Made to fit all your adhesive challenges. Designed to last.

G-CEM LinkForce™

from GC

TECHNICAL MANUAL

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1 Introduction to G-CEM LinkForce

The development of CAD/CAM and the evolution of adhesive dentistry have revolutionised the possibilities for indirect restorations: from retentive crowns and bridges to less invasive solutions such as inlays, onlays, overlays and veneers which need to be bonded instead of cemented. Parallel to this trend, new substrates such as zirconia, lithium disilicate and hybrid ceramics have emerged. The **plethora of treatment** options now available can be confusing for many dentists, and mastering all of the cementation procedures to cover all indications is very challenging (Table 1).

Choosing the luting procedure is an important part of the prosthetic treatment plan. Many factors will influence this decision such as the difficulty to isolate, the retention, level of the preparation, the possibility to light-cure the cement through the restoration, aesthetic considerations and the ease of use of the luting agent.

In cases where the preparation provides sufficient retention and/or isolation is difficult, the **glass ionomer based luting cements** such as the Fuji products from GC (Fuji I, FujiCEM and Fuji Plus) are an excellent alternative. They are biocompatible and pulp-friendly[1], chemically bond to dental tissue with good sealing ability[2] and contain fluoride[3]. These are important factors in the prevention of caries recurrence. Because they are moisture-tolerant[4] and cement excess is easily removed, they are also very user-friendly. Glass ionomer based luting cements will be particularly indicated for metal and zirconia-based restorations. With more than 30 use in clinics and numerous publications, they represent a reliable and proven luting solution.

	Inlays & onlays				Crowns & bridges				Posts & inlay-cores			Veneers
	Metal	• Feldspathic ceramics • Leucite-reinforced ceramics	• Lithium disilicate • Composite (e.g. GC GRADIA P LUS)	Hybrid ceramics (e.g. CERASMART)	• Metal (e.g. GC Initial Cast NP) • Zirconia (e.g. GC Initial Zirconia disk) • Alumina	• Lithium disilicate • Composite (e.g. GC GRADIA PLUS)	• Feldspathic ceramics • Leucite-reinforced ceramics	Hybrid ceramics (e.g. CERASMART)	Fibre reinforced (e.g. EverStick POST & GC Fiber post)	Metal	Zirconia (e.g. GC Initial Zirconia disk)	• Feldspathic ceramics • Leucite reinforced ceramics • Lithium disilicate • Hybrid ceramics (e.g. CERASMART) • Composite
Fuji I Conventional glass ionomer cement	•	-	-	-	•	-	-	-	-	•	-	-
Fuji PLUS Resin-modified glass ionomer cement	•	• (inlays)	•	-	•	•	-	-	•	•	•	-
FujiCEM 2 Resin-modified glass ionomer cement												
G-CEM LinkAce Self-adhesive resin cement	•	•	•	-	•	•	•	-	•	•	•	-
G-CEM Self-adhesive resin cement												
G-CEM LinkForce Adhesive resin cement	•	•	•	•	•	•	•	•	•	•	•	•
G-ænial Universal Flo Adhesive resin cement	-	• (if less than 2.0 mm thickness)*	•	•	-	-	-	-	-	-	-	•

Table 1: Overview of luting indications depending on the restorative material used and the type luting products.

However, for c**ontemporary minimally invasive preparations** that may lack the necessary retention, additional bonding is often necessary. G-CEM resin cements have been developed for those cases. With the self-adhesive resin cement G-CEM LinkAce, adhesion is provided with a simple procedure in just one step, whereas G-ænial Universal Flo offers excellent aesthetics in case the restoration allows light-curing of the resin composite.

Prosthetic restorations are changing: introducing G-CEM LinkForce

With the **increase in diversity** of restorative materials and preparation designs, it became more and more important to have a luting agent that can be used in **all indications**. This type of cement should possess **excellent aesthetics** as well as **high bond strength.** G-CEM LinkForce, a dual-cure adhesive resin cement, has been developed with this objective in mind. GC could rely for the development of this luting system on an extensive knowledge in primers, adhesives and flowable composites. By offering a **universal**, yet strong resin cement for every substrate, an all-in-one system to simplify luting procedures could be reached. **One standard cementation procedure** can now be used with predictable outcome in all cases; traditional crowns and bridges as well as non-retentive restorations, regardless of both restorative material and substrate.

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HIGH 5

LUTING SOLUTIONS

In order to ease of selection of appropriated luting cement for each indication, GC has developed a luting app which can be downloaded for free. The choice of cement type is made easy in 5 main steps (indicating the type of restoration, type of material, retention level, expected duration of adhesion and isolation level). Step by step description of the procedure will help further the practitioner to optimise his clinical results.

2 Product description

G-CEM LinkForce is a system consisting of three base elements (Figure 1):

- **G-Premio BOND:** a strong, universal adhesive
- **G-Multi PRIMER:** to ensure adhesion to all restorations
- **G-CEM LinkForce:** the proper resin cement

Figure 1: Base elements of G-CEM LinkForce

The system contains additional products which widens the possibility of treatments:

- **G-Premio BOND DCA:** used in combination with G-Premio BOND to allow effective bonding in places where light cannot reach, such as root canal surfaces
- **G-CEM LinkForce Try-in Paste:** to test and confirm the correct shade selection

2.1 G-Premio BOND

G-Premio BOND (Figure 2, Table 2) is the successor of G-BOND, which has a proven track record of clinical success[5–8].

As G-BOND, G-Premio BOND is free of 2-hydroyethylmethacrylate, an allergic and hydrophilic substance that is still used ubiquitously in other one-bottle adhesives[9].

Three functional monomers to bond to all preparations.

G-Premio BOND contains functional monomers to bond to every preparation: 4-MET (4-methacryloyloxyethyl trimellitic acid) and MDP (methacryloyloxydecyl dihydrogen phosphate) assure adhesion to enamel and dentin tissues, since the phosphoric acid and carboxylic acid functional groups of those monomers can chemically bond to calcium. More than bonding to tooth structure, MPD provides further adhesion to resin core build-up and non-precious metal core through bonding of the phosphoric acid group with silicic acid groups, zirconia and non-precious metal oxides, respectively. On the other hand, MDTP (methacryloyloxydecyl dihydrogen thiophosphate) provides adhesion to precious metal cores through chemical

Figure 2: Functional monomers in G-Premio BOND

G-PREMIO BOND
Acetone
Water
4-Methacryloxyethyl trimellitate anhydride (4-MET)
Phosphoric ester monomers (MDP & MDTP)
Methacrylate monomer
Silicon dioxide

Table 2: General composition of G-Premio BOND.

bonding of sulfur to precious metals such as gold, platinum and palladium. Hence, this one-bottle universal adhesive system has been designed to bond to ALL preparations.

Free choice of etching mode

G-Premio BOND can be used in all etching modes: self-etching, selective etching of enamel or total etch (Figure 3). This allows to adapt to the type of preparation to be restored. In general, etching of enamel has been shown to be of interest[10,11], particularly with preparations involving mainly enamel such as preparations for veneer or table tops.

Figure 3: The choice of etching mode makes it possible to adapt to the preparation design.

However, etching of dentin does not seem to have a significant influence on the bond strength, whilst it could also induce post-operative sensitivity in vital teeth[12]. Therefore, selective etching would be recommended when possible. However, to reduce the risk of post-operative sensitivity in all modes, G-Premio BOND has been designed to wet the dentin optimally and to seal the dentinal tubuli, even when the dentin has been etched.

Recommendation to light-cure the adhesive for an optimal performance

It is recommended to light-cure the bonding agent on the tooth surface[13]. This will promote a stronger bond due to a higher conversion without interfering with the adaptation of the crown as the thickness of the G-Premio BOND is only 3 µm (Figure 4).

In cases where an efficient light-cure is not possible such as in root canals, G-Premio BOND should be mixed with G-Premio Bond DCA (dual cure activator) and left longer on the tooth (total 20 seconds) prior to air-drying.

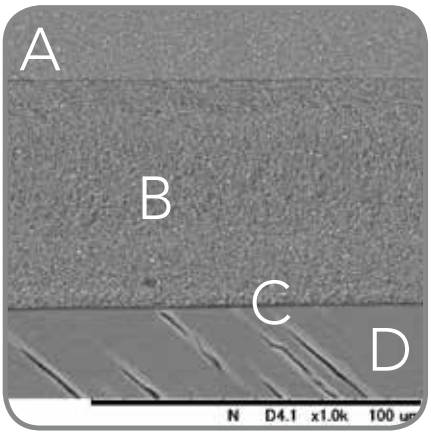


Figure 4: SEM picture of a Cerasmart restoration (A) bonded to dentin (D) using G-Premio Bond(C) and G-CEM LinkForce (B).
Source: GC Corporation R&D,

Separating the bonding agent from the primer: the choice for resistance

It is recommended not to use G-Premio BOND on the restoration for the following reasons:

1. G-Premio BOND does not contain silane. Silane is needed for the adhesion to ceramics. Internal tests have shown that when silane is added to a self-etching adhesive, it becomes less effective after thermocycling (Cf. page 11).
2. In case the bonding is also applied on the restoration, light-curing would be needed. These two polymerized bonding layers (one on the tooth and one on the restoration) together could interfere with the adaptation of the crown.
3. G-Premio BOND should not be used with the dual cure activator (DCA) on the restoration because the DCA will also triggers a faster setting of the cement. This might lead to maladaptation of the crown onto the tooth due to partially set cement.

For these reasons, G-Multi PRIMER has been developed to offer a stable adhesion to the restoration (Part 2.2)

2.1.1 G-Premio BOND DCA

As mentioned above, G-Premio BOND can be safely light-cured when luting indirect restorations as the adhesive film, as thin as 3µm, will not interfere with the adaptation of the crown.

However, when G-Premio BOND is not light-cured, it should be mixed with the G-Premio BOND DCA (Figure 5, Table 3). This is principally recommended when luting posts. Given this indication, DCA will ensure sufficient polymerisation of G-Premio BOND in the deep canals that cannot be reached sufficiently by light.

Figure 5: G-Premio BOND DCA.

