.

Results:



Mean flexural modulus in the Tetric plus and Tetric Power composites after curing in 3s mode.

Summary:

In dental composites the flexural modulus indicates stiffness and how prone a material is to deformation. A higher value denotes strength but too high can mean a tendency to fracture. A lower value indicates more flexibility which may absorb stress/shrinkage better but too low can mean a lack of strength or excessive wear. Natural dentin exhibits levels between 10–30 GPa (Kinney 2003). Tetric plus Fill and Flow exhibit slightly higher (stronger) values than the established bulk products Tetric PowerFill and Tetric PowerFlow, respectively.

Conclusion:

Both Tetric plus Fill and Tetric plus Flow exhibit reliable flexural modulus values at approximately 10 GPa and 8 GPa respectively – when cured in the 3s/3000 mW/cm² mode. The values are slightly higher than those of the predecessor Tetric Power products when cured in the same way.

Reference: Bielec (2024b)

Quantitative margin analysis of Tetric plus Flow in Class V restorations after different light-curing times

Study location: Charité-Universitätsmedizin Berlin, Germany
Study release: September 2023
Study author(s): U. Blunck

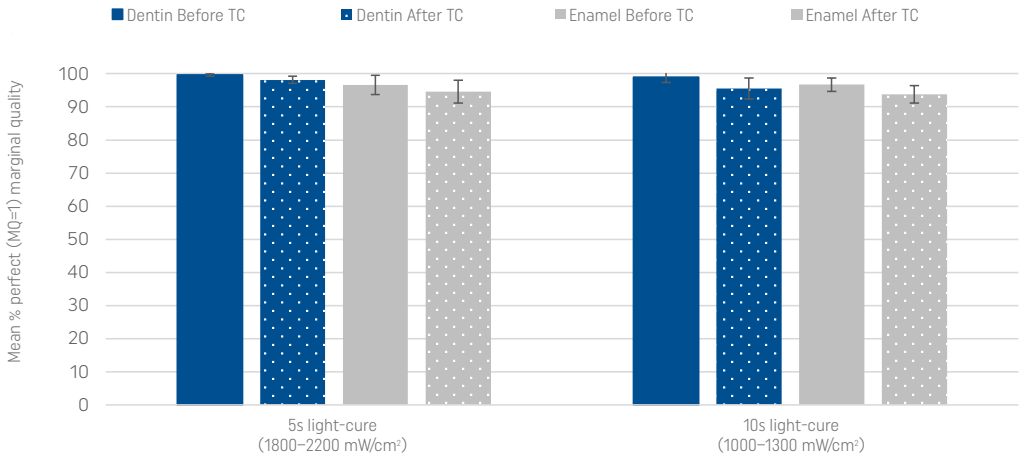
Objective:

To evaluate the effect of different light-curing times on the marginal adaptation of Tetric plus Flow restorations in Class V cavities.

Method:

16 oval-shaped cavities approx. 4 mm high, 3 mm wide and 1.5 mm deep were prepared in extracted, caries-free human teeth with a diamond bur. All cavities were filled with Tetric plus Flow using Adhese Universal in self-etch mode. Two groups were formed (n=8) whereby one group was light-cured for 5s in Turbo (1800–2200 mW/cm²) mode and the other for 10s in High (1000–1300 mW/cm²) power mode, using the Bluephase PowerCure light. After finishing and polishing, the teeth were stored in water for 21 days. Silicone impressions were made before and after thermocycling (2000 cycles between 5°C and 55°C) with which replicas were made for analysis of the surface quality. Margins were examined using a scanning electron microscope (200x) and marginal quality (MQ) was evaluated according to a 1–4 scale with 1 representing perfect continuous margins with no marginal gaps observable and 4 representing e.g. large marginal gaps of >2 µm. The mean values for MQ1 are shown below.

Results:



Mean percentage perfect marginal adaptation in Tetric plus Flow/Adhese Universal Self-Etch restorations when cured for 5 or 10 seconds.

Summary:

As would be expected, all values were slightly reduced after thermocycling (TC). Kruskal Wallis tests were conducted to establish significance and no statistically significant difference in the quality of the margins in dentin or enamel was found for either the 5s or 10s-cure group. After thermocycling, mean values were slightly higher in the 5s cure group for dentin and enamel, but not significantly so.

Conclusion:

It can be concluded that Tetric plus Flow in combination with Adhese Universal provides for effective marginal adaptation in both dentin and enamel in Class V restorations – independent of the light-curing time.

Reference: Blunck (2023)

Marginal integrity of Tetric plus Fill and Tetric plus Flow restorations in primary and permanent teeth with conventional and simplified curing protocols

Study location: Centre for dentistry, University of Zurich, Zurich, Switzerland
Study release: April 2024
Study author(s): T. Attin, B. Hamza, T. Tauböck

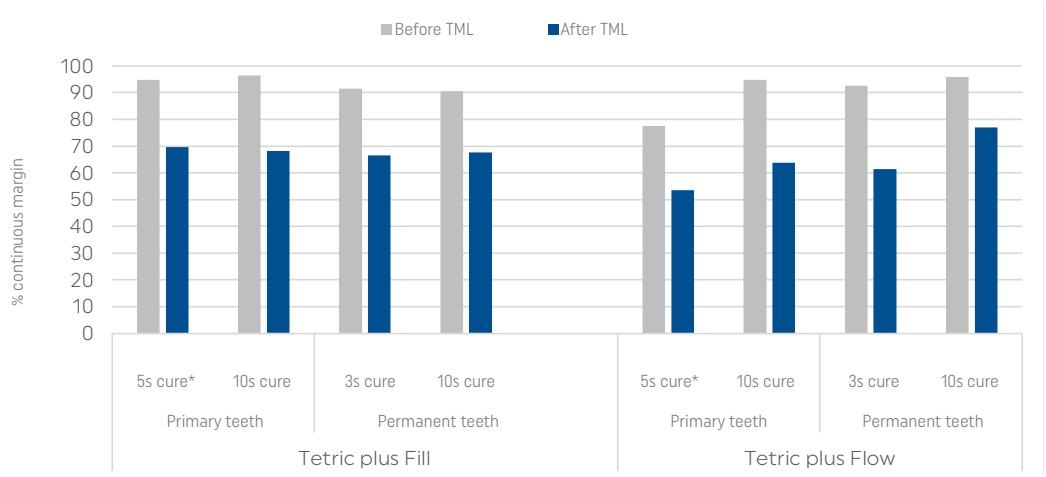
Objective:

To investigate the marginal integrity of Tetric plus Fill and Tetric plus Flow restorations – light cured with conventional and simplified (shorter) protocols in primary and permanent molars.

Method:

Standardized Class II cavities were prepared on the sound proximal surface of 40 primary and 40 permanent extracted human molars. All non-beveled cavity margins ended within enamel. Molars were randomized into eight groups (n=10) – split by type of molar (primary or permanent), composite (sculptable or flowable) and curing mode (simplified/shorter or conventional). The shorter curing mode involved 3s/3000mW/cm² curing for permanent teeth and 5s/2000mW/cm² in primary molars. Conventional curing was always for 10s/1200mW/cm². Adhese Universal adhesive was applied in self-etch mode to all teeth. Primary teeth received one 3-mm layer of either composite and permanent teeth received one 4-mm layer of the sculptable material or 2 mm of the flowable topped with 2 mm of the sculptable. Composites and adhesives were cured using Bluephase PowerCure, in the same manner according to the group. Fillings were finished, polished with Sof-Lex discs/3M Espe and stored in 37°C tap water for 7 days. Silicone impressions were made before and after thermomechanical loading (TML), with which replicas were made for SEM marginal analysis.

