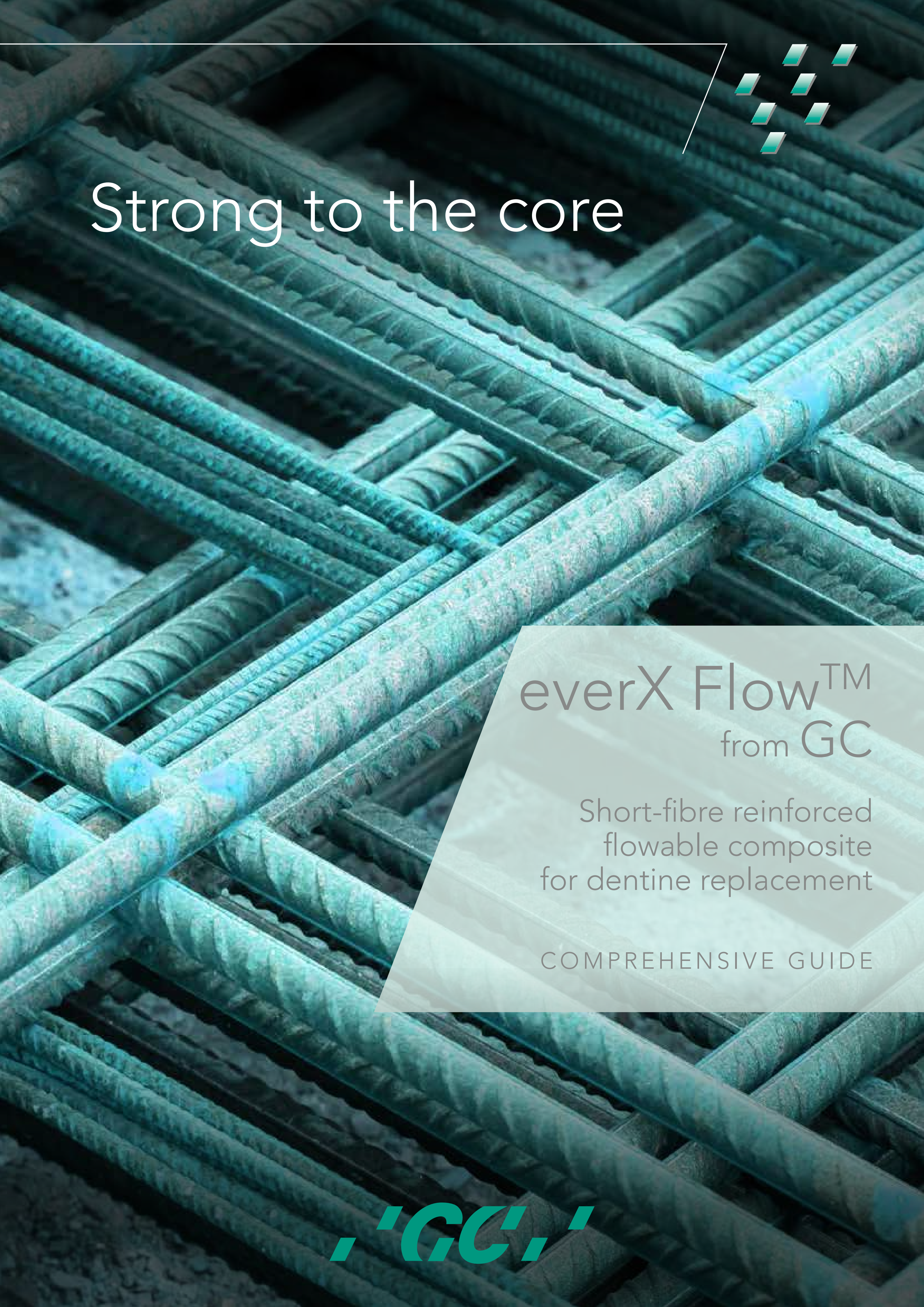


Strong to the core

everX Flow™ from GC

Short-fibre reinforced flowable composite for dentine replacement

COMPREHENSIVE GUIDE

Table of contents

1 Background

Recent advances in the technology of adhesive systems and composite resins have improved the longevity of direct restorations. However, a certain amount of failures remains, and the replacement of a restoration often leads to a further weakening of the tooth by additional loss of remaining tooth structure. According to literature[1-2] , **the most common reason for failure of composite restorations is the fracture of the composite**, followed by secondary caries. These studies[1-2] have shown a failure rate of 10 to 15% in Class II composite restorations after 6 to 7 years, of which nearly 50% were fractures. Additionally, when comparing the periods 1995-2005 and 2006-2016, Alvanforoush et al[3] observed **an increase of both overall failure rate and failures due to fractures**: from 10,6% (32,3% of which were fractures) to 13,1% (62,8% of which were fractures). While the overall failure rates showed little difference, the percentage of the failures linked to fractures significantly increased; **this could be due to the increased use of composite materials for larger restorations**.

A core objective of GC R&D is to **develop more durable restorative materials**. An ageing population with an increasing desire to remain dentate means that restoration longevity is a critical point for both clinician and patient. Our objective to increase restoration durability demands **new material technologies**, so that composites are less prone to degradation in the oral environment and can remain functional over longer periods of time. At the same time, we cannot ignore the "operator factor" on restoration longevity, meaning that materials that are not only performant, but also **easier and faster to use** will help clinicians to improve restorative outcomes for their patients.

Addressing these core needs has led to the development of **everX Flow - a unique fibre-reinforced material with a fracture toughness by far superior to conventional posterior composites**[4], delivered in a **thixotropic consistency that allows you to place the material easily in any situation**.

1. van Dijken JWV, Pallesen U. Clinical performance of a hybrid resin composite with and without an intermediate layer of flowable resin composite: A 7-year evaluation. Dent Mat 2011;27:150-156
2. van Dijken JWV, Pallesen U. Durability of a low shrinkage TEGDMA/HEMA-free resin composite system in Class II restorations. A 6-year follow-up. Dent Mat 2017;33:944-953
3. Alvanforoush N, Palamara J, Wong RH, Burrow MF. Comparison between published clinical success of direct resin composite restorations in vital posterior teeth in 1995-2005 and 2006-2016 periods. Aust Dent J 2017; 62:132-145.
4. Refer to section "8.1 Fracture toughness" of this Technical Manual

2 Introduction to everX Flow

Starting from the fact that fractures are the most common cause of restoration failure, Stick Tech Ltd (a member of GC group) has been working since many years on the **reinforcement of dental materials using glass fibres**. everX Posterior, a paste-type fibre-reinforced composite, has shown in both in vitro and in vivo trials its excellent fracture toughness that in turn positively impacts the strength and durability of the restorations. Studies also show that the fibre reinforcement has an impact on the fracture patterns, reducing the number of catastrophic failures.

However, in posterior indications adaptation is also a key factor, and to improve this parameter as well as the ease of use of the product, a lower viscosity was requested by many users of everX Posterior. The issue was that while glass fibres were needed to maintain the reinforcing effect the material, they also made it much more viscous and more difficult to apply. This was solved by the **Optimal Aspect Ratio (OAR) technology, which is using shorter and thinner fibres.** This enables to **improve significantly the manipulation, while maintaining the reinforcement effect of the fibres.**

Another extremely important factor is the efficient coating of particles with a silane coupling agent. Coating influences the durability of the link between the fillers and the matrix, as well as the surface energy of the particles. Thanks to the **Full-coverage Silane Coating (FSC) technology** developed by GC R&D, the silanisation of both particle fillers and fibres has been drastically improved, which enables to have **a higher filler load while maintaining the low viscosity of the material**.

Based on these new technologies and years of expertise on the use of fibres in dentistry, Stick Tech Ltd and GC R&D developed everX Flow together: a new short-fibre reinforced flowable composite material capable of strengthening posterior restorations.

3 Product description

everX Flow is a short-fibre reinforced flowable composite designed to replace dentine and reinforce restorations. Following the same principle as the iron rebar in construction, the glass fibres in everX Flow strengthen restorations and prevent them from cracking – thus improving their longevity.