G-PREMIO BOND DCA
Initiator
Distilled water
Ethanol

Table 3: General composition of G-Premio BOND DCA

2.2 G-Multi PRIMER

To further simplify the luting process, a universal primer, G-Multi PRIMER will be used to pre-treat ALL restoration materials (Figure 6, Table 4).

G-Multi PRIMER contains functional monomers to bond to every restoration: silane is added to bond to glass ceramics, hybrid ceramics and composites fillers, while MDP will ensure adhesion to zirconia, alumina and non-precious metals and MDTP will ensure a strong adhesion to precious metal (figure 6). The stability of the adhesion is assured because the components do not interfere with the silane coupling[14].

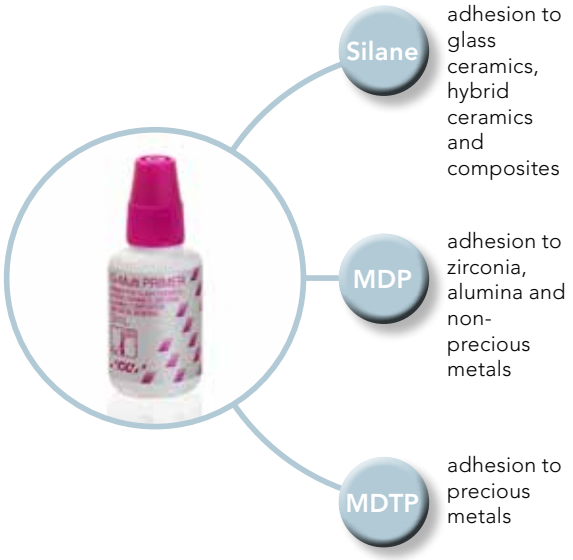


Figure 6: Functional components of G-Multi PRIMER.

G-MULTI PRIMER
Ethanol
Methacryloyloxydecyl Dihydrogen Phosphate (MDP)
Methacryloyloxydecyl dihydrogen thiophosphate (MDTP)
γ-Methacryloxypropyl trimethoxysilane (Silane)
Methacrylate monomer

Table 4: General composition of G-Premio BOND DCA

2.3 G-CEM LinkForce

G-CEM LinkForce (Figure 7, Table 5) is a dual cure resin cement that can be used for all purposes:

Featuring a high filler rate of 62 vol.%, G-CEM LinkForce has been designed to offer a high flexural strength for a strong adhesion over time.

The barium fillers of 300 nm are evenly dispersed in the matrix to ensure low film thickness and high wear resistance. This will also provide a high polishability of the margins; thereby reducing the risk of plaque accumulation and improving the marginal stability in time, especially in case of occlusal margins.
An optimal wettability and viscosity ensure that the paste spreads evenly, with an exceptional film thickness of just 4 µm. This further secures an excellent adaptation of the prosthetic restorations and reduces the risk of need for occlusion adjustment. Recent studies have shown that the amount of light going though prosthetic restorations is highly variable depending on the material and the thickness used[15].

G-CEM LinkForce has been therefore designed to offer outstanding dual-cure performance, ensuring efficient polymerisation in both light-cure and self-cure mode.
Available in four shades (Translucent, A2, Opaque and Bleach) with tooth-like fluorescence and colour stability over time, all aesthetic challenges are covered (Figure 8).
With the easy automix system to dispense the resin cement directly into the restoration or in the root canal with an endo tip, handling of the material is very convenient.

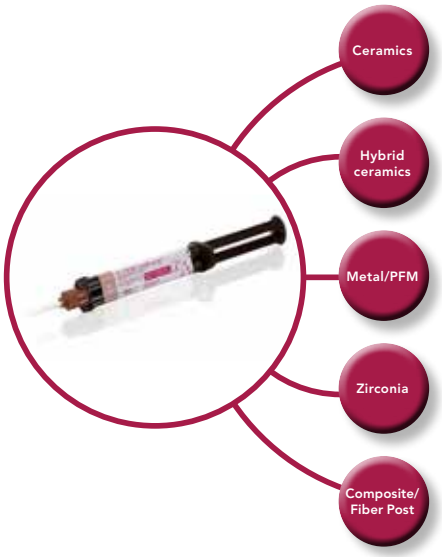


Figure 7: Indications of G-CEM LinkForce Composite Paste

G-CEM LINKFORCE	
Paste A	Paste B
bis-GMA	bis-MEPP
Urethanedimethacrylate	Urethanedimethacrylate
Dimethacrylate	Dimethacrylate
Barium glass	Barium glass
Initiator	Initiator
Pigments	

Table 5: General composition of G-CEM LinkForce Composite Paste

Translucent
(clear translucent)

A2
(A2 translucent)

Opaque
(universal opaque)

Bleach
(bleach opaque)

Figure 8: Shades of G-CEM LinkForce

2.3.1 Try-in Paste

Try-In Pastes (Figure 9, Table 6) are used to test the selected shade before the final cementation with G-CEM LinkForce to predict the aesthetic outcome after cementation. The shades of the Try-in Paste accurately match the final cured shade of G-CEM LinkForce. Dispense G-CEM LinkForce Try-In Paste into internal surface of the restoration and seat onto preparation. Check fit, occlusion and aesthetics of the restoration. Thereafter, remove the restoration and clean the inner surface thoroughly with water to remove all remnants of the Try-in Paste.

Figure 9: G-CEM LinkForce Try-in Paste

TRY-IN PASTE
Glycerol
Silicon dioxide
Pigments

Table 6: General composition of G-CEM LinkForce Try-in Paste

3 Indications for use

Placement of indirect restorations is considerably simplified with G-CEM LinkForce, since one standardised procedure can be used for most common cases, with one universal primer for all surfaces. Hence, G-CEM LinkForce is an extremely versatile solution for all indications (Figure 10):

- **Inlays, onlays, crowns and bridges**
  Strong and stable bond ensures proper retention of the restoration, even on non-retentive preparations. The excellent wear properties ensure marginal stability over time, even at the occlusal margins. GC G-CEM LinkForce performs excellent in the self-cure mode, which is important for restorations where the light cannot sufficiently pass through to rely solely on light-curing. This is the case for restoration with a relatively high opacity and/or when a higher thickness is required.

- **Veneers**
  Bonding and cement can be efficiently light-cured and show excellent optical properties, with natural fluorescence and colour stability over time in four different shades (Translucent, A2, Opaque and Bleach).

- **Posts and cores**
  The self-etching adhesive can efficiently etch the dentin, even in deep canals. Addition of the DCA ensures sufficient polymerization of G-Premio Bond, while the low viscosity and excellent self-cure properties of LinkForce ensure perfect adaptation of the post while maintaining a strong and durable adhesion.

courtesy of Dr. Jacobo Mattiusi

courtesy of Dr. Max Cordelette

courtesy of Dr. Olivier Etienne

courtesy of Dr. Rafal Medzin

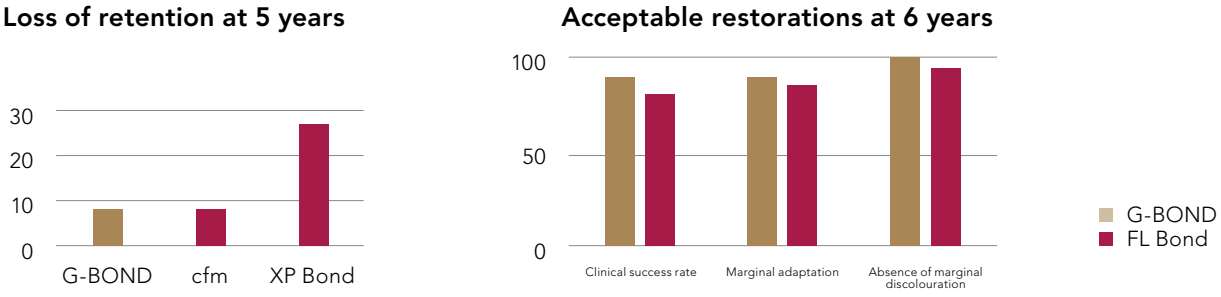
Figure 10: Various indications of G-CEM LinkForce.

4 Scientific research on G-CEM LinkForce

4.1 Clinical research on the adhesive

G-Premio BOND evolved from G-BOND maintaining its proven clinical performance: in a randomized clinical trial at KU Leuven, it has been shown that after nine years of clinical function, G-BOND had similar retention rates (89,5% vs. 90,3%) as the etch-and-rinse adhesive Optibond FL* (Kerr) that is still regarded as the gold standard[6].

Similarly, van Dijken *et al.* have reported retention rates over 90% after 5 and 6 years, by which G-BOND achieved one of the best reported clinical dentin bonding performances, in line with the best etch-and-rinse adhesives (Figure 11)[16,7].



Adapted from: JWV Van Dijken, Dent Mater 2013; 29:e271-280.

Adapted from: JWV Van Dijken, Dent Mater 2013; 29:e271-280.

Figure 11: For the clinical function of G-Premio BOND, one can rely on the excellent retention rates and clinical function of its predecessor G-BOND after 5 and 6 years, respectively.*Source: Van Dijken, Dent Mater 2013 (a and b).

** G-BOND is a trademark from GC. Optibond FL, cfm, XP Bond and FL Bond are not trademarks of GC.*

4.2 Stability of the silane coupling

Research conducted at the University of Okayama has demonstrated that the effect of silane coupling incorporated in universal adhesives is not very effective and stable, most likely because an acidic solution promotes dehydration condensation (Figure 12)[14]. For this reason, the silane coupling agent, which promotes bonding to ceramics and composites, has been added to the restoration primer (G-Multi PRIMER), to assure stable and reliable bonding.