Results:



Mean percentage perfect margins for each experimental group. *5s curing not indicated for primary teeth

Summary:

There was no difference in marginal integrity between primary/permanent molars, with the same material and curing protocol, before and after TML. Before TML and in primary molars, the marginal integrity of Tetric plus Flow was statistically significantly higher with conventional light curing. After TML, no marginal difference was found between curing protocols within the same molar type and material. No difference in marginal integrity was found between Tetric plus Fill and Tetric plus Flow, within the same curing protocol and molar type, before and after TML.

Conclusion:

After thermo-mechanical loading, Tetric plus Fill and Tetric plus Flow achieve similar marginal integrity when used in primary and permanent molars, regardless of light-curing protocol.

Reference: Attin (2024)

Polishability of Tetric plus Fill & Tetric plus Flow: Product comparison

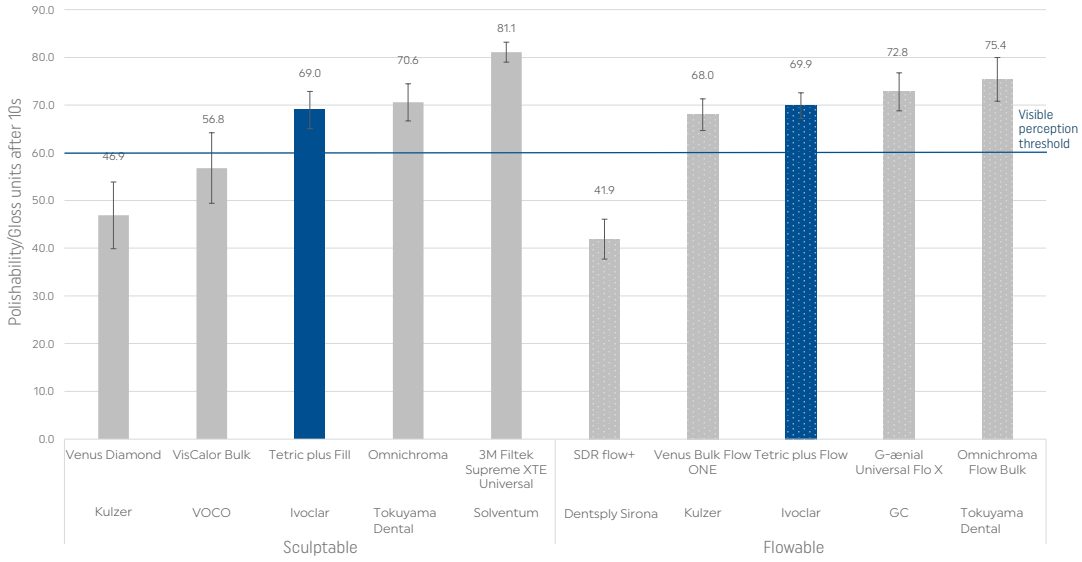
Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

Objective:

To investigate the polishability of Tetric plus Fill and Tetric plus Flow with respect to comparable products.

Method:

Eight samples each of Tetric plus Fill & Tetric plus Flow and various other sculptable and flowable composites (all in A3 or universal shades) were prepared as 1 cm diameter 6 mm high discs. Materials were cured from below and above for the time and intensity indicated in the respective instructions for use (shortest times). After dry storage at 37°C for 24 hours, samples were roughened with 320 grit abrasive paper. Samples were polished with OptraGloss Lens HP for 10s each at a standardized pressure of 2 N at 10,000 rpm under water cooling. The surface gloss was then determined with a Novo-Curve gloss meter.



Gloss units after 10 seconds of polishing with sculptable and flowable composites

Summary:

Both Tetric plus materials exhibited good surface gloss – at near to 70 gloss units (GU) after 10s polishing. It is also generally accepted that most values beyond 60 GU are not visible to the naked eye.

Conclusion:

Polishing and final surface roughness represent a critical step in direct restorative treatment, with a pleasing gloss decisive for esthetic appearance and smooth surfaces less conducive to plaque accretion. Both products polish well within a short space of time (10s) and comparably to similar composites.

Reference: Bielec (2024c)

Surface roughness of Tetric plus Fill & Tetric plus Flow: Product comparison

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

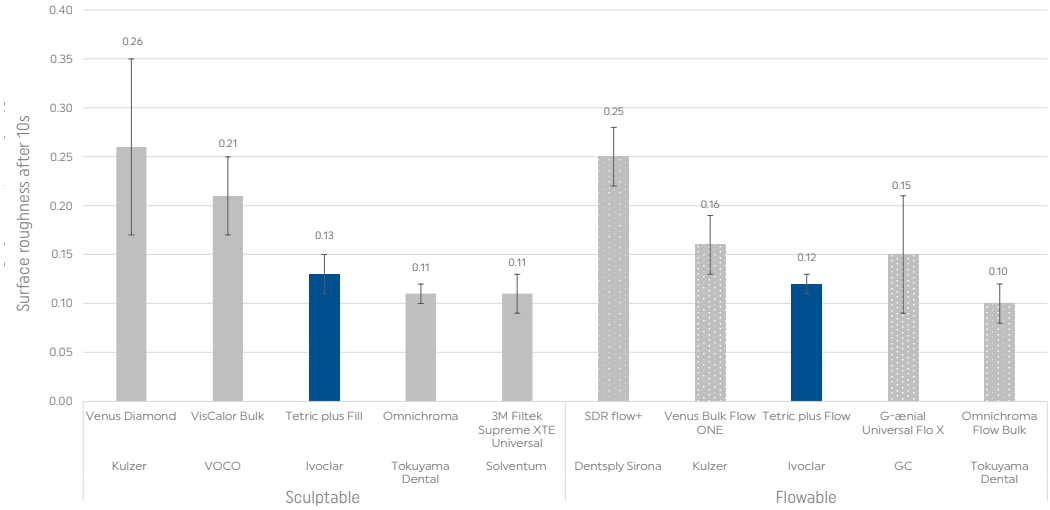
Objective:

To investigate the surface roughness of Tetric plus Fill and Tetric plus Flow with respect to comparable products This was conducted as a second measurement, as part of the previous polishability investigation.

Method:

Eight sample discs (1 cm Ø / 6 mm high) each, of Tetric plus Fill, Tetric plus Flow and various other sculptable and flowable composites (all in A3 or universal shades) were prepared. Materials were cured from below and above for the time and intensity indicated in the respective instructions for use (shortest times). After dry storage at 37°C for 24 hours, samples were roughened with 320 grit abrasive paper. Samples were then polished with OptraGloss Lens HP for 10s each at a standardized pressure of 2 N at 10,000 rpm under water cooling. The surface roughness Ra was measured with an FRT MicroProf measuring device and surface gloss was determined with a Novo-Curve gloss meter. The lower the surface roughness, the better the polishability of the material. A mean surface roughness of <0.1 µm indicates very good polishability, <0.2 µm suggests good polishability, a value between 0.2 – 0.4 µm corresponds to a medium polishability, and >0.4 µm suggests poor polishability.

Results:



Surface roughness after 10 seconds of polishing with sculptable and flowable composites

Summary:

Both Tetric plus materials exhibited good (low) values for surface roughness after only 10s polishing. The standard deviations were also within the standard deviations at the same level as the products with the best results.

Conclusion:

Polishing and final surface roughness represent a critical step in direct restorative treatment, with a pleasing gloss decisive for esthetic appearance and smooth surfaces less conducive to plaque accretion. Both products exhibited low surface roughness after a short polishing time and performed comparably well with similar composites.