Figure 1: Raw short glass fibres used in everX Flow

4 Indications

everX Flow is indicated for **dentine replacement in all direct restorations**, especially those in need of reinforcement such as:

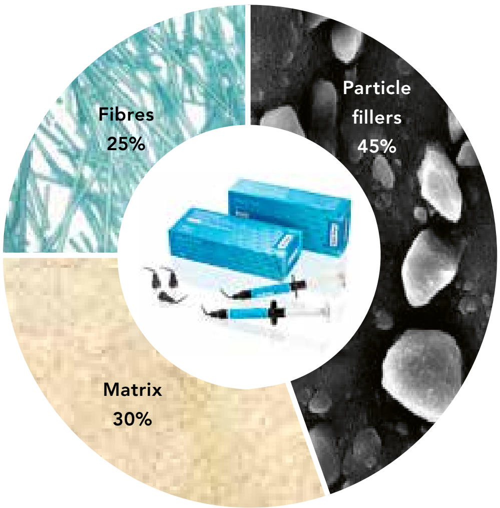
- Large posterior cavities
- Deep cavities and endo-treated teeth
- Cavities with missing cusps or after amalgam removal
- Cavities where inlays and onlays would also be recommended

This makes everX Flow an **affordable alternative to some indirect restorations**, when patients cannot afford other treatment options (eg. ceramic restoration), or when the treatment is not covered by national reimbursement or insurance systems. Thanks to its flowable & thixotropic viscosity, everX Flow can also be used easily in **smaller cavities**. It is also recommended for **core build-up preparations**.

Note - everX Flow contains glass fibres and should therefore always be covered by a final layer of conventional composite as enamel replacement.

5 Composition

everX Flow is based on a **combination of organic resin** matrix and **inorganic glass fibres** and filler particles.
The resin matrix contains Bis-MEPP, TEGDMA and UDMA.
The fillers are a mix of short E-glass fibres and particle fillers, mostly barium glass.
The total filler rate of everX Flow is **70% in weight.**



everX Flow	
Glass fibres	E-glass fibres
Average length of fibres	140μm
Diameter of fibres	6μm
Particulate fillers	Barium glass
Main monomers in resin matrix	Bis-MEPP, TEGDMA, UDMA
Filler rate (w/w)	70%
% of fibres (w/w)	25%
% of particle fillers (w/w)	Barium glass: 42-52% Silicon dioxide: Trace
% of resin matrix (w/w)	Bis-MEPP: 15-25% TEGDMA: 1-10% UDMA: 1-10%

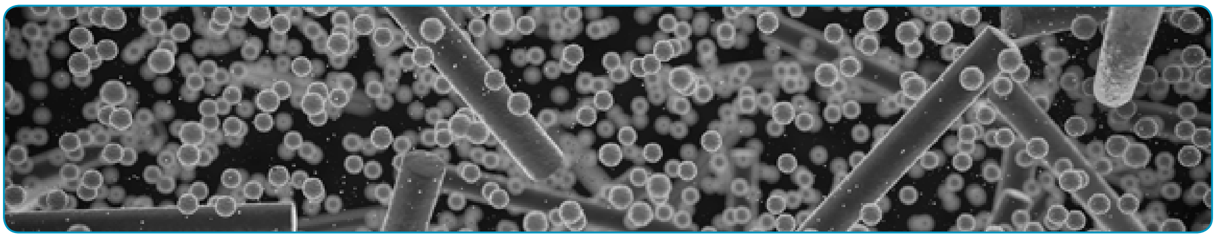


Figure 2: everX Flow is based on fibres and particle fillers in a resin matrix (computer-generated image)

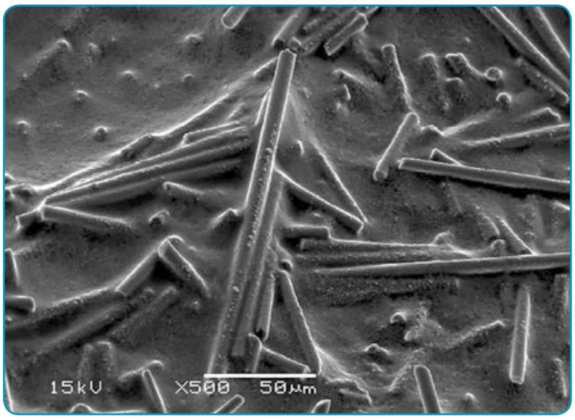


Figure 3: SEM image of the glass fibres in everX Flow
Courtesy of Dr Lippo Lassila, University of Turku

6 Core material technologies

6.1 Full-coverage Silane Coating (FSC)

An important feature that impacts the strength and toughness of the material is the interfacial adhesion strength between the particle fillers / fibres and the polymer matrix. A strong adhesion between the fibres and the polymer matrix is necessary for an efficient local transfer of the load from the matrix to the stronger fibres.
All fillers in everX Flow (particle fillers & fibres) display an optimal bonding to the resin matrix thanks to GC's latest silanisation technology: Full-coverage Silane Coating (FSC). The chemistry of the silane & filler surfaces and the interaction between them play an important role in ensuring full coating of particles. The FSC technology reduces degradation at the filler-resin interface to optimise durability.

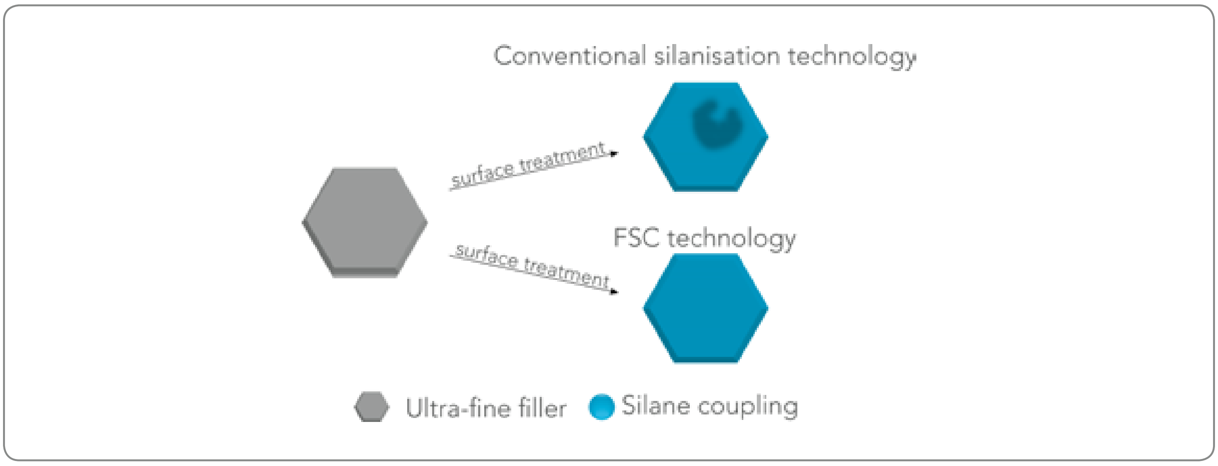


Figure 4: Efficient coating of the fillers thanks to GC's FSC technology

The FSC technology provides important benefits:

- The surface of the fillers is **fully coated** by the silane coupling agent
- The **wettability** of the fillers and **linkage to monomers** are improved
- The fillers are **dispersed** in a very efficient way
- The **percentage of fillers can be increased** while maintaining an excellent flowability
- The **resistance to degradation** & **flexural strength** are improved
- The **extrusion pressure** and **stickiness** of the material are reduced
- An **excellent thixotropy is achieved**: perfect adaptation and high resistance to slumping

6.2 Optimal Aspect Ratio (OAR)

Fibre aspect ratio is the ratio of length to diameter of a fibre. To obtain a sufficient stress transfer from the matrix to the fibres and thus an efficient reinforcement of the restoration, this ratio needs to be optimised. This is the case with everX Flow thanks to the **OAR technology**. Owing to this technology, an exceptional resistance to fracture could be reached even though everX Flow contains short fibres.

Figure 5: Optimised fibre aspect ratio

7 Main features and benefits

- Strong dentin replacement for **all sizes of cavities & for core build-up**
- **Exceptional fracture toughness** thanks to the reinforcement effect of fibres
- **Excellent flexural strength** to withstand masticatory load
- Flowable and thixotropic viscosity that enables a **great adaptation and an easy application** even in the upper jaw, without slumping
- Comfortable syringe allowing an **easy extrusion** and complete control of flow
- **Two shades with different depths** of cure to meet all aesthetic demands

Figure 6: Flowable & thixotropic viscosity

Figure 7: No slumping even in the upper jaw
Courtesy of Dr Javier Tapia Guadix, Spain

8 Physical properties

8.1 Fracture toughness

As a result of fibre incorporation, everX Flow reduces the risk of filling, cusp and root fracture by preventing the crack propagation from the surface of the material into deeper areas of the restored tooth structure. The very high fracture toughness of this material provides a durable foundation for composite restorations. As a result, everX Flow resists continuous mastication forces exceptionally well and prevents fractures of the filling and surrounding tooth structure.