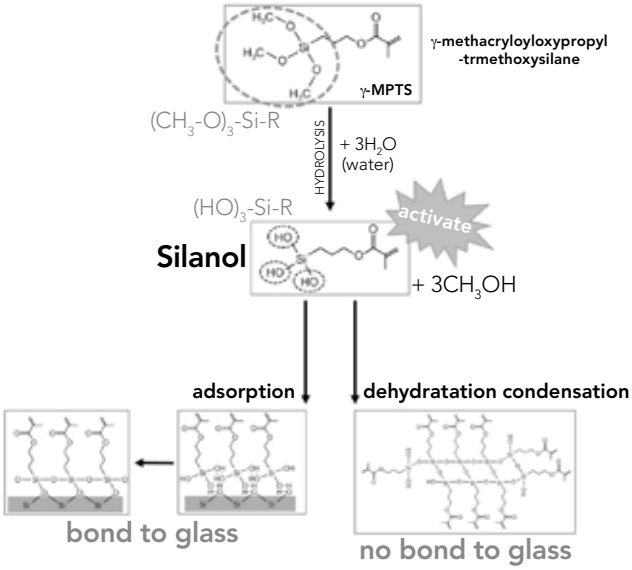


Figure 12: Schematic diagram of the chemical interaction of a silane coupling agent with glass-rich materials. Incorporating the silane in the universal adhesive lead to dehydration condensation, by which it can no longer bond to glass.

Source: adapted from Yoshihara *et al.*, Dent Master2016.

4.3 Bond strength

G-CEM LinkForce exhibits excellent bond strength to various substrates, which makes it suitable for minimally invasive preparations with low retention (Figure 13).

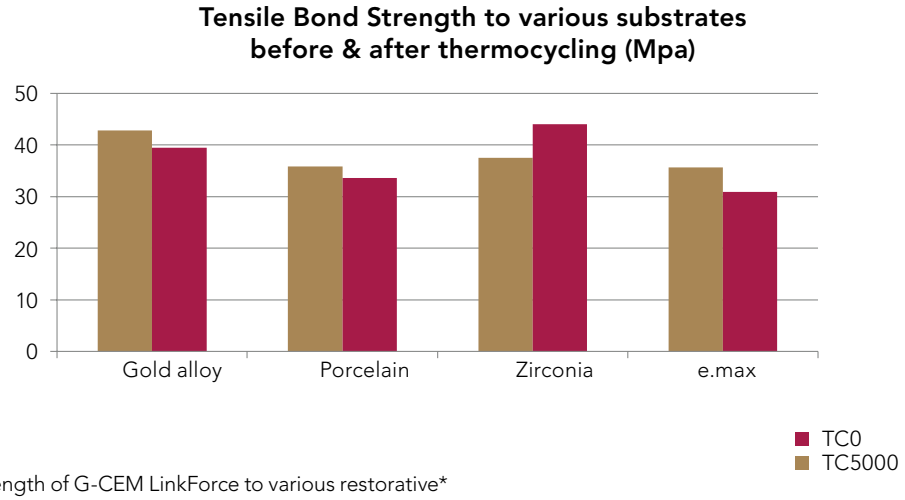


Figure 13: Bond strength of G-CEM LinkForce to various restorative*
Source: GC Corporation R&D, 2015

Method: The bond strength was tested for all substrates and restorative materials[17]. Teeth were abraded with #320 SiC paper and a bonding area of 2.5 mm, while other substrates were abraded with #1500 SiC paper and a bonding area of 3.0 mm, respectively.
Specimens were bonded with the resin cement in self-cure mode. Tensile bond strength was measured according to ISO 11405: 2003, immediately after bonding and after thermo-cycling (5°C-55°C) for 24h. The tests results showed excellent strength in self-cure mode.

4.3.1 Bond strength to zirconia

Thanks to the presence of MDP18in the composition of G-Multi PRIMER, a stable adhesion can be achieved. The ageing process can be simulated by the use of thermocycling in in vitro tests.

Method from figure 14, 15, 16, 17 and 18: Surfaces were abraded with #1500 SiC paper. Specimens were bonded in with one of the six resin cements in self-cure mode. Tensile bond strength was measured according to ISO 11405: 2003, immediately after bonding and after thermo-cycling (5°C-55°C) for 24h.

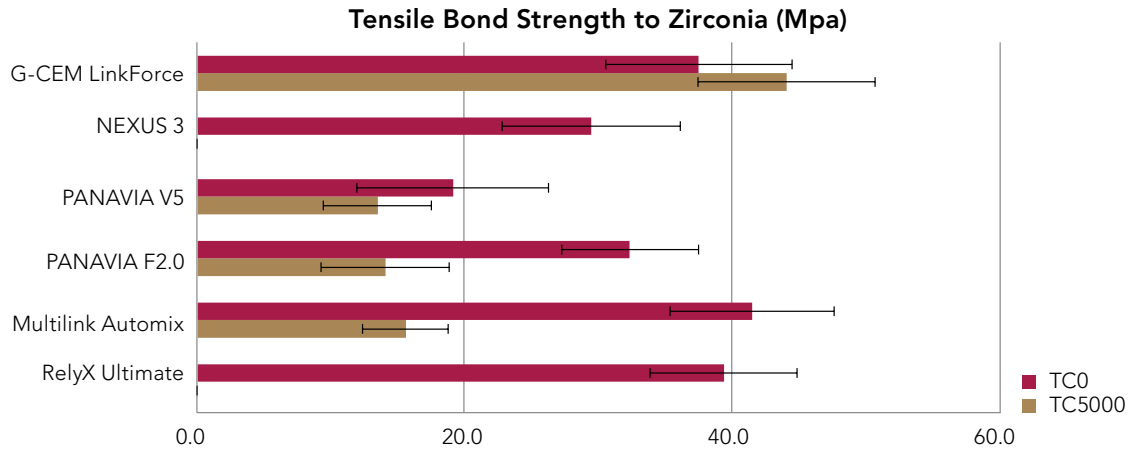


Figure 14: Bond strength of G-CEM LinkForce to zirconia in comparison to different competitors before and after thermocycling (N=5000 cycles)* Source: GC Corporation R&D, 2015

*e.max, NEXUS3, PANAVIA V5, PANAVIA F2.0, Multilink Automix, Relyx Ultimate and Calibra are not trademarks of GC.

4.3.2 Bond strength to ceramics and hybrid composites

In order to be truly universal in use, and especially with regard to low-retentive restorations such as veneers or overlays, G-CEM LinkForce demonstrates high bond strengths on a large variety of substrates, including glass ceramics, lithium disilicate (such as Initial LiSi Press, GC) and hybrid ceramics such as CERASMART (GC) (Figures 15-17). Because the silane is not added to the adhesive but is incorporated in a separate restoration primer, the bond to these materials remains stable[19] over time. Ageing is simulated in the lab by thermocycling.

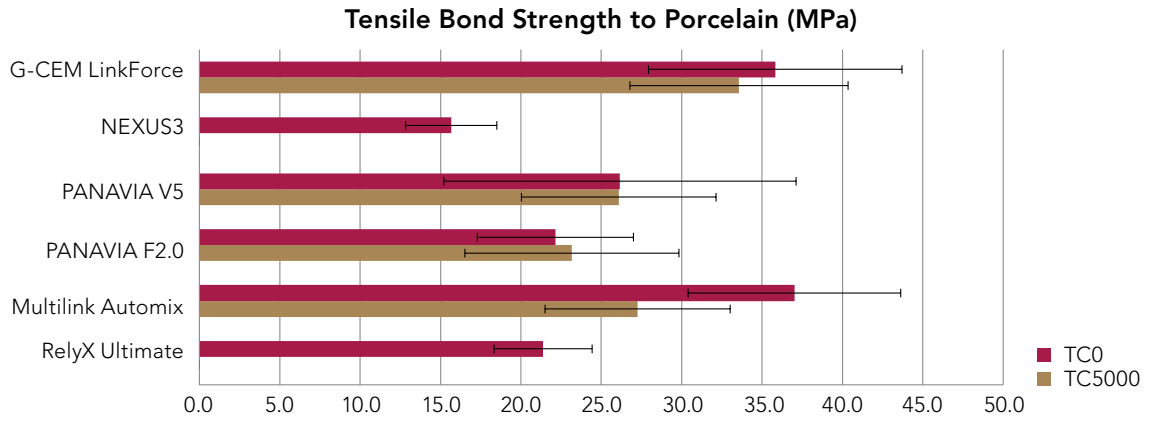


Figure 15: Bond strength of G-CEM LinkForce to glass ceramics in comparison to different competitors, before and after thermocycling (n=5000 cycles)

Source: GC Corporation R&D, 2015

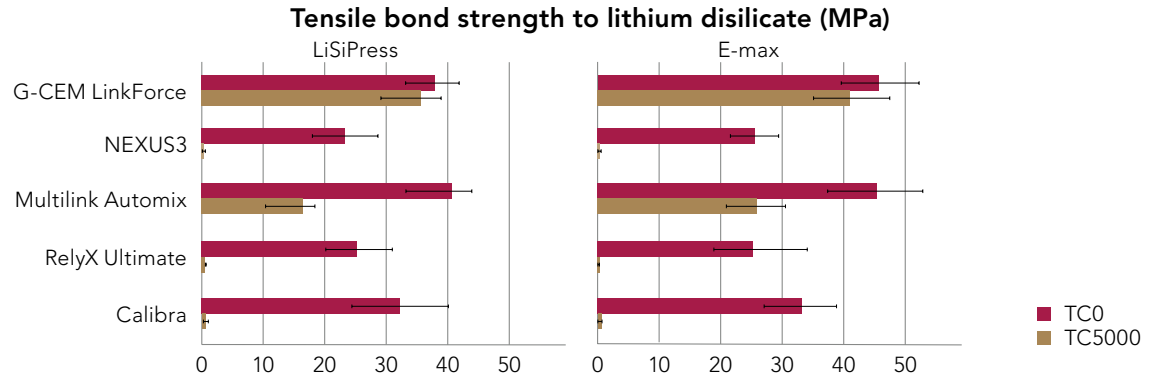


Figure 16: Bond strength of G-CEM LinkForce to lithium disilicate (Initial LiSi Press, GC and IPS e.max Press, Ivoclar-Vivadent) in comparison to different competitors, before and after thermocycling (n=5000 cycles)

Source: adapted from Fujimori *et al.*, Dent Mater 2016. 32S:e29 (#56). GC Corporation data.