Reference: Bielec (2024d)

Light sensitivity of Tetric plus Fill and other sculptable composites

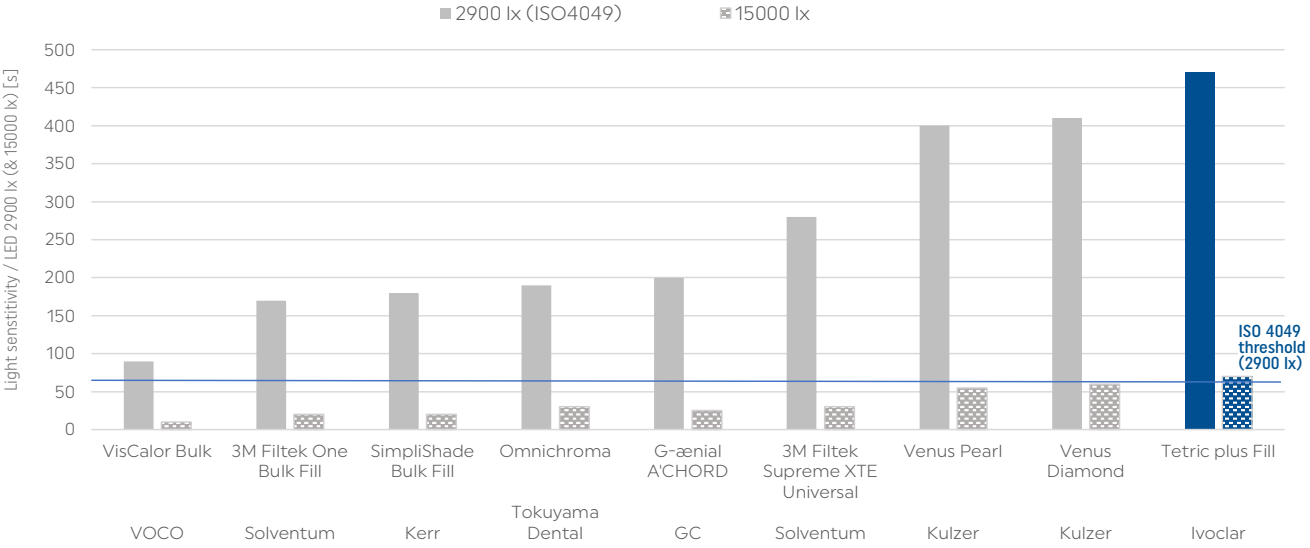
Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

Objective:

To establish the light sensitivity and therefore ease of handling (working time) with regard to the sculptability of Tetric plus Fill and comparable sculptable composites.

Method:

In dentistry, composite sensitivity to ambient light is tested according to ISO 4049 at a level of 2900 lx. 30 mg of each material is applied to a glass microscope slide and exposed to the light. If a material begins to set, discontinuities and voids appear in the specimen. The maximum exposure time, during which a material does not set/polymerize is measured.



Light sensitivity / working time until polymerization at an LED-illumination of 2900 ± 200 lx (and 15000 lx ± 200 lx)

Summary:

Tests were carried out with Tetric plus Fill and comparable sculptable products as sufficient working time is necessary to create cusps and natural tooth topography. Higher values indicate less sensitivity to ambient light. In particular with bulk composites, a balance between reliable depth of cure and good handling properties is necessary. Tetric plus Fill achieves both. The ISO standard gives a threshold of 60 lx [s], which all products exceed at 2900 lx [s]. As well as reliable curing at depth, Tetric plus Fill exhibits the least ambient light sensitivity of the group i.e. longest working time. The other 3 "bulk" products offer the least working time (left of diagram).

Conclusion:

Tetric plus offers the longest working time in this investigation when tested according to ISO 4049.

As the stipulated light level of 2900 lx has little to do with clinical reality however, Ivoclar also tests composites at a higher light level of 15,000 lx. The 15,000 lx value represents the realistic scenario of a dentist using e.g. dental loupes for optimum vision in an already relatively bright practice setting. Under these circumstances Tetric plus Fill elicited a working time of 70s which still exceeded the ISO threshold of 60s. The other materials polymerized more quickly (between 10 and 60s. This scenario, leaves the dentist with a choice of either poor visibility or little working time for modelling.

Reference: Bielec (2024e)

Shrinkage stress: Tetric plus Fill and other sculptable composites

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Schroll

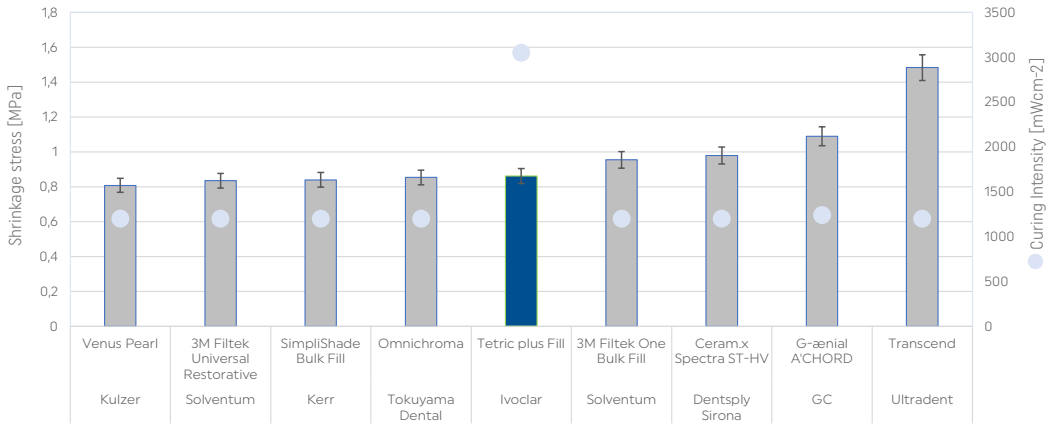
Objective:

To establish the levels of shrinkage stress when curing Tetric plus Fill, in comparison to other sculptable composites.

Method:

Shrinkage stress was established in various composites (shaded A3 or Universal) using a Bioman shrinkage force tester. A defined amount (0.2 g) of composite was placed between a metal cylinder and a glass plate and polymerized (using Bluephase PowerCure at various light intensities) through the glass plate. The tension detected on the force arm of the Bioman device is converted to an electrical signal by means of an amplified voltage display energy converter and recorded. The shrinkage force is divided by the contact area of the cylinder giving the shrinkage stress value. An average value via 2 tests per material was established.

Results:



Mean shrinkage stress in Tetric plus Fill and other sculptable composites

Summary:

With a shrinkage stress level of 0.86 MPa, Tetric plus Fill falls within a range that is typical for sculptable composites.

Conclusion:

Tetric plus Fill exhibits comparable shrinkage stress to other sculptable composite materials. Also when cured at a higher intensity as shown by the dots ● pertaining to the right hand vertical axis of the graph.