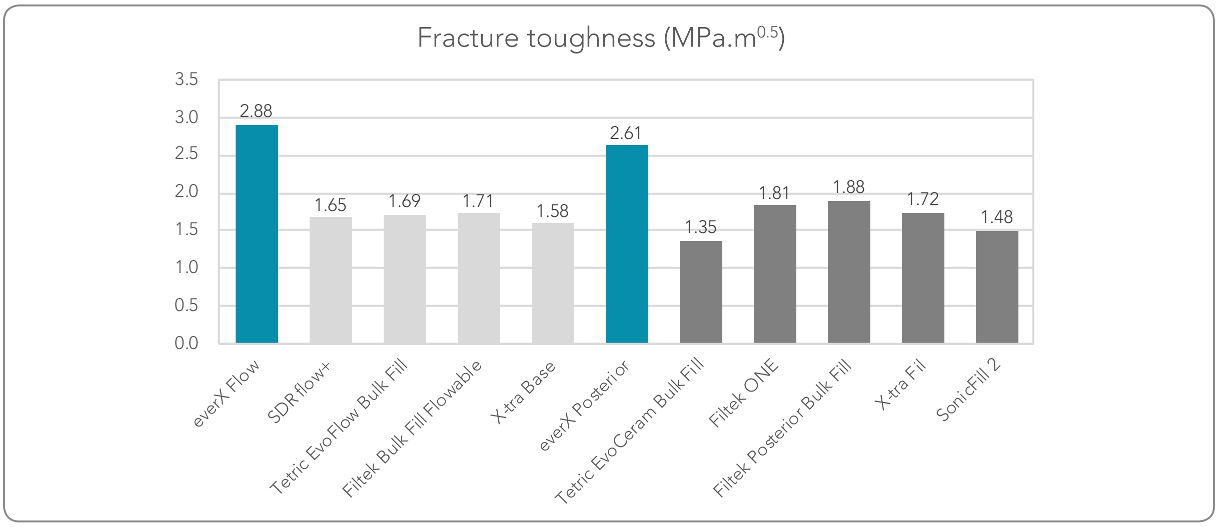


Figure 8: Fracture toughness of everX Flow and other paste & flowable bulk-fill composites.
Source: GCC R&D, Japan, 2018. Test method: as per ASTM E399-90 (1997). Data on file.

These superior results were confirmed by the University of Turku when testing the fracture toughness of everX Flow against other flowable bulk materials. **everX Flow achieved a fracture toughness about double that of all other products tested.**

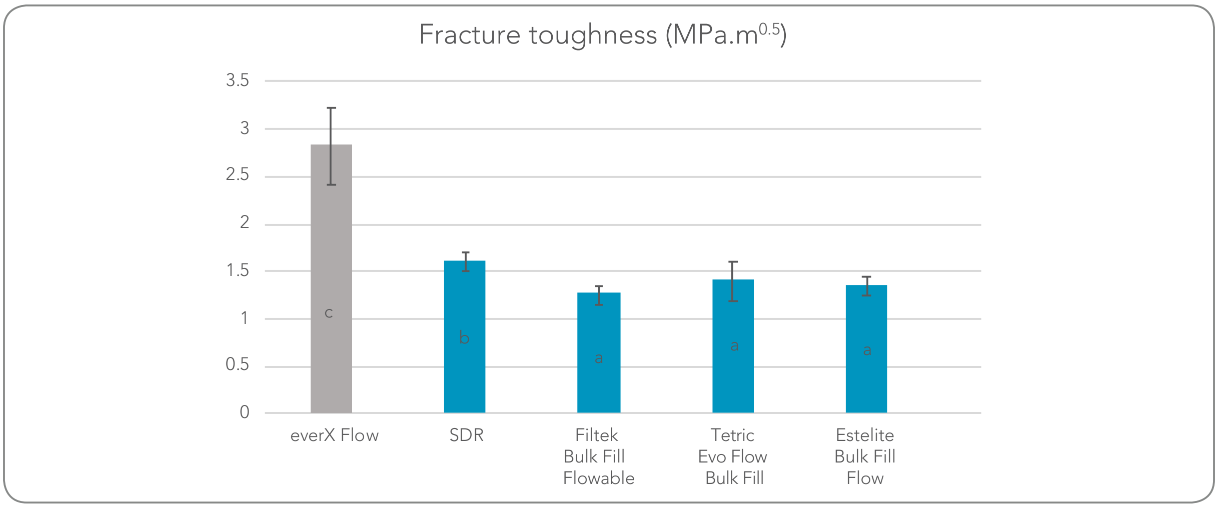


Figure 9: Fracture toughness of everX Flow compared to other bulk-fill flowable composites
Source: Characterization of a new fibre-reinforced flowable composite, Lassila et al, Odontology, 2018
The same letters inside the bars represent non-statistically significant differences (p>0.05) among the groups.

Lyon University (LMI – Laboratoire des Biomatériaux et Interfaces) also confirmed the **superior fracture toughness exhibited by everX Flow**, compared to Filtek One and SDR.

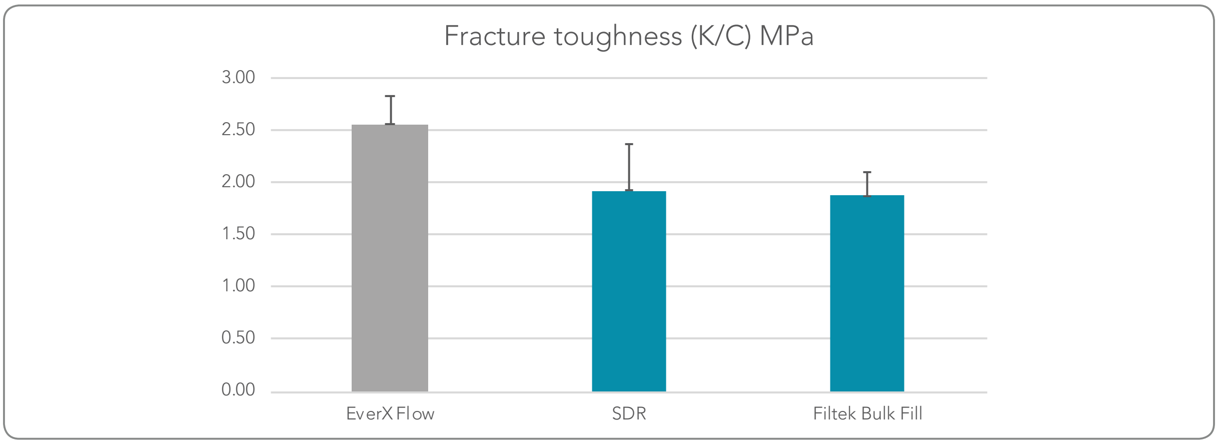


Figure 10: Fracture toughness of everX Flow compared to a bulk paste and a bulk flowable composite
Source: Lyon University (LMI), France, 2019. Test performed according to ISO 20795-1. Data on file.

Another interesting observation from Lyon University regarding this fracture toughness test is that everX Flow samples display a unique behaviour. Even after the samples fail, the composite bars do not break apart, while conventional composites usually break in two pieces. Lyon University considers “there is a potential clinical relevance for this behaviour”.

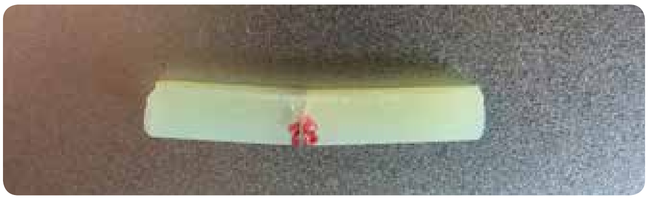


Figure 11: everX Flow sample after failure, still in one piece
Source: Lyon University (LMI), France, 2019. Data on file.