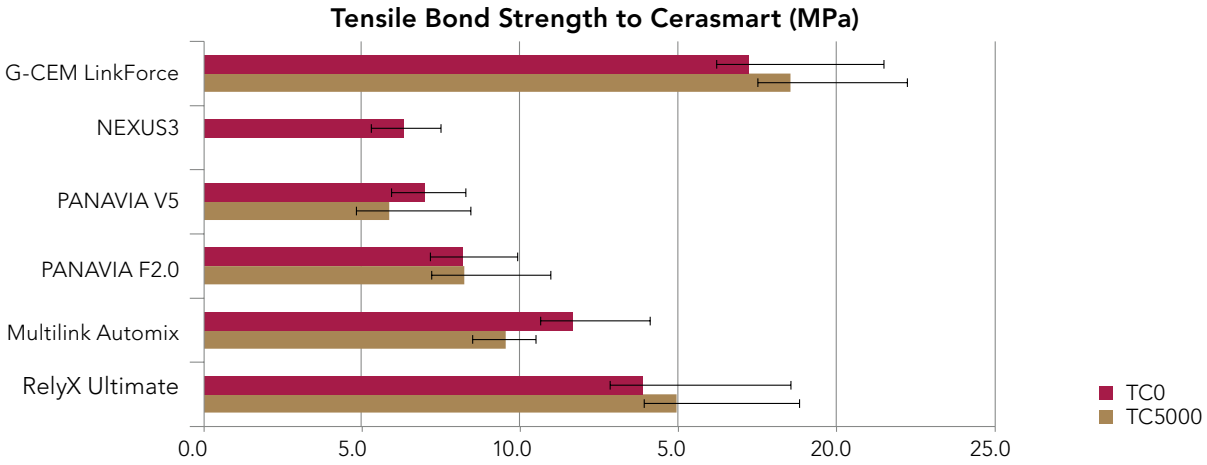


Figure 17: Bond strength of G-CEM LinkForce to Cerasmart in comparison to different competitors, before and after thermocycling (n=5000 cycles)

Source: GC Corporation R&D, 2015

4.3.3 Bond strength to gold alloy

Unlike most primers currently available, G-Multi Primer also contains methacryloyloxydecyl dihydrogen thiophosphate (MDTP) which gives to the primer the ability to bond to non-precious metals, such as platinum, palladium and gold (Figure 18). This feature makes G-Multi PRIMER a truly versatile product and provides further universal indication to the G-CEM LinkForce system.

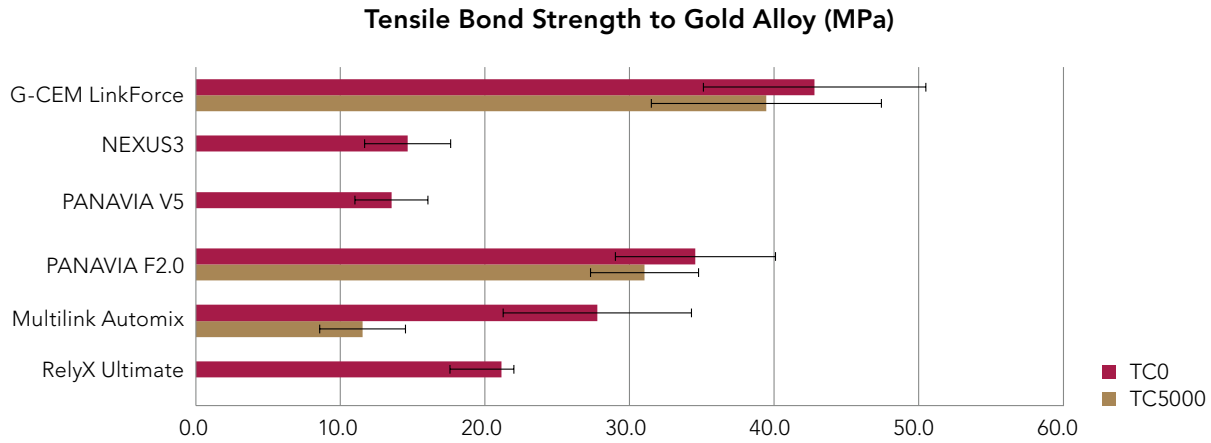


Figure 18: Bond strength of G-CEM LinkForce to gold alloy in comparison to different competitors, before and after thermocycling (n=5000 cycles)

Source: GC Corporation R&D, 2015

4.4 Film thickness

With G-CEM LinkForce, a very low film thickness (Figure 19) can be obtained thanks to the ultra-fine fillers, which is crucial for the seating and marginal adaptation of the restoration. The adaptation is further ensured by the very low film thickness of G-Premio BOND. The uniformity of the bonding layer is also favored by the light-curing of the bonding agent before application of the cement. (Figure 20)

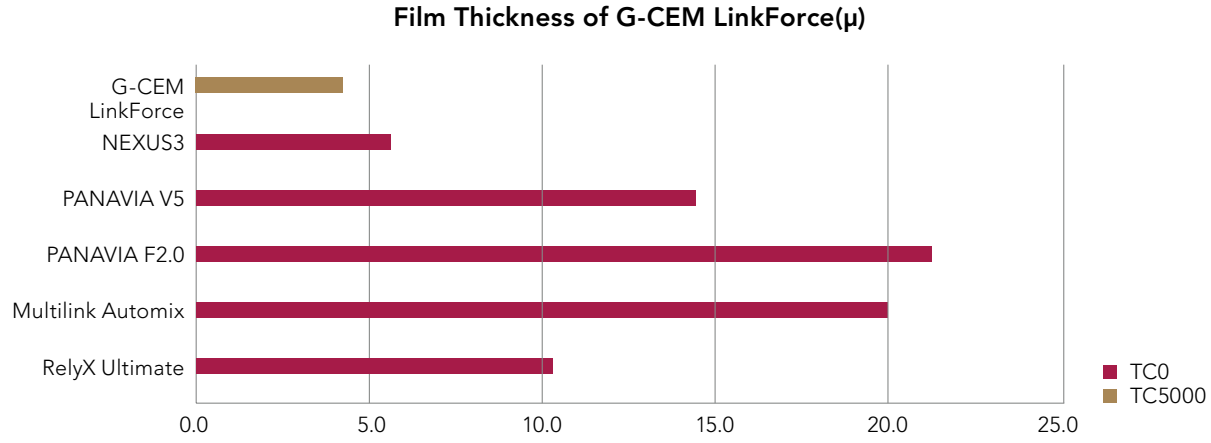


Figure 19: Film thickness of G-CEM LinkForce in comparison with competitive resin cements.

Source: GC Corporation R&D, 2015

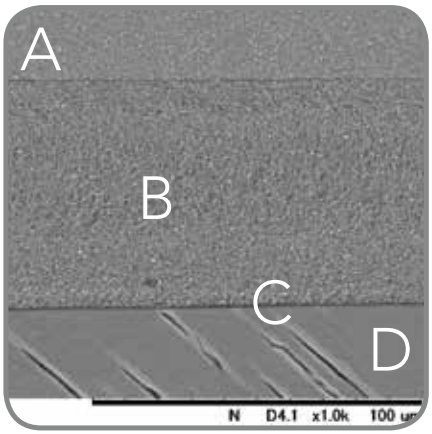


Figure 20: SEM picture of a Cerasmart restoration (A) bonded to dentin (D) using G-Premio Bond(C) and G-CEM LinkForce (B).
Source: GC Corporation R&D,

4.5 Efficient polymerisation in both curing modes

To be able to use a luting agent for all purposes, **it is crucial that it works properly in the absence of light**, as many indirect restorations do not allow sufficient light to pass[15]. In many cases, the luting agent is dependent on its self-curing ability (Figure 21).

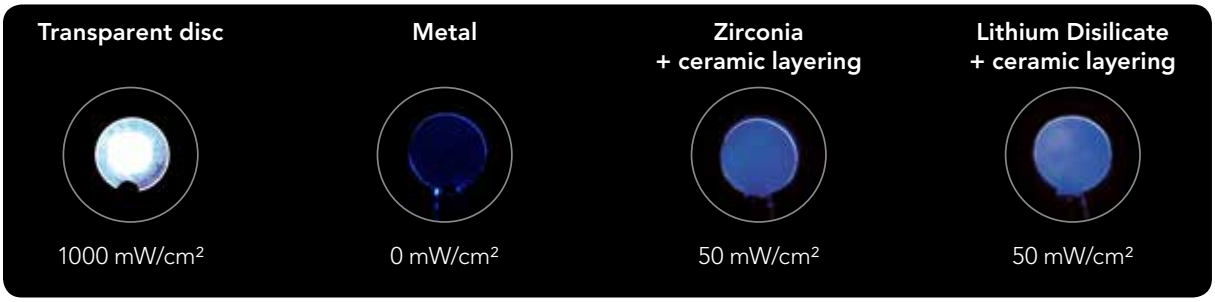


Figure 21: Light attenuation through different kinds of indirect restorative materials.
Source: Pereira *et al.*, São Paulo University, Brazil

Results:

- 1 mm metal: NO light transmission
- 0.4 mm Zirconia, layering up to 2 mm (in total): Very low light transmission (50 mW/cm²)
- 0.5 mm e.Max Ceramic plus layering up to 2 mm (in total): Very low light transmission (50 mW/cm²)

Radical formation

The quantity of radicals that is formed, influences the conversion rate and consequently the mechanical properties. **The polymerization initiators** in G-CEM LinkForce **are very potent, forming a high proportion of radicals. The high amount of radicals formed accounts for the excellent mechanical properties in self-cure mode:** the high strength and surface hardness ensure very low abrasion and wear, high bond strengths and good colour stability.