Reference: Schroll (2024b)

Polymerization shrinkage within Tetric plus Flow as shown via micro-CT

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Schroll

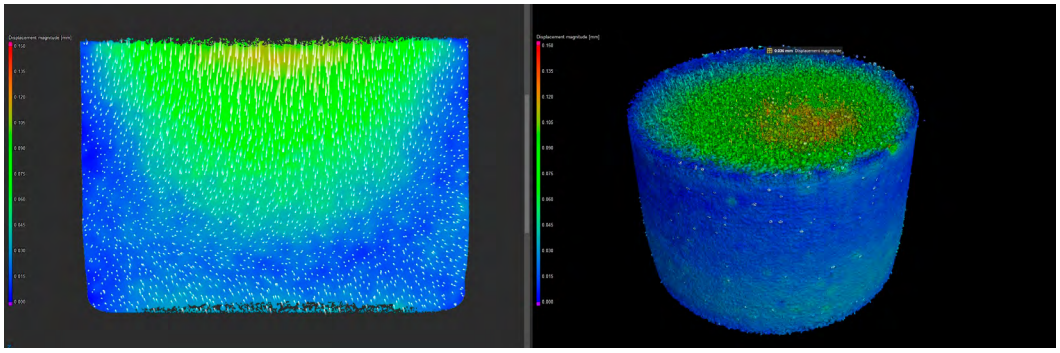
Objective:

To visualize the type and movement of stress within the flowable composite Tetric plus Flow

Method:

Tetric plus Flow was placed in a cavity mould (6 mm diameter and 4 mm height.) and polymerized with Bluephase PowerCure for 3s at 3000mW/cm². Micro-CT (X-ray micro-computed tomography) images were made showing the volumetric shrinkage process within the composite. In order to trace these composite-movements during polymerization, experimental Tetric plus Flow material was enriched with 2.5wt% ZrO_2-particles (45–63 µm). The material movements were then tracked and translated into a colour code, whereby blue indicated little movement, green moderate movement and red stronger movement. In general, movement translates to volumetric shrinkage.

Results:



Micro-CT images – visualizing the shrinkage process in Tetric plus Flow – Left: Cross section Right: Oblique view

Summary:

Shrinkage within Tetric plus Flow represents a worst case (compared to sculptable composites) scenario situation. Flowable composites are known in general to experience higher volumetric shrinkage and shrinkage stress than sculptable materials due to their higher monomer content.

The micro-CT images show that the highest movement/shrinkage occurs at the surface of the material (red colour) where it was exposed to light and not at the bottom or sides (blue colour). No separation from the cavity walls was observed.

Conclusion:

These images show that volume shrinkage occurs at the top of the cavity and not at the side or bottom. Importantly, no lifting off from the cavity walls or floor is seen. As a material that can be applied in increments of up to 4 mm shrinkage behaviour is unremarkable. It can also be concluded that Tetric plus Fill which in any case experiences lower (as a sculptable material) shrinkage behaves similarly or better in this regard.

Reference: Schroll (2024c)

In vitro Investigations: EFFICIENCY

Comparison of the degree of conversion with Tetric plus Fill and Tetric Prime

Study location: Dalhousie University, Nova Scotia, Canada
Study release: February 2024
Study author(s): R. Price

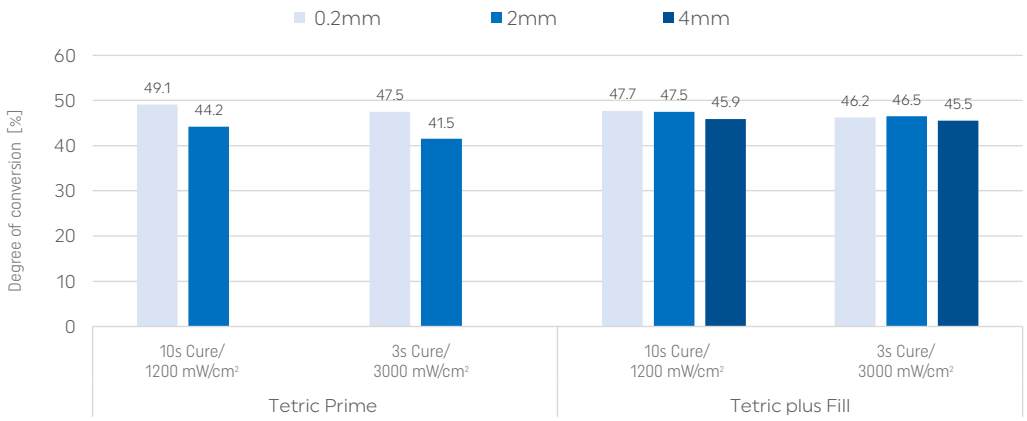
Objective:

To investigate the degree of double-bond conversion in the 4-mm composite Tetric plus Fill compared to the conventional 2-mm layering composite Tetric Prime.

Method:

The degree of conversion was measured using Fourier-transform infrared (FT-IR) spectroscopy. The absorption of infrared radiation is specific to the polymerized state of the material. Samples were prepared by packing the composites directly onto the attenuated total reflectance (ATR) attachment sensor on a Bruker Vertex 70 FT-IR spectrometer. Curing was carried out with Bluephase PowerCure for 10s in High Power mode or 3s in PowerCure mode. Using an external trigger, the spectrometer was programmed to collect data as soon as the curing light turned on. The degree of conversion was measured at depths of 0.2 mm and 2 mm in the conventional 2-mm composite Tetric Prime and in addition at 4-mm depth in Tetric plus Fill. Three specimens were made in each group. All measurements were calculated 720 seconds post curing.

Results:



Degree of conversion at various depths in Tetric Prime and Tetric plus Fill, with different curing protocols

Summary:

Both composites exhibited degree of conversion values between 40% and 50%. Double bond conversion values of 40% to 75% (depending on the matrix and technique) are common in direct restoratives (Peutzfeld 1997). Tetric Prime is a conventional layering composite that utilizes a standard photoinitiator system with camphorquinone. Tetric plus Fill is intended to be used in larger increments and utilizes the photoinitiator Ivocerin and camphorquinone. Tetric Prime is not intended to be used in large increments nor cured using a high irradiance for 3 seconds. The conversion values for Tetric Prime show a drop with increasing depth (0.2 to 2 mm) whereas this drop is far more gradual and less pronounced in the bulk product Tetric plus Fill (0.2 mm to 2 mm to 4 mm).

Conclusion:

Tetric plus Fill exhibits very similar degree of conversion values at 4 mm depth whether cured for 10s/1200mW/cm² or 3s/3000mW/cm². The degree of conversion in Tetric plus Fill is maintained up to a 4-mm depth no matter how it is cured.

Reference: Price (2024c)

Tetric plus Fill: Curing depth and esthetics

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Bielec

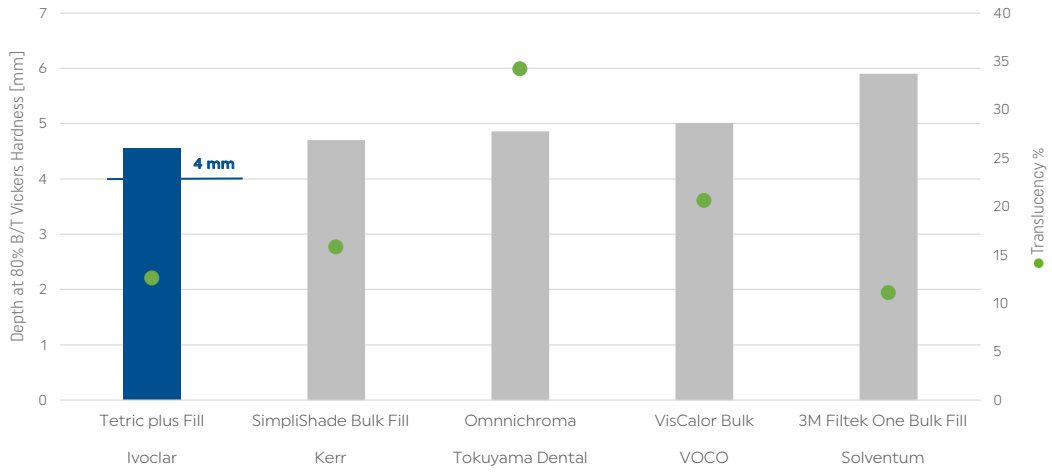
Objective:

To establish depth of cure via Vickers Hardness measurements through Tetric plus Fill.