The same behaviour was also observed by GC R&D when performing fracture toughness tests:

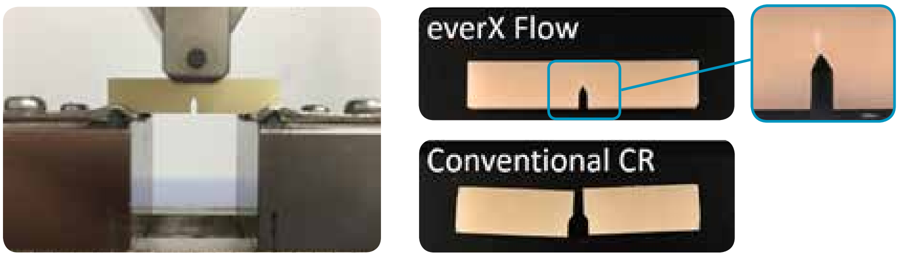


Figure 12: everX Flow sample arresting crack propagation
Source: GC R&D, Japan, 2019. Data on file.

Another independent study by Prof Lohbauer, Dr Belli, and Dr Tiu at Friedrich-Alexander Universität Erlangen-Nürnberg (Data on file; 2019) tested the behaviour of cracks starting at the surface of a layer of conventional composite and propagating towards the dentin-replacing everX Flow material. Dr Tiu *(et al)* observed a **noticeable increase in the fracture toughness when reaching the everX Flow layer**. Another interesting observation was that **the crack generally stops at the interface between the two materials**. SEM pictures of the samples after the test also show clear evidence of fibre bridging.

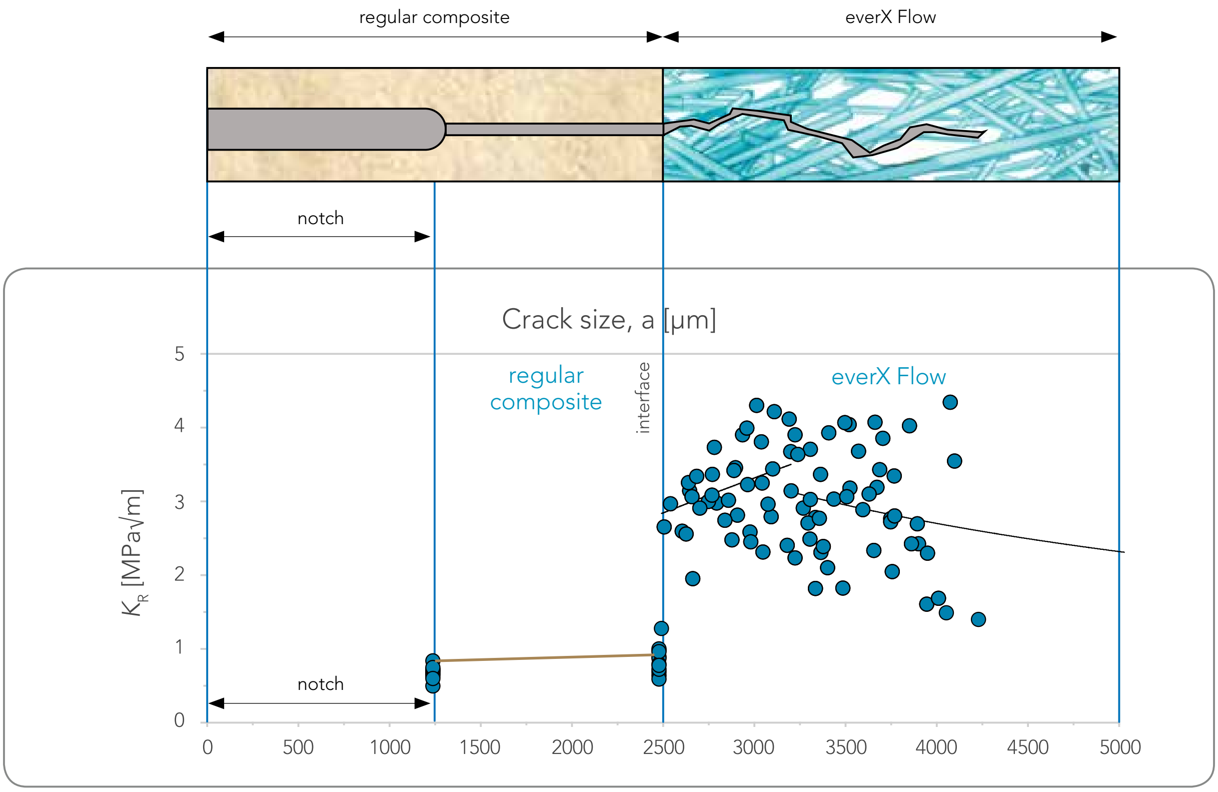


Figure 13: **Above:** schematic drawing of a bi-layer composite sample with pre-crack notch
Below: Remarkable toughening at the interface when the crack reaches the everX Flow layer

Source: Tiu J, Belli R, Lohbauer U. Rising R-curves in particulate/fiber-reinforced resin composite layered systems. J Mech Behav Biomed Mater. 2019 Nov 16;103:103537.

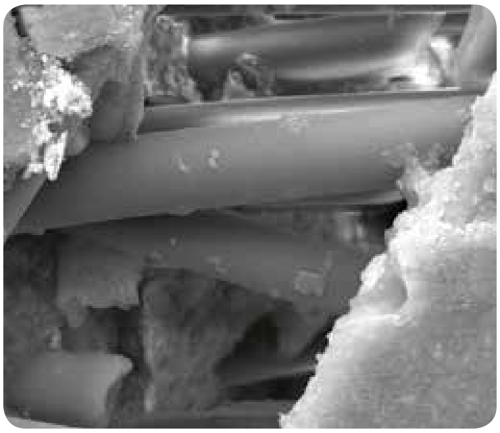
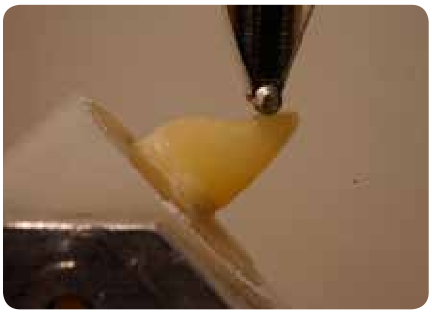


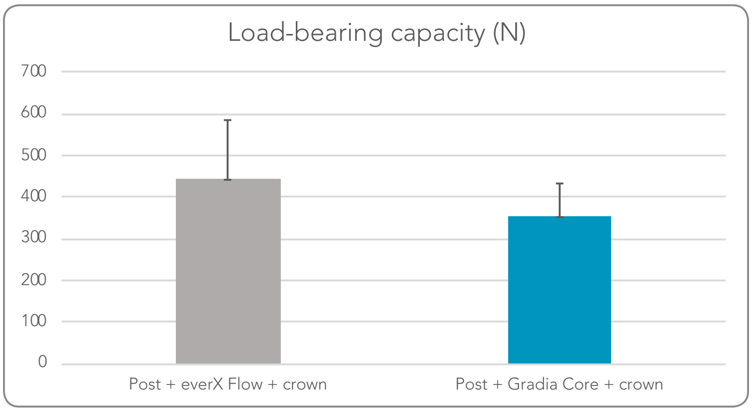
Figure 14-15: The fibres in everX Flow prevent crack propagation. Fiber bridging is seen along the entire crack length.
Source: Tiu J, Belli R, Lohbauer U. Rising R-curves in particulate/fiber-reinforced resin composite layered systems. J Mech Behav Biomed Mater. 2019 Nov 16;103:103537.