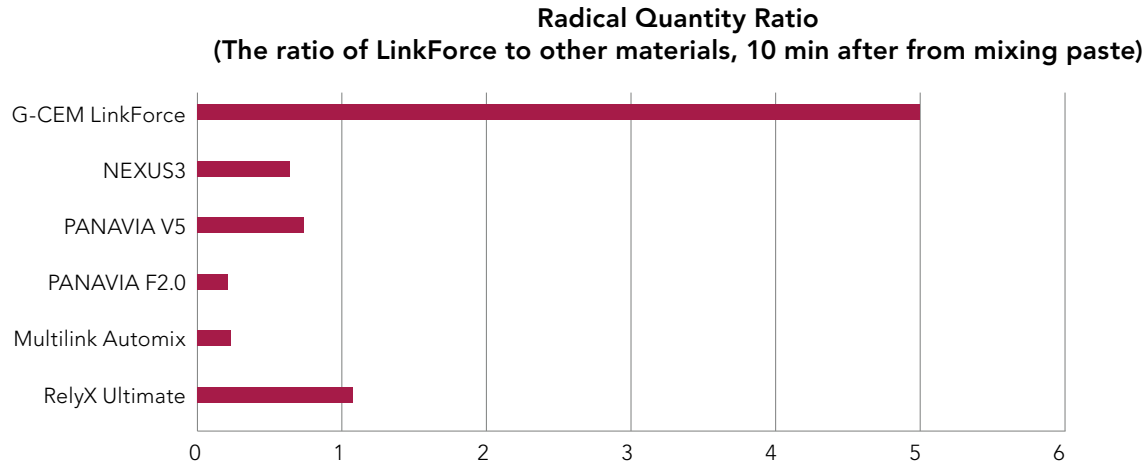


Figure 22: The relative proportion of radicals formed, 10 minutes after mixing.
Source: GC Corporation R&D, 2015.

4.5.1 Vickers hardness in self cure mode

In a study conducted at the National and Kapodistrian University of Athens, Vickers hardness of G-CEM LinkForce and three competitive resin cements were measured in self-cure mode after 10 min, 1h and 3 weeks. The excellent hardness values of G-CEM LinkAce and G-CEM LinkForce are related to **their polymerization efficiency in self-cure mode** (Figure 23).

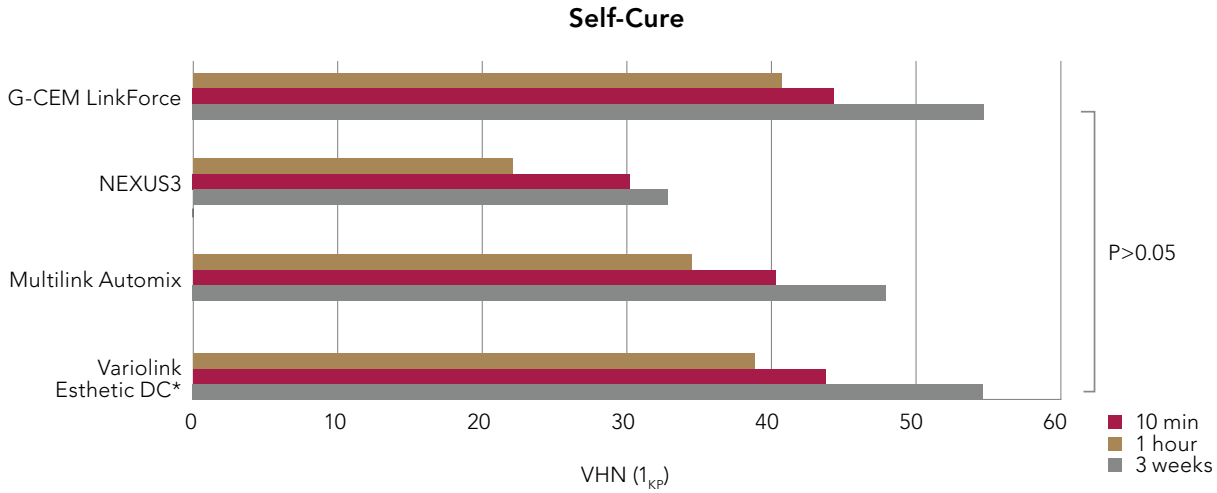


Figure 23: Histogram (means and standard deviations) of the VHN1kp measurements for the materials tested in SC mode after 10 min,1 h and 3 w storage. Horizontal lines connect mean values without statistical significant differences (P>0.05).
Source: Zinelis *et al.*, J Dent Res, 2017; 96B: #0289 CED.

**Variolink Esthetic DC is not a trademark of GC.*

4.5.2 Flexural strength in light-cure vs. self cure mode

The high flexural strength found with G-CEM LinkForce in both curing modes reflects its proper conversion in both polymerization modes (Figure 24).

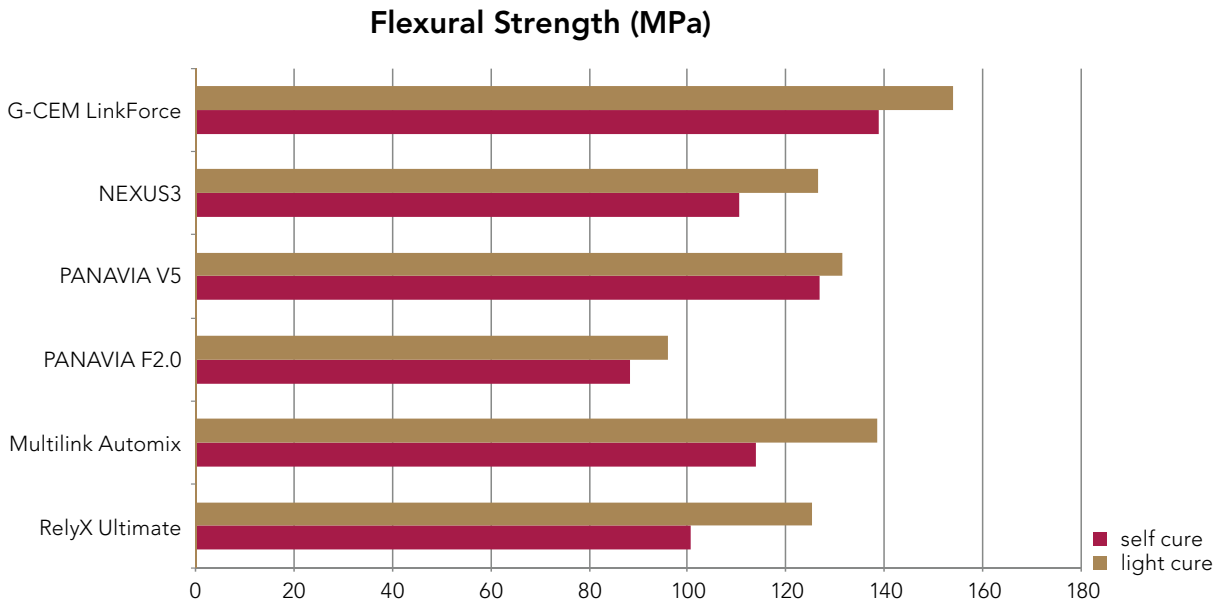


Figure 24: Flexural strength of various resin cements in light-cure vs. self cure mode.
Source: GC Corporation R&D, 2015.

4.5.3 Occlusal wear in light-cure vs. self cure mode

Thanks to the high concentration of ultra-fine fillers homogeneously dispersed in the resin matrix, G-CEM LinkForce shows excellent resistance to occlusal wear, ensuring the marginal stability, which is especially important for occlusal margins. When the luting cement wears out, marginal chipping of the restoration can occur due to lack of support, as was seen in a study with a **competitive luting cement** (Figure 25)[20].

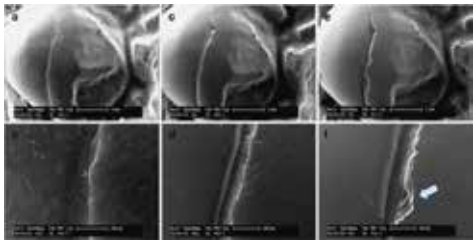


Figure 25: Example of very small fractures of the porcelain margin occurred due to wearing out of a competitive luting composite (large arrow).
Source: Peumans *et al.*, Clin Oral Investig. 2013

In the case of G-CEM LinkForce, the wear resistance is extremely high, even in self-cure mode. (Figure 26)

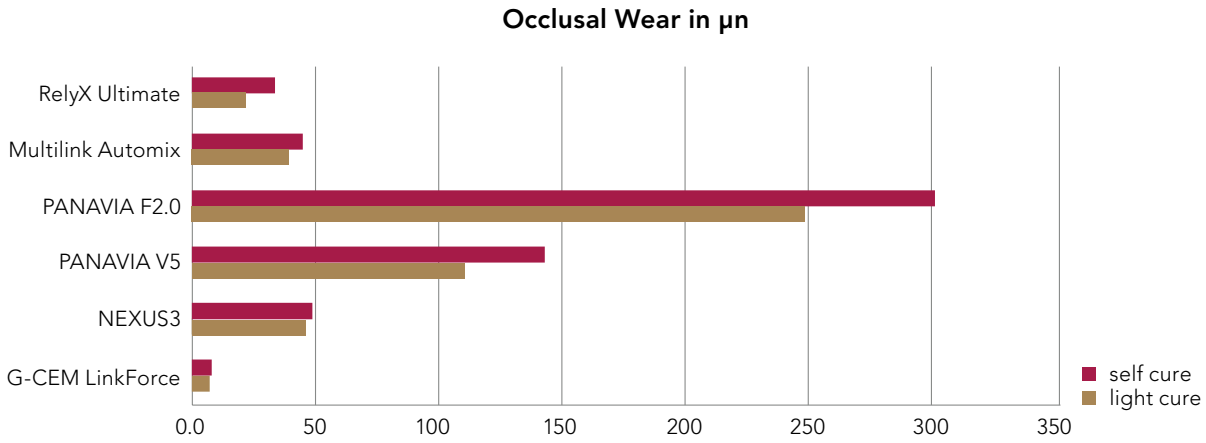


Figure 26: Occlusal wear of various resin cements in self cure vs. light-cure.
Source: GC Corporation R&D

In a recent study at Nihon University (Japan)[21], gap wear of 5 different resin cements was evaluated using a Leinfelder-Suzuki wear simulator (100000 cycles, max. 80N). Among all resin cements, G-CEM LinkForce showed the least volume loss (mm^3) (Figure 27) and a more shallow facet depth (µm) among all resin cements in the respective curing modes (light-cure or self cure), confirming the excellent wear resistance of G-CEM LinkForce.