Method:

Vickers hardness (VH) profiles are made using a square-diamond indentation device. Cylinders of the material are prepared in cylindrical moulds. Composite cylinders of Tetric plus Fill and other comparable sculptable, bulk materials were prepared, polymerized and then cut vertically into two pieces. VH measurements were taken at 0.5 mm intervals from the top to the bottom. VH is commonly expressed as a percentage of the surface hardness which is considered 100%. In a study by Professor David Watts of the University of Manchester, UK, an acceptable depth of cure was considered achieved when the bottom hardness corresponded to at least 80% of the surface hardness (Watts 1984). This value has become an accepted threshold for measuring and comparing depth of cure. In order to simulate a worst case scenario in terms of light penetration, the shortest possible curing times according to all instructions for use were chosen. Dark shades were also used: Tetric plus Fill in A3 plus and the closest A3 or universal shade for competitor products.

Results:



Depth of cure in sculptable, bulk fill composites – together with post-polymerization translucency

Summary:

The graph shows the deepest depth at which a cure (80% of the surface value) was met. All the materials exceeded 4 mm. Tetric plus Fill does not exhibit the highest depth of cure; however it achieves good 4-mm curing, alongside high esthetics. The green dots (right hand axis) show the translucency values post polymerization and storage in water at 37°C.

Conclusion:

The darker and/or more opaque a material is, the shallower the depth of cure, as less light can reach the initiators within the composite. Bulk products are therefore often very translucent – negatively affecting final esthetics or they require high levels of curing energy (e.g. 3M Filtek One Bulk Fill). Tetric plus Fill achieves both good depth of cure and esthetics (low final translucency) all at low curing energies – due to its optimized filler and light-initiator technologies enabling a marked translucency shift.

Reference: Bielec (2024f)

Tetric plus Flow: Curing depth and esthetics

Study location: R&D Department, Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): P. Schroll

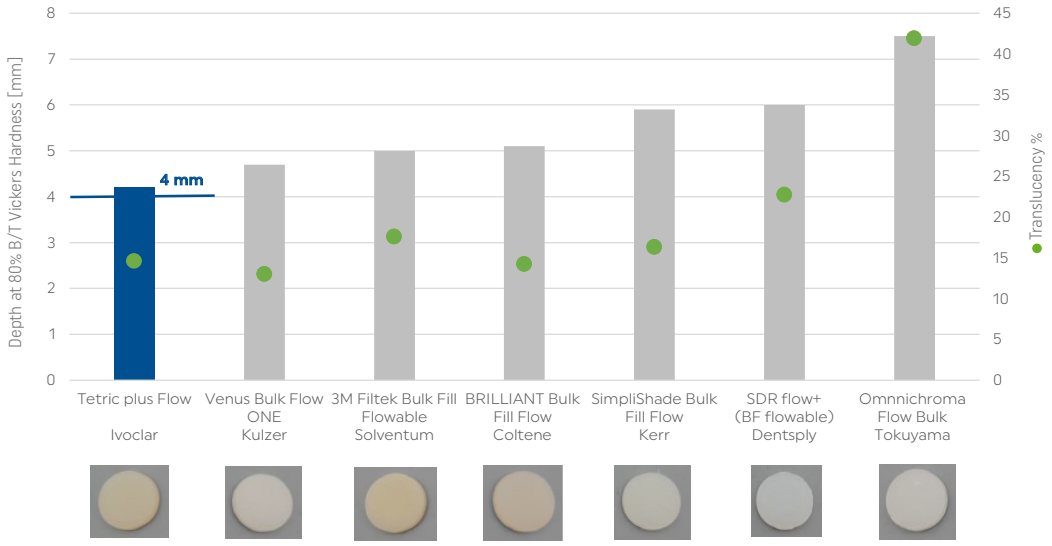
Objective:

To establish depth of cure via Vickers Hardness measurements through Tetric plus Flow.

Method:

Vickers hardness (VH) profiles are made using a square-diamond indentation device. Cylinders of the material are prepared in cylindrical moulds. Composite cylinders of Tetric plus Flow and other comparable flowable bulk materials were prepared, polymerized and then cut vertically into two pieces. VH measurements were taken at 1mm intervals from the top to the bottom. VH is commonly expressed as a percentage of the surface hardness which is considered 100% An acceptable depth of cure was considered achieved when the bottom hardness corresponded to at least 80% of the surface hardness. (Watts 1984). This value has become an accepted threshold for measuring and comparing depth of cure. In order to simulate a worst case scenario in terms of light penetration, the darkest shade (A3.5 plus) of Tetric plus Flow was chosen and the closest A3 or universal shade of the other products.

Results:



DoC in flowable, bulk fill composites shown together with shade and post-polymerization translucency

Summary:

The graph shows the deepest depth at which a cure (80% of the surface value) was met. All the materials exceeded 4 mm. Tetric plus Flow does not exhibit the highest depth of cure, however similarly to Tetric plus Fill, it achieves good curing up to 4 mm alongside high esthetics. The green dots (right hand axis) show the translucency values post polymerization and 37°C water storage.

Conclusion:

The darker and/or more opaque a material is, the shallower the depth of cure, as less light can reach photoinitiators within the composite. Bulk products are therefore often very translucent – negatively affecting final esthetics. Tetric plus Flow achieves both good depth of cure up to 4 mm and esthetics (low enamel like translucency and high chroma) due to its optimized curing and filler technologies. It is also the only flowable on the market to achieve this together with short 3s curing times.

Reference: Schroll (2024d)

In vivo Investigations

Clinical evaluation of Tetric plus Flow for treating Class V non-carious lesions. A prospective randomized, double-blind, split-mouth study: 1 month results

Study location: Dental Clinic, R&D Ivoclar, Schaan, Liechtenstein
Study release: July 2024
Study author(s): C-S. Pentelescu

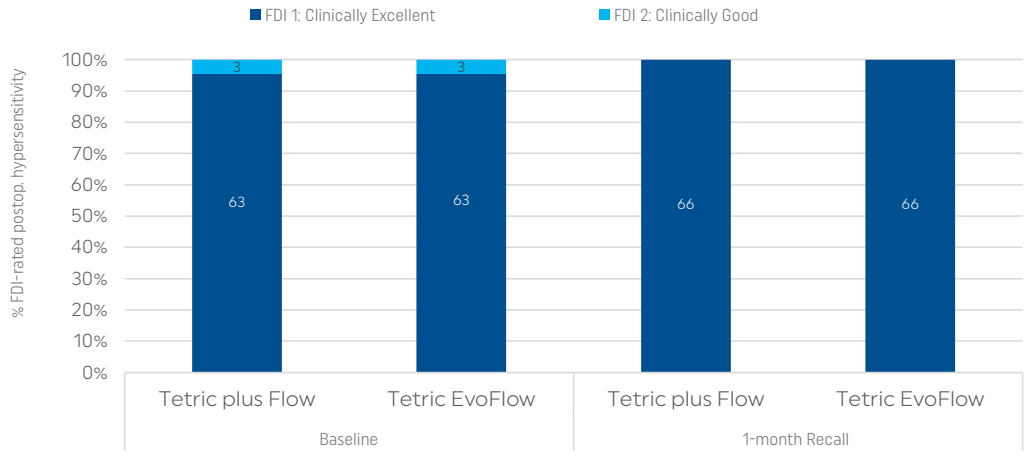
Objective:

To evaluate and compare the long-term clinical effectiveness of using Tetric plus Flow to treat non-carious cervical (Class V) lesions (NCCL) and the incidence of postoperative sensitivity (POS) in the short term.