8.2 Load-bearing capacity

Measuring the load-bearing capacity is another way of evaluating the strength of a material, by applying a static load on the material and measuring the load needed to break it.
In order to define if a fibre-reinforced core build-up could have a positive impact on the fracture load of the final restoration, the University of Turku carried out a study to compare the fracture load of:

- One sample group of teeth restored using a **regular fibre post and Gradia Core as core build-up** with a complete crown made of particulate-filler composite
- One sample group of teeth restored using a **regular fibre post and everX Flow as core build-up** with a complete crown made of particulate-filler composite





Figures 16 & 17: Testing the load-bearing capacity with a conventional core compared to an everX Flow core
Source: The influence of resin composite with high fibre aspect ratio on fracture resistance of severely damaged bovine incisors, Lassila et al, 2019

The results show that the chosen restorative technique significantly affected the load-bearing capacity. The sample group featuring an **everX Flow core had the highest load-bearing capacity** and "showed a substantial improvement in load-bearing capacity and failure mode" when compared with the group based on a conventional core build-up material.
The authors also conclude that "the restoration of structurally compromised incisor teeth with the use of flowable SFRC as core material with regular fibre post displayed **promising performance in matter of load bearing capacity and failure mode.**"

8.3 Flexural strength

Flexural strength is defined as **a material's ability to resist deformation under load**. In clinical situations, dental restorations need to withstand repeated masticatory forces. A high flexural strength is desired to maintain the shape when these forces impact the restorations.

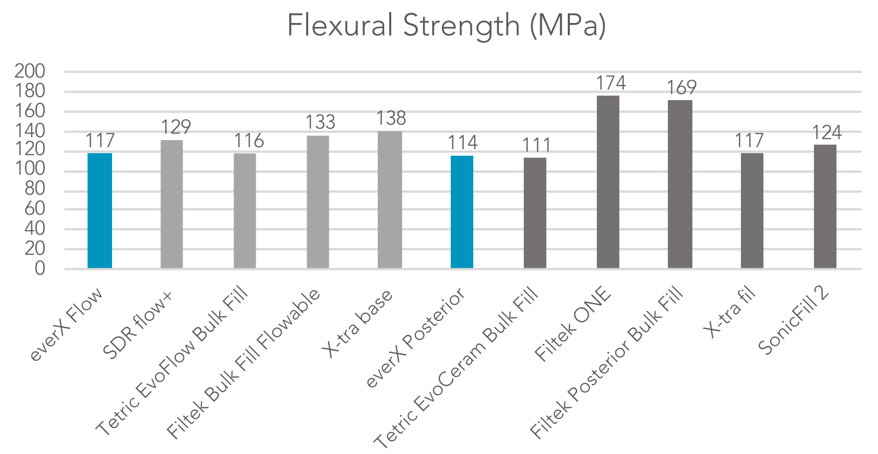


Figure 18: Flexural strength of everX Flow compared to other flowable and paste bulk composites.
Source: GCC R&D, 2018. Test method: as per ISO4049(2009), Flexural Strength. Data on file.

To verify the effectiveness of innovative silane and resin technologies on durability and resistance to degradation, GC R&D tested the **flexural strength of the material before and after thermocycling** (10,000 cycles). The results show no significant difference - which should in turn have a positive impact on its stability and long-term durability.

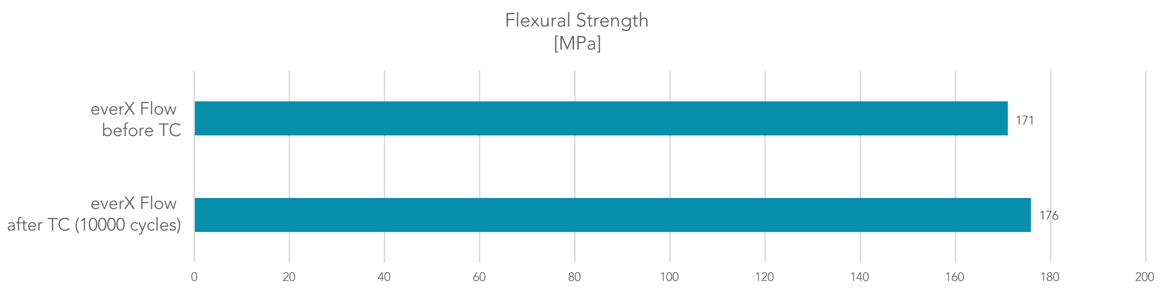


Figure 19 : Flexural strength of everX Flow before and after thermocycling (10000 cycles).
Source: GCC R&D, Japan, 2018. Data on file.

Within the limitations of the two above tests, it can be concluded that **the flexural strength of everX Flow is by far superior to the other flowable bulk fill composites on the market, and even similar or superior to the paste-type composites**. The thermocycling test also shows that the material has an **excellent stability** and can withstand intraoral conditions.

The University of Turku also tested flexural strength according to ISO 4049, and **confirmed everX Flow was achieving a higher strength than the bulk flowable competitors tested**.

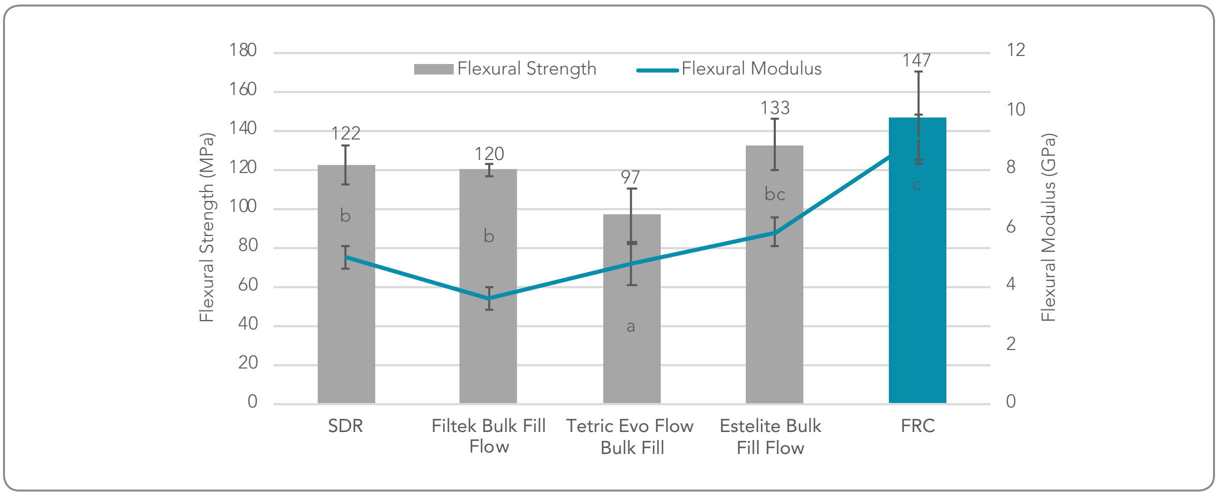


Figure 20: Flexural strength & flexural modulus of everX Flow (FRC) compared to other bulk flowable composites.
Source: Lassila L, Säilynoja E, Prinssi R, Vallittu P, Garoushi S. Characterization of a new fiber-reinforced flowable composite. Odontology. 2019;107(3):342-352. The same letters inside the bars represent non-statistically significant differences (p>0.05) among the groups.

8.4 Modulus of elasticity

The modulus of elasticity (Young's modulus) is a **measure of the rigidity of the material** and is defined by the initial slope of the stress-strain curve. A high modulus of elasticity means that the material is rigid and stiff. A material with a low modulus of elasticity is more flexible and is better able to buffer the masticatory pressure.