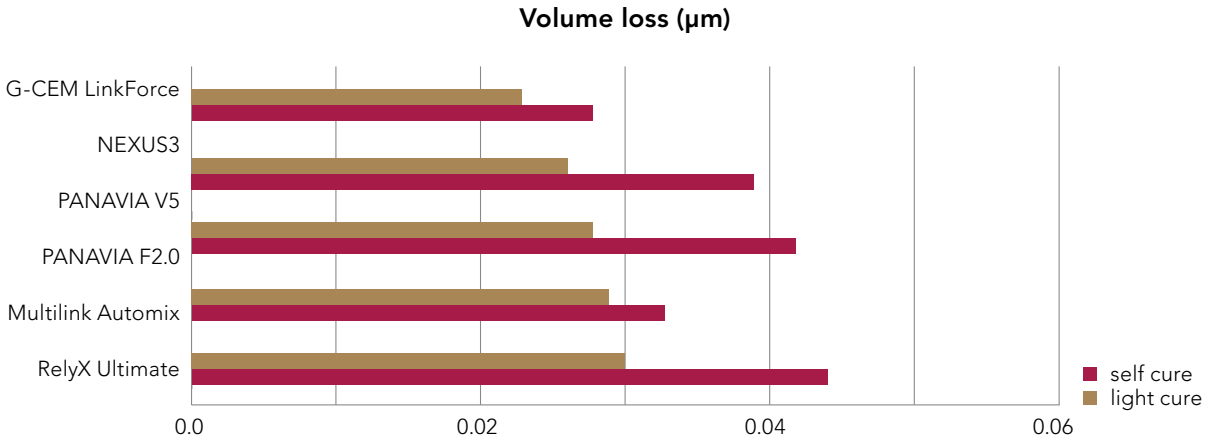


Figure 27: Simulated Gap Wear of Resin Luting Cements
Source: Adapted from Tsujimoto *et al.*, Oper Dent 2017

4.5.4 Bond strength with or without DCA

G-Premio BOND maintains sufficient bond strength with DCA (Figure 28), which is important when G-CEM LinkForce is being used in areas were insufficient light can reach the adhesive, principally when a post is luted into the root canal. For the adhesive cementation of indirect restorations, G-Premio BOND can be used in the light-cure mode, as the film thickness is merely 3 µm.

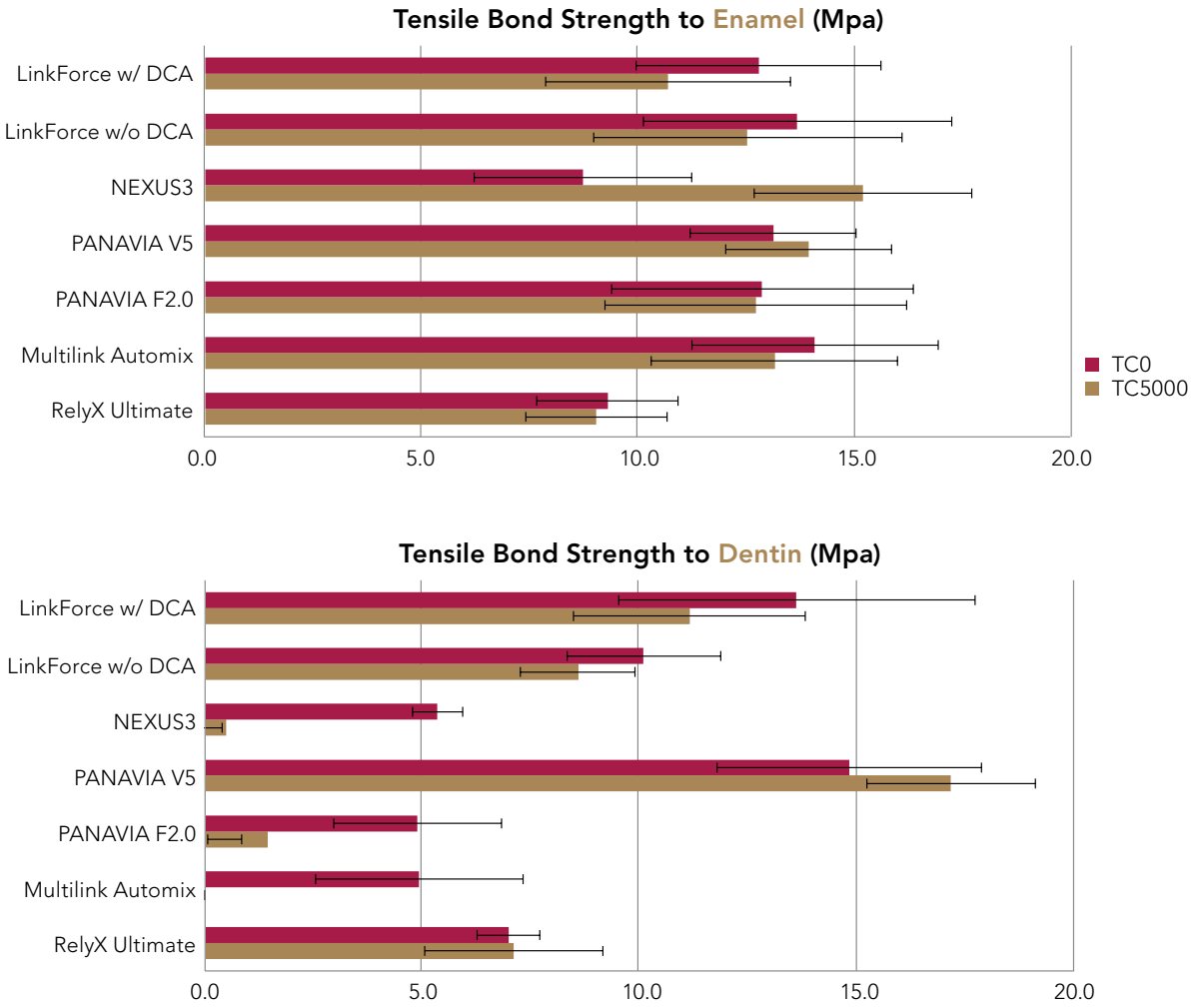


Figure 28: Bond strength of G-CEM LinkForce to dentin and enamel in comparison to different competitors, before and after thermocycling (n= 20.000 cycles).

Source: GC Corporation R&D

Method: Surfaces were abraded with #320 SiC paper. Specimens were bonded in with one of the six resin cements in self-cure mode; G-CEM LinkForce was used with or without DCA, respectively. Tensile bond strength was measured according to ISO 11405: 2003, immediately after bonding and after thermo-cycling (5°C-55°C) for 24 h.

4.6 Filler technology

Thanks to the ultra-fine, homogeneously distributed filler particles, a higher wear resistance and a low film thickness can be obtained, with high polishability and wear resistance (Figure 29). These are important criteria to avoid accumulation of plaque at the margins. They also provide the radiopacity necessary to diagnose of secondary caries.

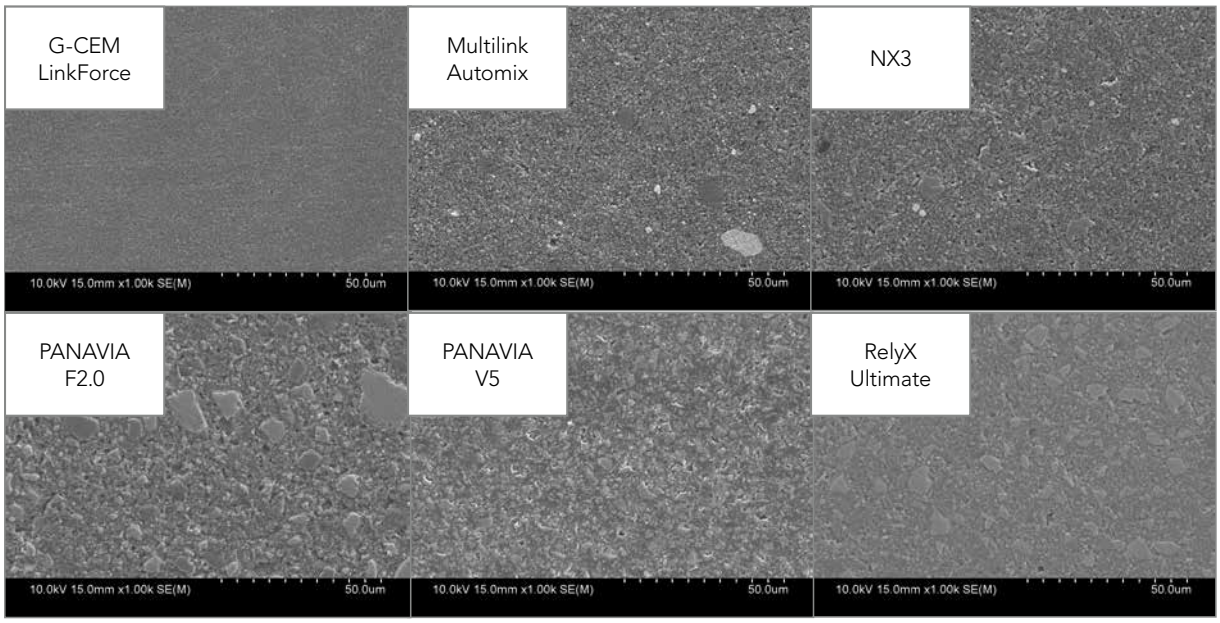


Figure 29: SEM images showing the filler distribution.
Source: GC Corporation R&D

In a recent study at Tohoku University (Japan)[22], surface roughness and occlusal wear of 4 different resin cements was evaluated after three-body wear test. In this study, the filler characteristics affected the surface roughness and the wear resistance. Among all resin cements, G-CEM LinkForce showed lower surface roughness (Figure 30) and significantly higher wear resistance.