Method:

66 patients aged 18–65, with regular sensitivity were treated according to split-mouth design. Two teeth per patient were treated. Test group teeth received one Tetric plus Flow restoration in layers of up to 4 mm (3.5 mm for shade A3.5 plus) and control group teeth received one Tetric EvoFlow filling in layers of up to 2 mm. Adhese Universal was used in the total-etch mode for all restorations and all filling layers were cured for 5s using the Bluephase PowerCure in Turbo mode/2000mW/cm^2. Restorations (n=132) were assessed according to selected FDI criteria at baseline (7–10 days post placement) and after 1 month. A visual analogue scale (to measure thermal and biting sensitivity) informed the FDI values for POS.

Results:



Postoperative hypersenstivity (n=66) at baseline & after 1 month in Class V Tetric plus Flow restorations

Summary:

Baseline and 1-month results are available from this 5-year investigation. The incidence rate for POS was the same in both groups at baseline. 63 of the 66 teeth (95.5% per group) were rated FDI 1 and the rest FDI 2 i.e. clinically excellent or good, respectively. Any sensitivity (FDI 2) subsided in both groups with all 66 (100%) rated clinically excellent (FDI 1) after 1 month. All other FDI parameters (e.g. surface lustre, vitality, fracture at margins and patient view), also demonstrated 100% FDI 1 or 2 (clinically excellent or good) scores at baseline and after 1 month.

Conclusion:

Both products performed effectively in treating non-carious cervical lesions and no treatment-associated sensitivity was reported after 1 month.

Reference: Pentelescu (2024a)

Clinical performance of rapidly-cured, bulk restorations with Tetric plus Flow + Tetric plus Fill in Class I/II cavities. Part I: FDI criteria evaluation of baseline and 1-month results

Study location: Dental Clinic, R&D Ivoclar, Schaan, Liechtenstein
Study release: October 2024
Study author(s): C-S. Pentelescu, L. Enggist

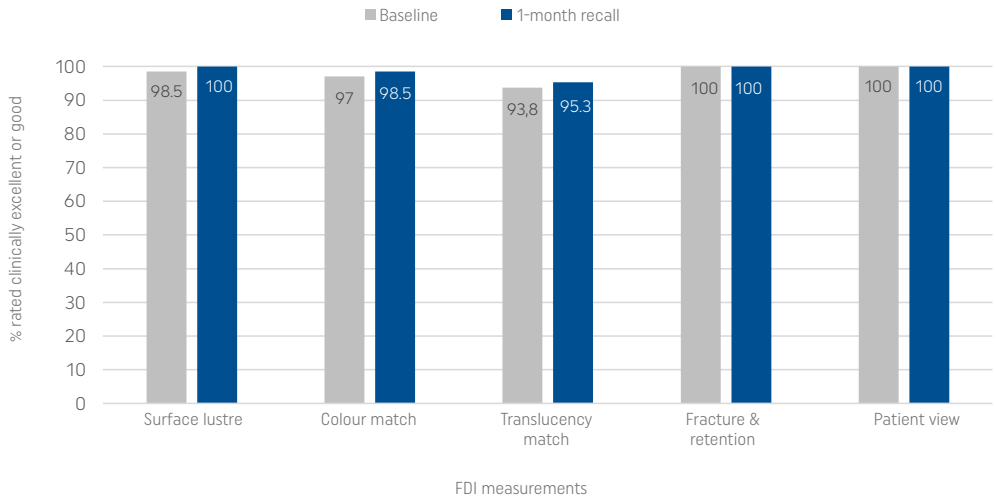
Objective:

To evaluate the clinical safety and performance of Tetric plus Fill in combination with Tetric plus Flow, for treating Class I and II cavities – in a prospective single-arm study.

Method:

65 restorations were placed in the vital premolars (n=16) and molars (n=49) of 65 patients aged between 18 and 65. 58% of patients were men, 42 % women and the majority (76%) were treated for secondary caries. After enamel etching for 30s and dentin for 15s, Adhese Universal/Ivoclar was applied and light cured for 3s at 3000 mW/cm². A first layer of ≤ 4 mm Tetric plus Flow was applied and cured for 3s, followed by a capping layer of Tetric plus Fill which was modelled and cured for 3s. Restorations were finished and polished with OptraGloss instruments. Treated teeth were matched to VITA shades (A1–C2), which were then allocated the most appropriate flowable/sculptable Tetric plus shade. A1 plus and bleach shades did not feature and some received a different sculptable to flowable shade. Restorations were assessed according to selected FDI criteria at baseline (7–10 days post placement) and after 1 month.

Results:



% FDI characteristics rated 1 or 2, at baseline (n=65) and after 1 month (n=64), in Tetric plus restorations

Summary:

At baseline all the FDI characteristics were rated overwhelmingly as clinically excellent or good (FDI 1 +2) and even more so after 1 month. Very few teeth received FDI 3 ratings and none lower. Surface lustre improved after 1 month (all FDI 1 + FDI 2 and no FDI 3), however a few cases lost some lustre (rated FDI 2 rather than FDI 1) – mostly in cases with extremely high initial gloss. All patients reported complete treatment satisfaction to date.

Conclusion:

Tetric plus Flow & Tetric plus Fill fillings, polymerized in 3sCure mode, proved safe and performed well in Class I and II restorations at baseline and after 1 month.

Reference: Pentelescu (2024b)

Clinical performance of rapidly cured bulk restorations with Tetric plus Flow + Tetric plus Fill in Class I/II cavities. Part II: Postoperative hypersensitivity

Study location: Dental Clinic, R&D Ivoclar, Schaan, Liechtenstein
Study release: October 2024
Study author(s): C-S. Pentelescu, L. Enggist

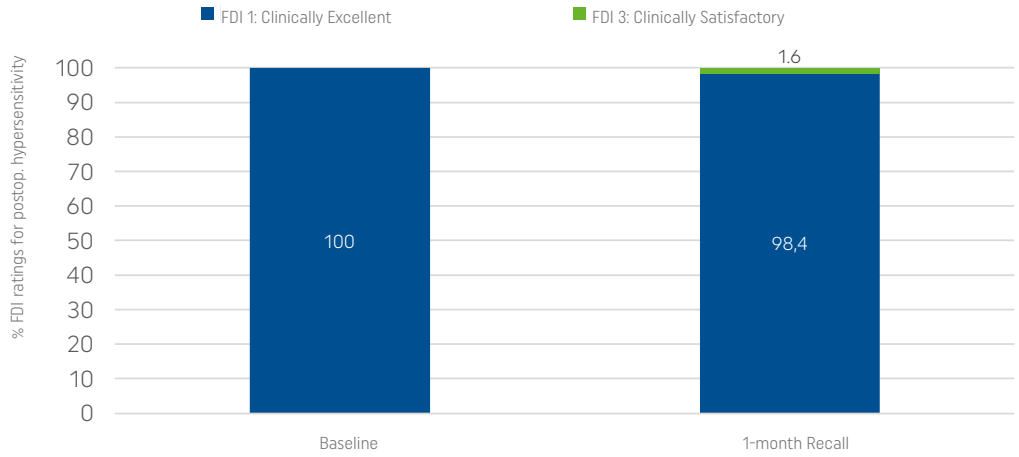
Objective:

To evaluate the occurrence of postoperative hypersensitivity (POS) in Tetric plus Fill in combination with Tetric plus Flow, for treating Class I and II cavities – in a prospective single-arm study.