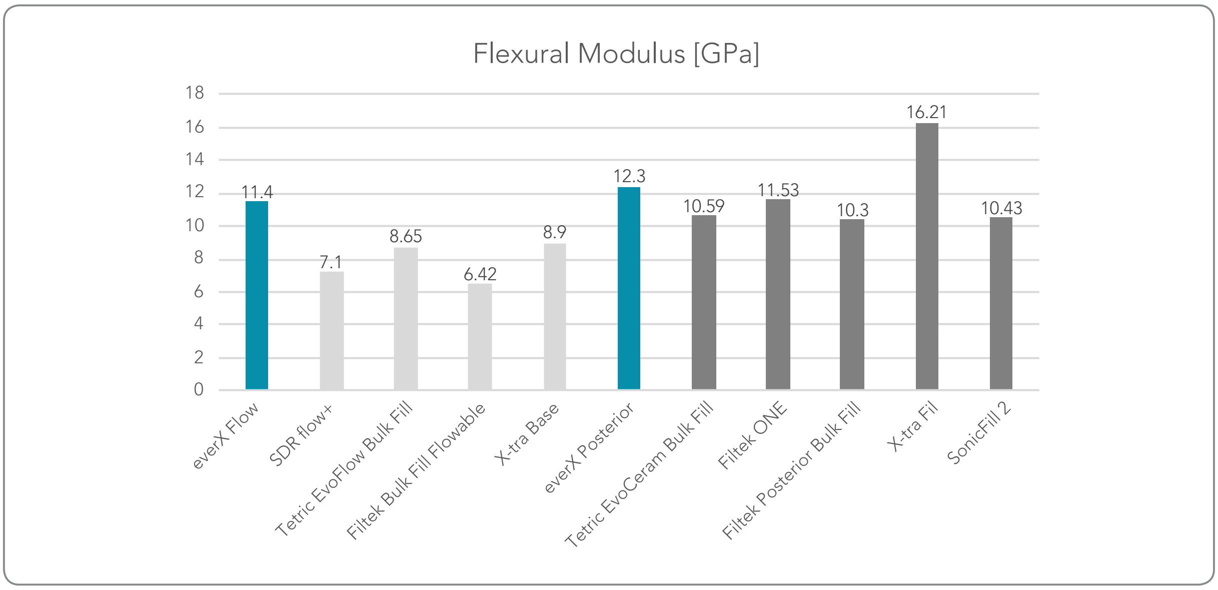


Figure 21: Modulus of elasticity of everX Flow compared to other bulk flowable & paste composites.
Source: GCC R&D, 2018. Test method: as per ISO4049(2009), Flexural Strength. Data on file.

Within the limitations of this test, it can be concluded that **everX Flow has a balanced elastic modulus**, in between those of conventional paste-like and flowable composites.

8.5 Three-body wear

Wear is the loss of material resulting from the contact between two or more materials. The three-body wear test is used to obtain a close reproduction of the wear in the oral cavity, including contact with opposing dentition, and the presence of a bolus.

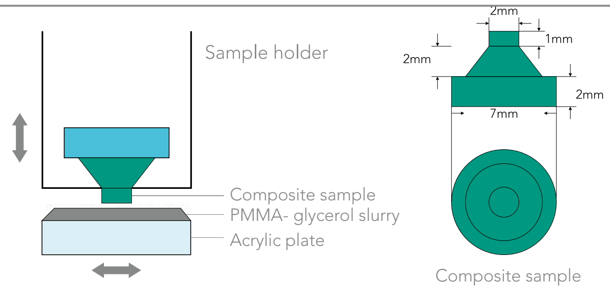


Figure 22 : Three-body wear test set-up

Although everX Flow is not designed to be exposed to the oral environment, GC R&D completed 3-body wear testing **to further verify the material's resistance to degradation and the durability of our silane and resin technologies**.

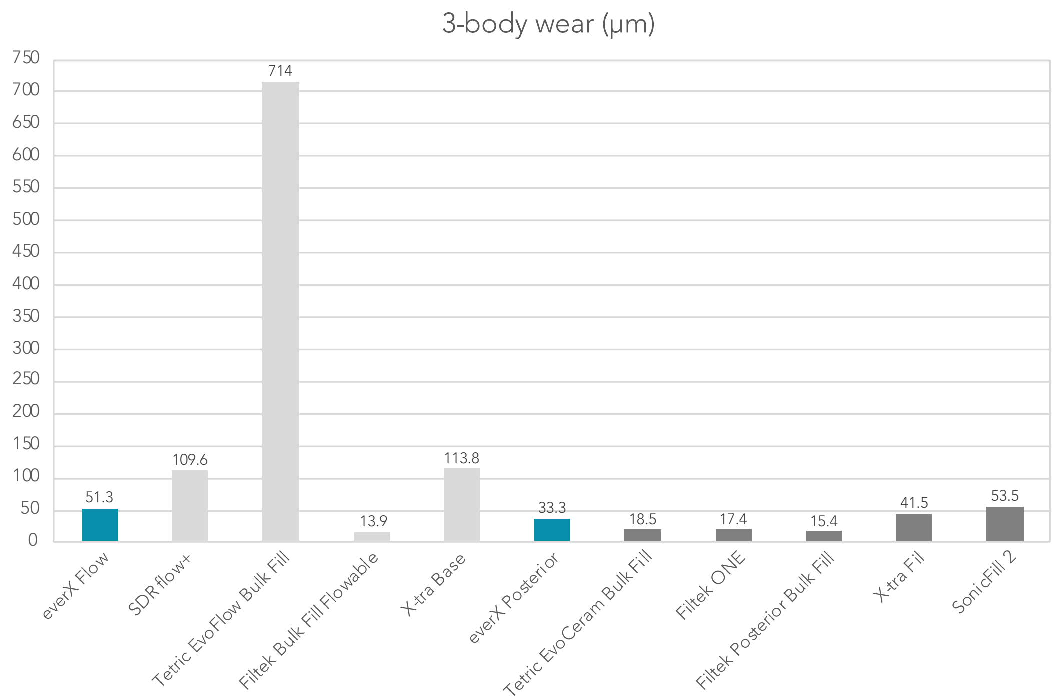


Figure 23 : Three-body wear of everX Flow compared to other bulk flowable & paste composites.
Source: GCC R&D, 2018. Data on file.

These results again **confirm the expectation of excellent long-term durability.**

8.6 Depth of cure

The depth of cure is an important parameter for composite materials, as **it has an impact on the number of layers required to complete a restoration and thus on the total procedure time**. However, a high depth of cure is usually obtained by increasing the translucency of materials, which can have a negative impact on the final aesthetic level of the restoration and provoke a grayish effect.

To give the clinician a choice between speed of procedure and high aesthetic outcome, everX Flow is available in two different shades:

- A **Bulk shade** - more translucent, with a **depth of cure of 5.5mm**; designed to be applied in bulk in the cavity. This shade is optimal to speed up the procedure or in case of deep cavities, for instance after endodontic treatment.
- A **Dentin shade** – more opaque, with a **depth of cure of 2mm**; designed to improve the aesthetic outcome by reproducing the natural shade of the tooth structure.

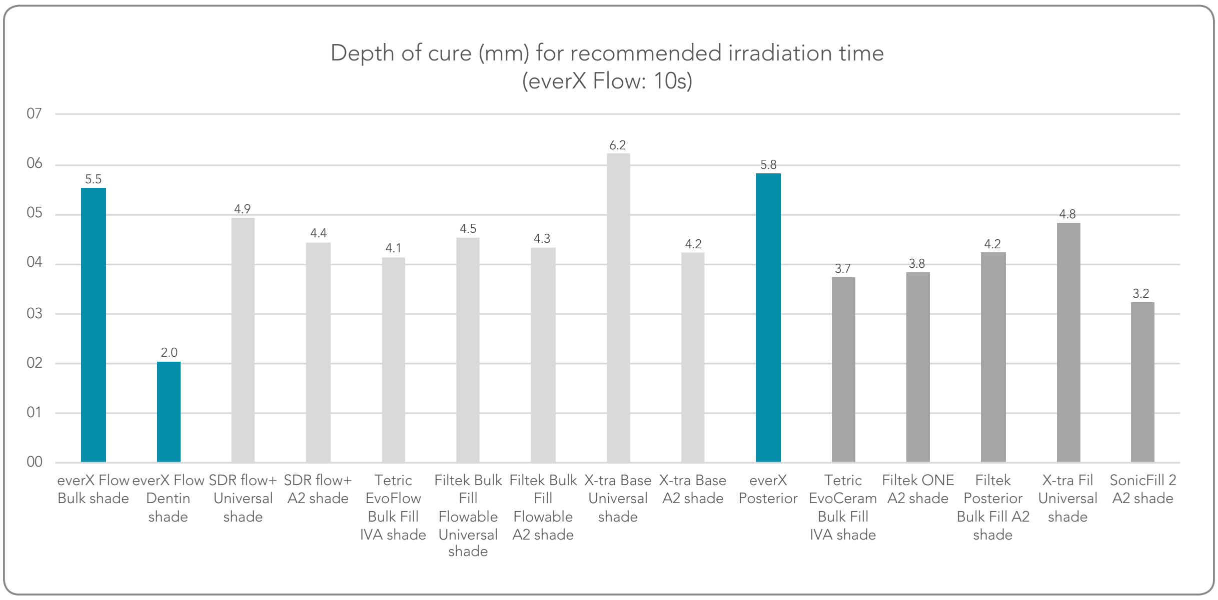


Figure 24 : Depth of cure of everX Flow compared to other bulk flowable & paste composites.
Source: GCC R&D, 2018. Test method: as per ISO4049(2009), Depth of Cure, Class 2 materials. Data on file.