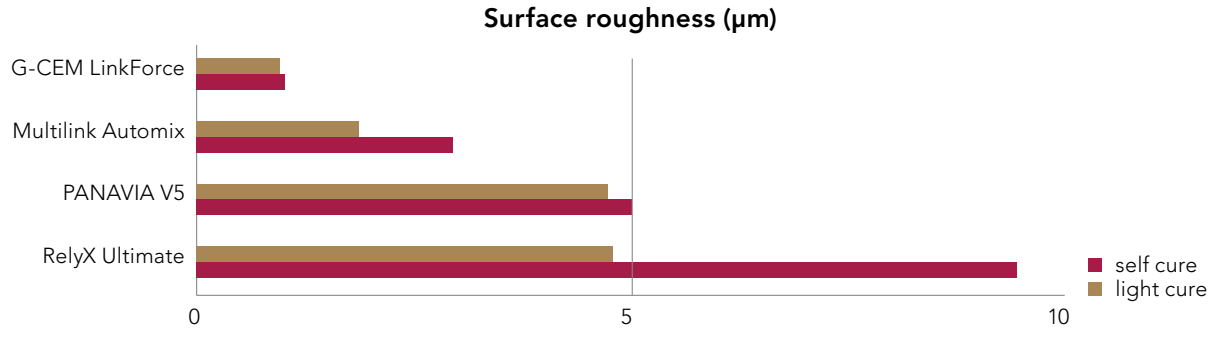


Figure 30: Surface roughness of Resin Luting Cements
Source: Adapted from Akiyama *et al.*, J Dent Res 2016

4.7 Aesthetic properties

4.7.1 Colour stability

G-CEM LinkForce shows higher colour stability in light curing mode than other resin cements, except for amine free cements because it can form a high-density polymer network due to high-quality initiators. Hence, no aesthetic compromises have to be made and thus it can be safely used for restorations in the anterior area, guaranteeing long-lasting aesthetic results (Figures 31-32).

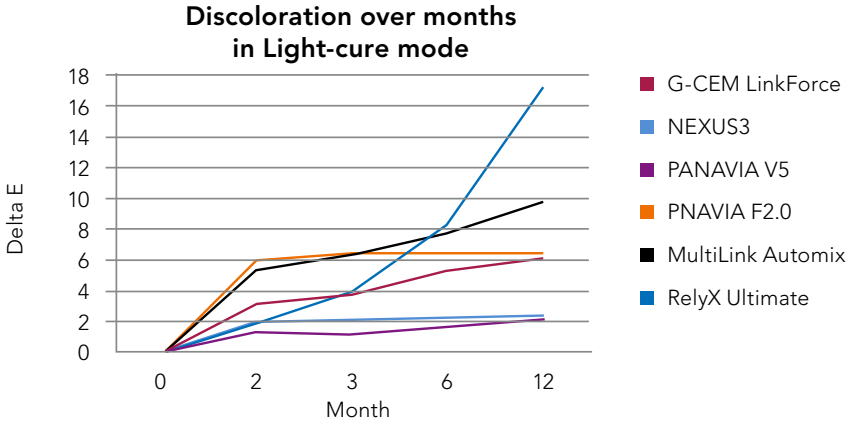


Figure 30: Discolouration (ΔE) over time of different resin cements. G-CEM LinkForce shows very little discolouration over time and thus can be safely used in the anterior area.
Source: GC Corporation R&D, 2015

Method: Cylindrical samples of 1 mm thickness were light-cured and stored at 37°C in water. The colour stability was photographically evaluated initially and after 3, 6 and 12 months, respectively.

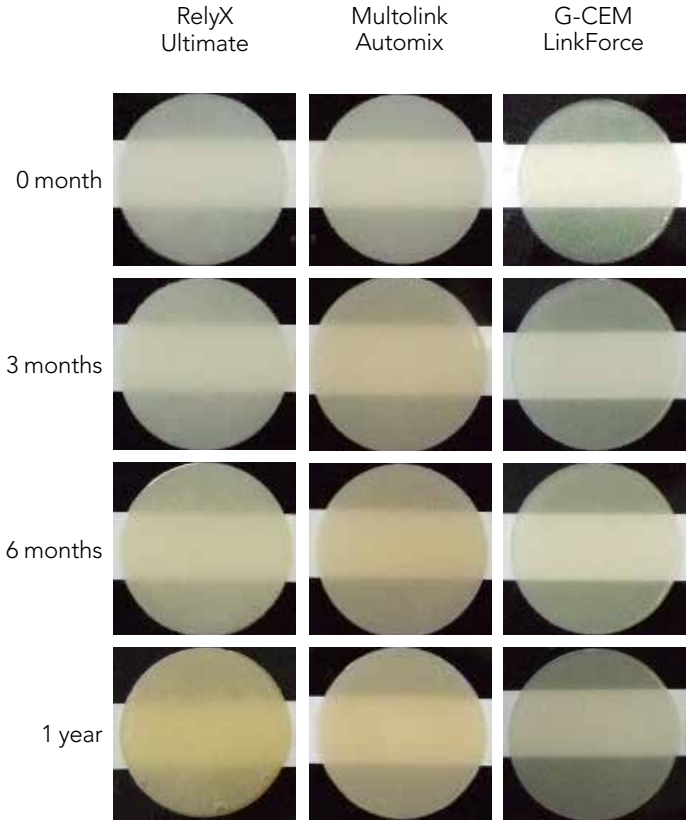


Figure 31: Colour stability of three resin cements.
Source: GC Corporation R&D, 2015

4.7.2 Fluorescence

G-CEM LinkForce exhibits a fluorescence that is very close to the natural tooth, as can be seen below. This is an essential aspect as it contributes directly to the final aesthetic result (Figure 33).

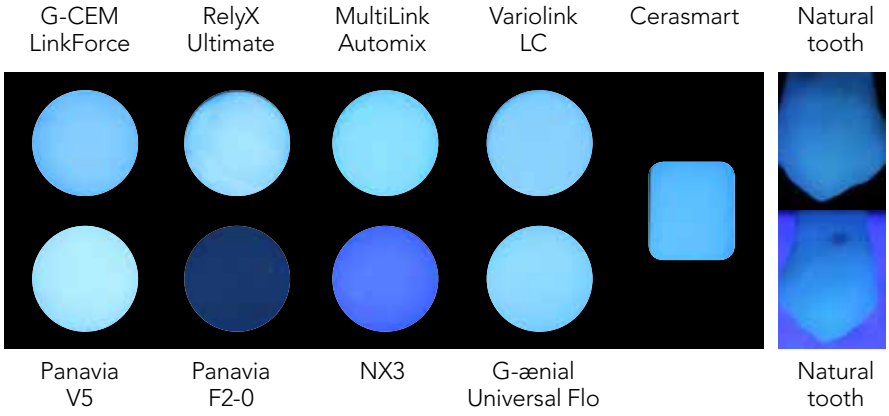


Figure 33: Fluorescence of eight luting agents in comparison with CERASMART and natural tooth tissue.
Source: GC Corporation R&D, 2015

4.8 Radiopacity

Radiopacity is one of the main requirements for luting cements, as it facilitates interpretation and diagnosis on radiographs. The use of materials with a radiopacity lower than or similar to dentine can lead to diagnostic difficulties when analysing the marginal integrity and detecting secondary caries. In contrast, higher radiopacities, as in amalgam, can impede diagnostic discrimination in areas covered by a restoration and e.g. cause streak artifacts on CBCT images. G-CEM LinkForce shows an optimal radiopacity, that allows sufficient discrimination with dental tissues and caries lesions.

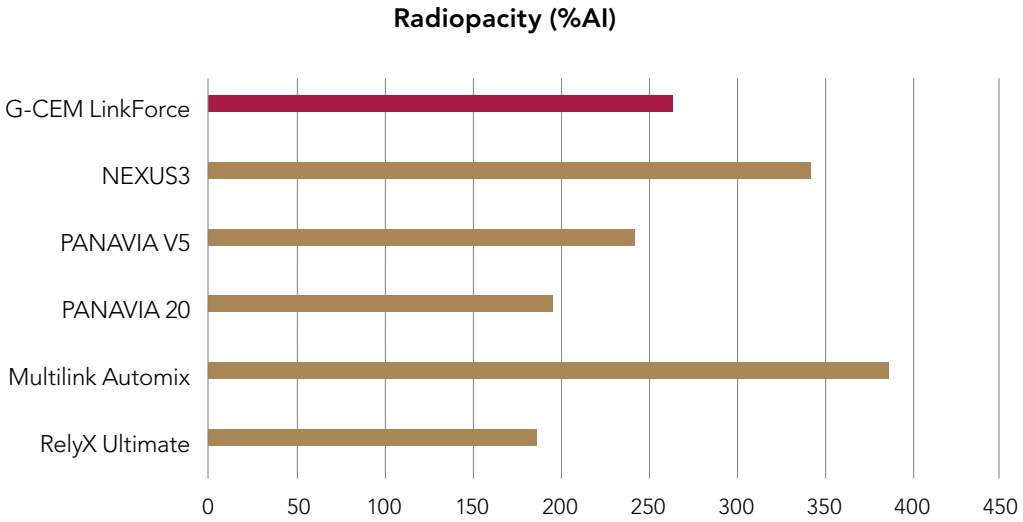


Figure 34: Radiopacity of G-CEM LinkForce in comparison to different competitors.
Source: GC Corporation R&D, 2015

5 Step-by-step procedures

5.1 Pretreatment guide for indirect restoration

5.1.1 PRE-TREATMENT OF GLASS- CERAMIC RESTORATION (FELDSPATHIC CERAMICS, LEUCITE-REINFORCED CERAMICS & LITHIUM DISILICATE). EXAMPLE: GC INITIAL LRF (LEUCITE-REINFORCED CERAMICS) GC INITIAL LISI PRESS (LITHIUM DISILICATE))

Etch with hydrofluoric acid (~ 5-9%) for 60 sec. in case of feldspatic & leucite-reinforced ceramics and for 20 sec. in case of lithium disilicate.

Rinse and dry.

Apply G-Multi PRIMER.*1

Dry with an air syringe.

5.1.2 PRE-TREATMENT OF METAL & PORCELAIN FUSED TO METAL RESTORATION. EXAMPLE: GC INITIAL CAST NP WITH GC'S VENEERING CERAMIC GC INITIAL MC

If not done by the lab, sandblast (Al_2O_3 ≤ 50µm).