Method:

65 restorations were placed in the vital premolars (n=16) and molars (n=49) of 65 patients aged 18-65 years. The restorations were placed as described in the previous study summary Part I. Restorations were assessed according to selected FDI criteria at baseline (7-10 days post placement) and after 1 month. A visual analogue scale (VAS to measure thermal and biting sensitivity) informed the FDI values for assessing postoperative sensitivity. FDI grades 3-5 were considered indicative of POS as grade 1 indicates no problem and grade 2 subsides requiring no treatment.

Results:



Postoperative hypersensitivity ratings at baseline and after 1 month, in Tetric plus restorations

Summary:

65 patients were checked at baseline and 64 at the 1 month recall - (due to a medical issue, one patient could not be physically assessed but was interviewed by phone regarding symptoms). No POS was detected at baseline, with 100% of the restorations rated clinically excellent (FDI 1). Importantly the patient-reported VAS scores also decreased pre to post placement. After 1 month 98.1% were rated FDI 1 because one patient had begun to experience occasional light sensitivity on biting and was rated clinically satisfactory (FDI 3).

Conclusion:

A bulk flowable plus sculptable-cap restoration is considered the worst-case scenario regarding potential POS, due to the higher monomer content and therefore exotherm polymerization reaction of flowable composites. Only one patient (1.6%) reported mild POS after 1 month – whereby no intervention was desired.

Reference: Pentelescu (2024b)

Clinical experience with Tetric plus Flow + Tetric plus Fill restorations

Study location: Dental Clinic, R&D Ivoclar, Schaan, Liechtenstein
Study release: October 2023
Study author(s): C-S. Pentelescu, L. Enggist

Objective:

To evaluate the esthetic potential of combined Tetric plus Flow + Tetric plus Fill restorations in Class I / II cavities, in different shade combinations.

Method:

A clinical study was carried out with Tetric plus Flow and Tetric plus Fill as described in the previous two study summaries. Treated teeth were matched to VITA shades (A1-C2), which were then allocated the most appropriate flowable/sculptable Tetric plus shade. A1 plus and bleach shades did not feature in this investigation and some patients received a different sculptable to flowable shade. Examples of the esthetic results possible with the Tetric plus shades A2, A3 and A3.5 plus are shown below.

Results:

Summary:

Good clinical esthetics were possible with various combinations. In this investigation, no patients required the lighter A1 plus or bleach shades and most patients received a combination with A3 plus. The case row using Tetric plus Fill and Tetric plus Flow in shade A3.5 plus, shows a 6-month recall picture as the patient was unable to attend after 1-month*. Not all 6-month data is available. Esthetics remained good throughout.

Conclusion:

Good esthetic results were achieved with the Tetric plus shades. The Tetric plus composites offered quality and efficiency without sacrificing esthetics.

Reference: Pentelescu (2024c)

Biocompatibility

Biocompatibility can be defined as the ability of a substance/material to be in contact with a living system without producing an adverse effect. When developing new, products, Ivoclar strives to use well-established raw materials that have already proven safe in vivo – in order to minimize any biocompatibility risks from the outset..

Medical device standards

Medical devices are subject to very strict requirements, which are designed to protect patients and operators from any potential biological risks. ISO 10993 "Biological evaluation of medical devices" defines how the biological safety of a medical device is to be evaluated. Furthermore, dental medical devices are subject to ISO 7405 "Dentistry - Evaluation of biocompatibility of medical devices used in dentistry" and standard risk management requirements as set out in ISO 14971 "Medical devices – Application of risk management to medical devices". The product specific standard EN ISO 4049 "Dentistry – Polymer based restorative materials" also prescribes how composites should be investigated regarding water solubility – the main relevant physical property for dental composites. The biocompatibility of the Tetric plus materials was evaluated during development, according to these standards with a series of different tests plus literature and database searches.

Water solubility

The limit set by the standard EN ISO 4049 is ≤ 7.5 µg/mm³.

Tetric plus	Water solubility [µg/mm³]	ISO 4049 threshold [µg/mm³]
Tetric plus Fill	2.1 ± 0.7	≤ 7.5
Tetric plus Flow	0.5 ± 0.4	

Water solubility of Tetric plus materials. (R&D Ivoclar, Schaan, FL)

The water solubility values for both materials are way below the threshold stipulated by the standard.

Sensitivity

Like virtually all light-cured dental materials, the Tetric plus composites contain (di)methacrylates. These materials (notably in their uncured state) may cause sensitisation to methacrylates, which can lead to allergic contact dermatitis. Allergic reactions are very rare in patients but occur more frequently among dental staff who handle uncured material on a daily basis. Such reactions can be minimised or avoided by clean working conditions and avoiding skin contact with uncured material. It should be noted however that commercially available medical gloves do not provide effective protection against the sensitising effects of methacrylates. Tetric plus Fill and Tetric plus Flow should not be used in patients known to be allergic to any of their constituents.

Testing regime and summary

Various biocompatibility assessments were conducted with the Tetric plus materials including cytotoxicity (potential to damage cells) and genotoxicity (potential to damage/alter genetic material) tests. According to the data available and general world-wide use with highly comparable products, it can be concluded that the products do not cause adverse reactions when used in the oral cavity and in general that:

- Tetric plus Fill and Tetric plus Flow pose no cytotoxic concern
- Tetric plus Fill and Tetric plus Flow present no risks for acute, sub-acute, sub-chronic or chronic toxicity
- Tetric plus Fill and Tetric plus Flow do not induce adverse implantation effects
- Tetric plus Fill and Tetric plus Flow are not genotoxic
- Tetric plus Fill and Tetric plus Flow are not carcinogenic
- Tetric plus Fill and Tetric plus Flow do not harm the pulp or dentin
- Tetric plus Fill and Tetric plus Flow can cause irritation and sensitization in their unpolymerized state, however if used according to the instructions for use, health risks can be avoided

Conclusion

In view of the present data, today's level of knowledge and longstanding worldwide use with very similar products, it can be concluded that the Tetric plus composite materials do not pose a toxicological risk. Health risks for patients (and users) can reasonably be excluded and the benefits provided by the final products exceed any potential risks, provided they are used as intended – in a professional dental setting according to the instructions of use.

Definition of terms

Studies

Studies are conducted to forecast or examine the behaviour of materials when used for the intended application. Aspects of functionality, reliability, safety, compatibility or user-friendliness are often of most interest.

In vitro studies

In vitro means "in glass". These examinations are conducted in a laboratory outside of their normal biological context. Many materials science or toxicological tests are carried out in vitro since they cannot be conducted on human beings for practical or ethical reasons. In vitro studies have the advantage that researchers can work under standardized conditions, and they are often quicker and less expensive than in vivo studies.

In vivo (clinical) studies

In vivo means "in the living object." Such studies are carried out within the biological context i.e. for dentistry – in human beings usually at a dental practice. The advantage is that results are more meaningful as the investigations are conducted under real conditions. They are however complex due to a wealth of possible influencing factors. They require exact planning, systematic methods, ethical permission and statistically correct evaluation. Randomized controlled studies are considered the gold standard.

Prospective study

A study planned to be conducted in the future in order to test a certain hypothesis, such as material A is as good as or superior to material B. After preparation of a test plan, the patients are recruited, and the material used. The test subjects are observed over a certain period of time and the results are subsequently compared and evaluated.

Retrospective study

Analysis of data collected in the past. For example - all cases of bridge fractures that occurred in a dental office are examined to find out if the fractures happen more frequently with one material rather than with another.