Within the limitations of this test, it can be concluded that **the official recommendation of 5.5mm thickness for the Bulk shade was achieved**. This depth of cure was higher than that of most bulk competitors tested. **The Dentin shade should however be applied in layers not exceeding 2mm thickness.**

8.7 Shrinkage

Shrinkage is inherent to all dental composites. Due to the confinement inside the cavity, shrinkage may manifest itself as shrinkage stress. **Shrinkage stress is a complex phenomenon and it is not linearly related to volumetric shrinkage**. Rather, it is dependent on many factors, such as material's properties (elastic modulus, water sorption and shrinkage kinetics) as well as clinical circumstances (cavity size and configuration) and thus may differ per indication. In fact, **there is no proven correlation between the volumetric shrinkage of dental composite restorations and their clinical outcome**[5].

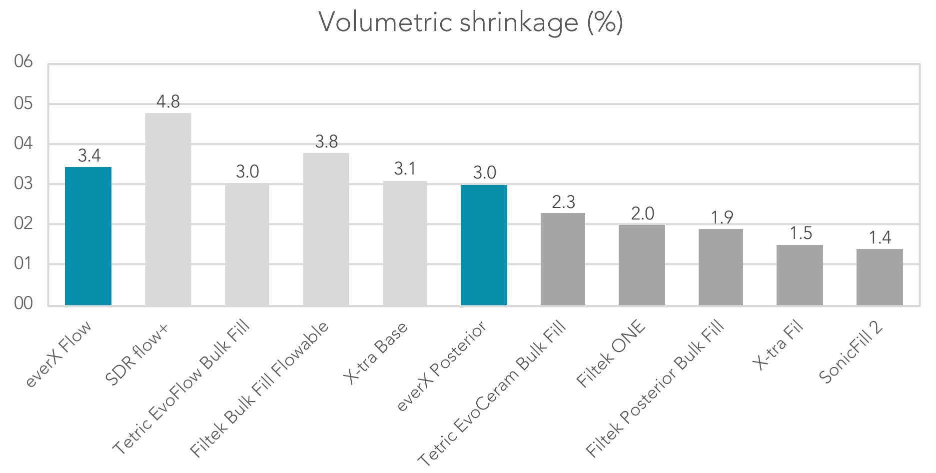


Figure 25 : Volumetric shrinkage of everX Flow compared to other bulk flowable & paste composites.
Source: GCC R&D, 2018. Test method: as per ISO17304(2013). Data on file.

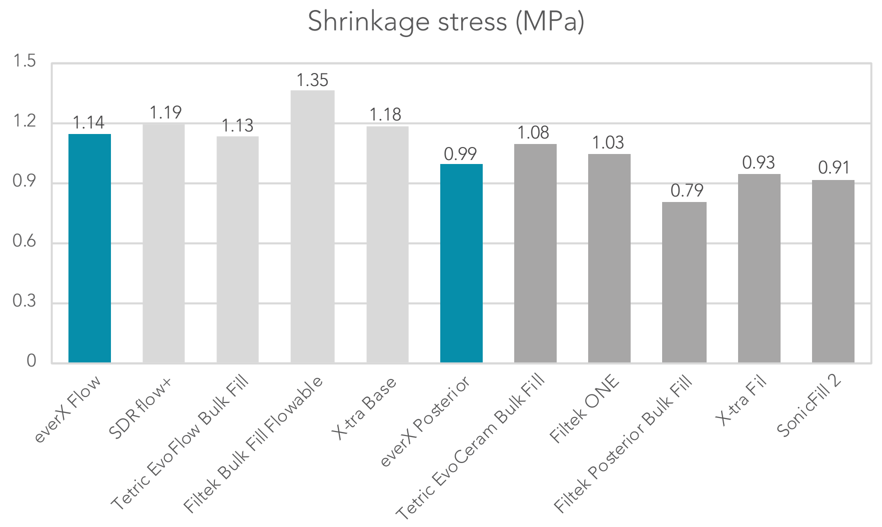


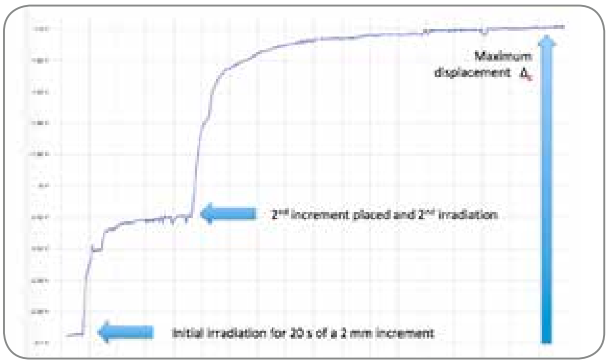
Figure 26 : Shrinkage stress of everX Flow compared to other bulk flowable & paste composites.
Source: GCC R&D, 2018. Data on file.

everX Flow has a **higher volumetric shrinkage than conventional composites, but comparable to most flowable bulk-fill composites.**

5. Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater 2005;21:36–42.

A study on cuspal deflection following polymerization shrinkage - lead by Prof Watts - also concluded that **everX Flow "exhibited a cuspal deflection well within acceptable limits"** and that **"there should be no concerns about safe clinical use in this regard"**.

Product	Maximum Cuspal Displacement (μm) at 20 min
everX Flow Bulk shade	20.0 (0.9)
everX Flow Dentin shade (2x2mm increments)	14.0 (0.8)



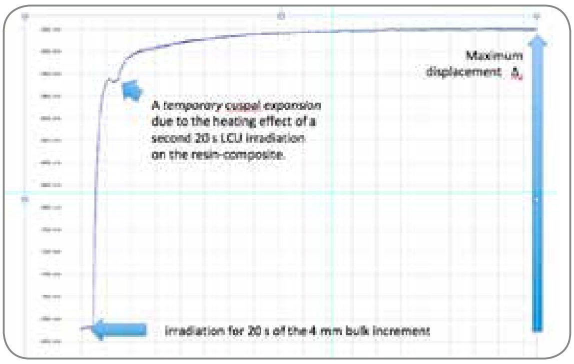


Figure 27, 28 & 29 : Cuspal displacement occurring with everX Flow Bulk & Dentin shades.
Source: Study by Prof David Watts, BioMan Materials Consultants Ltd, Manchester, UK, 2019. Data on file.

This **limited cusp deflection** and the **excellent visco-elastic behaviour** of the material in a rather long pre-gelation phase imply that **its volumetric shrinkage will not necessarily lead to a high shrinkage stress in a clinical set-up**.

Furthermore, the influence of shrinkage stress is most noticeable on the enamel margins, due to the higher modulus of elasticity of enamel and to the crystal structure of the enamel prisms, which make it more sensitive to stress-related chipping. **Taking into account that everX Flow is designed to be used as dentine replacement, the influence of shrinkage stress on the final restoration should be minimal.**

8.8 Radiopacity

For restorative materials, **a high radiopacity is required in order to distinguish the material from the remaining tooth structure**. As such, the follow-up of the restoration and the detection of potential secondary caries will be made possible. The radiopacity of specimens is compared with that of an aluminium sample of the same thickness.

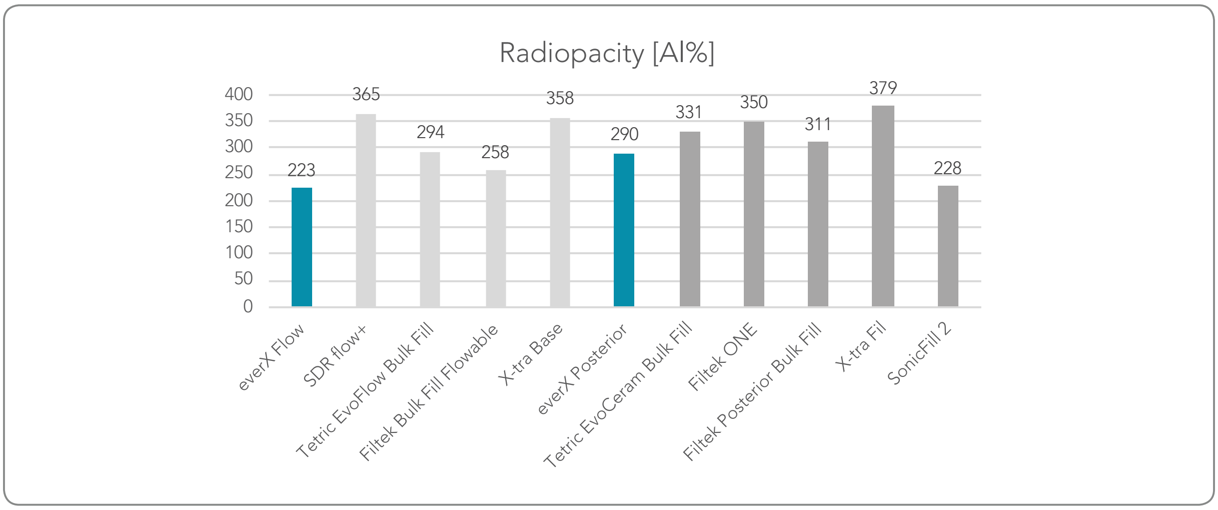


Figure 30 : Radiopacity of everX Flow compared to other flowable & paste bulk composites.
Source: GCC R&D, Japan, 2018. Data on file.

everX Flow exhibits **a sufficient radiopacity to easily distinguish it from caries and tooth tissue, but not too high to avoid any artifacts**. This level of radiopacity is achieved thanks to the use of **barium particle fillers**.

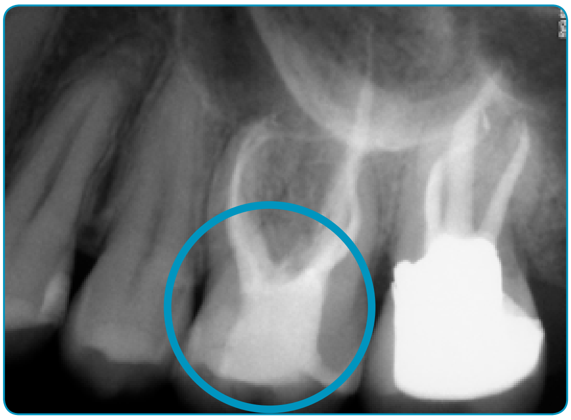


Figure 31 : X-ray displaying the adequate radiopacity level of everX Flow
Courtesy of Prof Joseph Sabbagh, Lebanon

9 Handling features

everX Flow exhibits **excellent thixotropic properties** which enable it to **adapt easily to any cavity**, but also to **avoid slumping** – making it easy to use in all indications, even in the upper jaw.


Figures 32 & 33 : During application: the material stays where it is placed and does not slump.

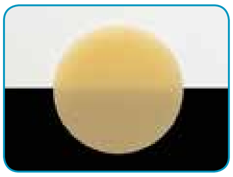

Figures 34 & 35 : Simply by moving the tip of the syringe, the material flows and perfectly adapts to the cavity.

The flawless adaptation of everX Flow to cavity preparations was also displayed by Prof Marco Ferrari (Siena University) using stereomicroscopy.

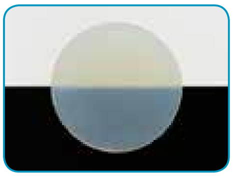
Figure 36 : Stereomicroscopy image showing the great cavity adaptation of everX Flow
Courtesy of Prof Marco Ferrari, Siena University

10 Shades

everX Flow is available in two shades:



The Bulk shade (depth of cure 5.5mm) is perfect for deep cavities or whenever a quick procedure is required.



The Dentin shade (depth of cure 2mm) is optimal for more aesthetic cases or core build-up, as it features a higher opacity and enables to achieve superior aesthetics.

Bulk shade

Depth of cure
5.5 mm

Optimal for deep posterior cavities and for a fast placement

Dentin shade

Depth of cure
2.0 mm

Optimal for more aesthetic results and for core build-up

11 Step-by-steps

11.1 Direct restorations

Class I

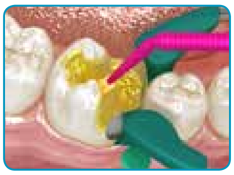
1 Prepare

2 Bond & light-cure

3 Fill the cavity with everX Flow

Class II

1 Prepare



2 Bond & light-cure

3a In case of a Class II cavity, first build the missing walls with a conventional composite

3b Fill the cavity with everX Flow

Step 4 and 5 are valid for both Class I & II

4 Light-cure for 10s per layer

5 Cover with a conventional composite

11.2 Core build-up

Initial situation

Apply a bonding agent

Dry the bonding agent

Light-cure the bonding agent

Build the core with everX Flow

Light-cure the composite

Final core build-up preparation

12 Clinical cases

12.1 Class II case – courtesy of Georg Benjamin, Germany

After rebuilding the missing cusp with G-ænial Universal Injectable in order to be able to place a matrix, the walls are also rebuilt and everX Flow (Dentin shade) is used as a dentine replacement. The last layer of the restoration is then created using Essentia Universal. A very nice aesthetic outcome is achieved.





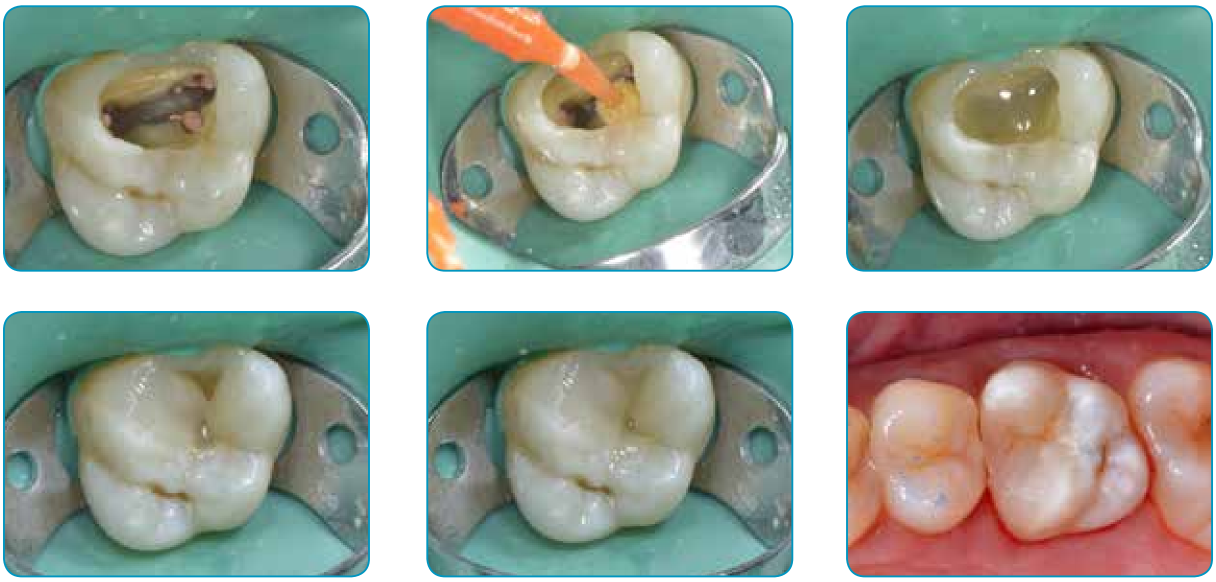



12.2 Class II case – courtesy of Dr Rudolf Novotny, Slovakia

After rebuilding the missing wall with Essentia LoFlo, everX Flow (Dentin shade) increments are used to fill the cavity. Essentia Universal is then used to build the last layer of the restoration. A very natural aesthetic outcome is obtained.

12.3 Class I case – courtesy of Dr Lucile Dahan, France

The cavity is completely filled with everX Flow (Bulk shade), only leaving sufficient space for the enamel layer. The everX Flow core is then covered by a final layer of G-ænial Universal Injectable. Despite the use of the more translucent Bulk shade, the outcome is aesthetically pleasing.



everX Flow from GC

Strong to the core

everX Flow	
012898	everX Flow, Syringe 2 ml (3.7g) Bulk shade
012899	everX Flow, Syringe 2 ml (3.7g) Dentin shade

Bulk shade for deep cavities

Dentin shade for highly aesthetic results

Also discover

G-Premio BOND
Universal bonding agent

G-ænial Universal Injectable
High-strength injectable restorative

Essentia Universal
Universal paste composite

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