Dental, Material & Curing terms

Bulk application / Bulk Fill

Dental composites denoted as bulk fill are restorative materials that can be applied in thick increments i.e. typically in increments of up to 4 mm – sometimes more. Standard composites are traditionally applied in up to 2-mm increments. Bulk Fill materials are available in sculptable and flowable form depending on the manufacturer. Sculptable bulk fill composites can be applied in one layer, flowable composites typically require the additional application of a sculptable composite in order to create the natural tooth topography.

Cemento-Enamel Junction

Cementum is a calcified connective tissue covering the outer surface of the root of the tooth. It is covered by the mucous membranes/gums. It is a specialized connective tissue that shares physical, chemical, and structural properties of bone. The Cemento-Enamel Junction (CEJ) is therefore found in the "cervical" region of teeth, where the cementum meets the enamel of the emerging tooth.

Total Energy Concept

This refers to the basic concept that the process of light-induced polymerization is energy-dependent and basically a product of light intensity and curing time.

Curing Time (s) x Light Intensity [mW/cm²] = Total Energy

Light intensity/irradiance is best measured using an integrating sphere. The light emitted from a light guide is measured, determining the exact emissive power in mW. Appropriate filters ensure that only light in the effective wavelength range is measured and the light intensity in mW/cm² is calculated on the basis of the surface area of the light guide tip.

$$\frac{\text{Power [mW]}}{\text{Surface area [cm}^2\text{]}} = \text{Irradiance [mw/cm}^2\text{]}$$

The "Total Energy" concept holds that a curing time of e.g. 10 seconds at a light intensity/irradiance of 1000 mW/cm² results in a dose of 10,000 mWs/cm², as would (theoretically) a curing time of 1s at 10,000 mW/cm². Logically the higher the intensity of the curing light, the shorter the necessary curing time.

This concept is also implied by the term "energy reciprocity."

Clinical Evaluation Techniques for Restorations

Cvar and Ryge/USPHS Criteria

Cvar and Ryge (Cvar & Ryge 1971 and 2005), developed their much-used measurement scale over 40 years ago. This method of evaluation is interchangeably referred to as Cvar & Ryge criteria, Ryge criteria or USPHS criteria. The criteria were drawn up at a time when the longevity of direct restorative materials other than amalgam was limited, thus many modifications of these criteria have been made by various authors, in an attempt to make the criteria more discriminating for modern restorative materials. These are referred to as modified Ryge or modified USPHS criteria. Virtually every modification is slightly different (Hickel et al, 2007).

The criteria use the Alpha, Bravo, Charlie, Delta evaluation scale. These scores have different meanings depending on the criteria being assessed, however in general: Alpha = excellent/optimal, Bravo = acceptable, Charlie = unacceptable/insufficient and Delta = needs replacing.

FDI Criteria

Hickel et al as part of the FDI World Dental Federation Science Committee, published a paper in 2007 (Hickel et al, 2007) outlining a proposal for a more modern clinical evaluation of composite restorations. They present evaluation criteria in 5 levels from clinically excellent to poor. The levels are detailed below and how Hickel et al related these to the original Cvar and Ryge criteria. Various aspects of the FDI criteria were updated in 2010 (Hickel et al, 2010) and 2023 (Hickel et al, 2023)

Cvar & Ryge	FDI (Hickel et al)			
Alpha	Score 1	Clinically excellent / very good	Ideal	Sufficient
	Score 2	Clinically good	Not ideal	
Bravo	Score 3	Clinically satisfactory	Minor shortcomings	
Charlie	Score 4	Clinically unsatisfactory	Repairable	Partially insufficient
Delta	Score 5	Clinically poor	Need replacing	Entirely insufficient

Mechanical properties and in vitro tests

In materials science, there are numerous test methods to determine the mechanical properties of materials. The object of mechanical testing in dentistry, is to make estimates about the clinical efficacy of a material. Standard test methods, however, frequently test isolated stress conditions, whereas the effects on a material are much more complex in clinical reality. Nevertheless, materials science examinations in the laboratory do at least permit the comparison of different materials when tested in exactly the same way.

Depth of cure

Refers to how deep a composite material has been polymerised. The international standard ISO 4049 for polymer based restorative materials suggests measuring depth of cure via preparing cylindrical specimens 6 mm long and 4 mm wide, or if a depth of cure greater than 3 mm is claimed, the length should be at least 2 mm longer than twice the claimed depth of cure. After curing according to the manufacturer's instructions , the material is removed from its mould. The inhibition layer and other uncured material is scraped away, and the height of the remaining material is measured. This value divided by 2 is considered to be the depth of cure.

Flexural strength

Flexural strength refers to the ability of a material/composite to resist bending deflection when external energy is applied. As composites are under pressure from the conditions in the oral cavity and opposing dentition, they require a certain level of flexural strength. The ISO standard 4049: Polymer based restorative materials, requires 80 MPa. Flexural strength is often measured via bending tests carried out on specially fabricated beams of the material in question.

Hardness

The hardness of a material is the resistance of a material to penetration by another body. Various methods can determine hardness, such as Vickers, Knoop, Brinell and Rockwell. Hardness is often expressed as a percentage of the surface hardness which is considered 100%. It is generally accepted that an acceptable curing depth is achieved if the bottom hardness corresponds to at least 80% of the surface hardness.

Vickers Hardness: This test uses a diamond pyramid shaped indenter that is ground in the form of a squared pyramid with an angle of 136° between faces.

Knoop Hardness: This test uses a diamond elongated pyramid shaped indenter that is ground to an elongated pyramidal form that produces a diamond shaped indentation.

Bottom/Top Hardness Ratio: The bottom/top hardness ratio (B/T Hardness Ratio) is based on the premise that a composite is considered sufficiently cured if the bottom hardness (or the hardness at whatever depth you are investigating corresponds to at least 80% of the surface hardness (100%). Adequate depth of cure if:
Bottom Hardness/Top Hardness x 100 > 80

Flexural modulus (Modulus of elasticity)

For dental materials, flexural modulus and the tensile modulus (Young's modulus) are equivalent. It is a measure of a material's ability to transiently deform when a force is applied. It quantifies the relationship between stress (force per unit) and strain (proportional deformation) within the range where a material returns to its original shape after stress is removed. It is the ratio of stress **σ** to strain **ε**:

$$E = \frac{\sigma}{\varepsilon}$$

A high modulus of elasticity denotes inelasticity, and a low modulus of elasticity denotes higher elasticity. During curing, the modulus increases i.e. the material becomes stiffer.

The modulus of elasticity is important in dental materials in terms of resisting the stresses of the oral cavity and providing mechanical characteristics that do not differ too much from natural dentin and enamel.

Polymerisation Shrinkage

Polymerisation shrinkage refers to the shrinking of resin based composite restorations during and after polymerisation. When a composite is cured, monomer chains located on the fillers together with the silanes begin a cross-linking process – the composite "sets" via free radical polymerisation and the modulus of elasticity increases. Shrinkage is considered a potential problem as it could lead to poor marginal seal, marginal staining or caries. Volumetric shrinkage – refers to the reduction in actual volume of the placed restoration after polymerisation. Shrinkage stress – refers to the stress on the tooth or cavity walls due to the volumetric shrinkage. As composites are fixed to the tooth structure with adhesive, they cannot shrink freely during the shrinkage process, which puts a strain on the adhesive bond.

Thixotropy

Thixotropy is a time-dependent shear thinning property. Certain gels or fluids that are thick or viscous under static conditions will flow (become thinner, less viscous) over time when shaken, agitated, shear-stressed, or otherwise stressed (time-dependent viscosity). Thixotropy refers to the property of certain materials where their viscosity decreases under shear stress (such as when they are stirred or applied with pressure), and then recovers to a more viscous state when that stress is removed.

Literature

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