Rinse and dry.

Apply G-Multi PRIMER.*2

Dry with an air syringe.

5.1.3 PRE-TREATMENT OF ZIRCONIA OR ALUMINA RESTORATION. EXAMPLE: GC INITIAL ZIRCONIA DISK

If not done by the lab, sandblast (Al_2O_3 ≤ 50µm).

Rinse and dry.

Apply G-Multi PRIMER.*3

Dry with an air syringe.

5.1.4 PRE-TREATMENT OF COMPOSITE RESTORATION. EXAMPLE: GC GRADIA PLUS

If not done by the lab, sandblast (Al_2O_3 ≤ 50µm).

Rinse and dry.

Apply G-Multi PRIMER.*4

Dry with an air syringe.

5.1.5 PRE-TREATMENT OF HYBRID CERAMIC RESTORATION. EXAMPLE: GC CERASMART

If not done by the lab, sandblast (Al_2O_3 ≤ 50µm). Alternatively, for CERASMART, if you don't have a sandblaster, apply hydrofluoric acid for 60 sec.

Rinse and dry.

Apply G-Multi PRIMER.

Dry with an air syringe.

5.1.6 PRE-TREATMENT OF FIBER POST. EXAMPLE: GC FIBER POST

Clean with alcohol.

Dry.

Apply G-Multi PRIMER.

Dry with an air syringe.

5.2 Cementation technique for inlay, onlay, crown and bridge

5.2.1 TRIAL FIT

Remove the temporary restoration and clean thoroughly.

Check the fit & occlusion. As necessary, use G-CEM Try-In Paste.

Remove the restoration and rinse with water.

5.2.2 PRE-TREATMENT OF GLASS- CERAMIC RESTORATION

Etch with hydrofluoric acid.

Rinse and dry.

5.2.3 METAL, ZIRCONIA, ALUMINA, HYBRID CERAMICS & COMPOSITE

Sandblast*
*For CERASMART, alternatively apply hydrofluoric acid.

Blow clean with air syringe. Rinse and dry.

Apply G-Multi PRIMER.*[1]

Dry with an air syringe.

5.2.4 PREPARATION OF THE TOOTH SURFACE

Rinse and dry the prepared tooth.

Select from the three etching techniques: self etching, selective etching or total etching. Rinse and dry.

Apply G-Premio BOND. Wait 10 seconds.

Dry with a MAXIMUM AIR PRESSURE for 5 seconds.

Light cure for 10 seconds (Halogen/LED 700mW/cm^2).

5.2.4.2 ALTERNATIVE DUAL-MODE

Mix G-Premio BOND and DCA in a 1:1 ratio.

Apply G-Premio BOND. Wait 20 seconds.

Dry with a MAXIMUM AIR PRESSURE for 5 seconds.

5.2.5 CEMENTATION

Extrude G-CEM LinkForce directly into the restoration.

Immediately seat onto prepared tooth/abutment. Maintain moderate pressure.

Remove excess while maintaining moderate pressure. Excess can tacked cure for 1-2 seconds for an easier excess removal.

Light cure each surface/margin for 20 seconds (Halogen/LED 700mW/cm^2).

If light-curing is not used, let it set for 4 minutes after seating. Finish and polish margins if necessary.

5.3 Cementation technique for veneer

5.3.1 TRIAL FIT

Remove the temporary restoration and clean thoroughly.

Check the fit & occlusion. As necessary, use G-CEM LinkForce Try-In Paste.

Remove the restoration and rinse with water.

5.3.2 PREPARATION OF THE CERAMIC RESTORATION

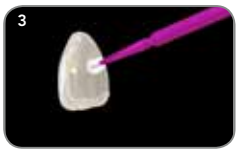
Etch with hydrofluoric acid.

Rinse and dry.

5.3.3 HYBRID CERAMICS & COMPOSITE

Sandblast*
*For CERASMART, alternatively apply hydrofluoric acid.

Blow clean with air syringe. Rinse and dry.



Apply G-Multi PRIMER.

Dry with an air syringe.

5.3.4 PREPARATION OF THE TOOTH SURFACE


Rinse and dry the prepared tooth.


Select either Selective Etch or Total Etch technique.


Rinse and dry.

5.3.4.2 LIGHT-CURE MODE


Apply G-Premio BOND. Wait 10 seconds


Dry with a MAXIMUM AIR PRESSURE for 5 seconds.


Light cure for 10 seconds (Halogen/LED 700mW/cm^2).

5.3.5 CEMENTATION

Apply directly the cement to the bonding surface of the veneer and/or tooth surface.


Immediately seat onto prepared tooth. Maintain moderate pressure.


Remove excess while maintaining moderate pressure. Excess can tacked cure for 1-2 seconds for an easier excess removal.


Light cure each surface/margin for 20 seconds (Halogen/LED 700mW/cm^2).


Finish and polish the margins.

5.4 Cementation technique for posts and cores

5.4.1 PREPARATION OF THE RESTORATION

Prepare the restoration according to the manufacturer's instructions.

Clean with alcohol.

Apply G-Multi PRIMER.

Dry with an air syringe.

5.4.2 PREPARATION OF POST SPACE

Clean the root canal with NaClO or EDTA. Rinse and thoroughly dry.


Mix G-Premio BOND and DCA in a 1:1 ratio.

Apply the mixture to the post space and leave for 20 seconds.

Dry with a MAXIMUM AIR PRESSURE for 5 seconds. Remove any excess bonding agent using paper points.

5.4.3 CEMENTATION

Extrude G-CEM LinkForce into the post space.

Insert post immediately into the post space. Remove excess cement.

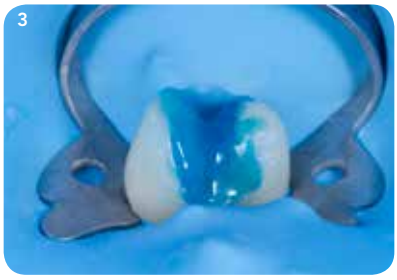
Light cure each surface/margin for 20 seconds (Halogen/LED 700mW/cm2).

Let the material undisturbed for 4 minutes after inserting the post. Continue to build up.

6 Clinical cases

Dr. Etienne O, France

After removal of the temporary restoration on 24 and the temporary composite inlay on 25, the prepared surfaces are cleaned with aqueous solution of chlorhexidine. The inlay is inserted with a glycerine try-in paste. This trial fit step is purely aesthetic and adaptational. No occlusal adjustment can be considered before bonding.



Orthophosphoric acid etching is started first on enamel and then on dentin in order to meet the respective recommendations of 30 seconds and 15 seconds for the two tissues.

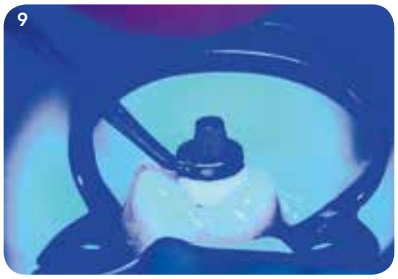
Thorough rinsing and delicate drying complete this stage of preparation of the tooth surfaces.

The G-Premio BOND Universal Adhesive is collected by agitating well a microbrush inside the unit dose. The adhesive is applied firmly to make it penetrate well into the etched enamel and dentine surfaces.

Finally, after spreading it with syringe strong air blow to avoid accumulation, the adhesive layer is light-cured.

After etching and silanisation of the ceramic inner surface, the inlay is coated with an Adhesive resin cement (G-Cem LinkForce) and positioned using a spatula before wiping the excess resin with a microbrush.

The inlay is then firmly pushed in with a flexible end instrument.



Slight excess of resin cement is intentionally left in place and light-curing is performed while maintaining pressure on the inlay.

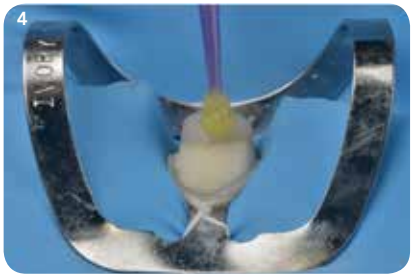
After removal of the rubber dam, the finishing of the margins is gently performed and the whole restoration-tooth complex is checked before proceeding to the bonding of the neighbouring prosthetic element. A control at one week confirms the periodontal health and occlusal function.

Dr. Saiz-Pardo AJ, Spain

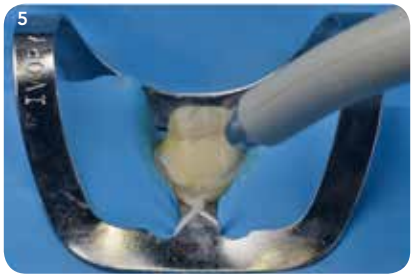
Preoperative view of the Class IV fracture of tooth #21. The core was first built up.

Restoration pretreatment with G-Multi PRIMER.

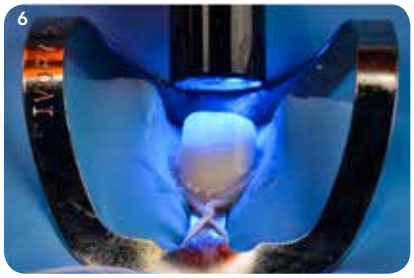
After core build-up and preparation, the all-ceramic crown was etched using a total-etch technique.



G-Premio BOND is a universal adhesive that ensures a predictable bond with all etching modes. The universal adhesive G-Premio BOND was applied to the preparation, then left undisturbed for 10 seconds.

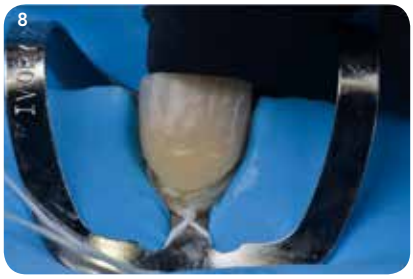


Before being air dried with maximum air pressure for 5 seconds.



The universal adhesive G-Premio BOND was then light-cured for 10 seconds.

Following pre-treatment of the restoration with G-Multi Primer, G-CEM LinkForce universal dual-cure adhesive resin cement—which is available in four shades (i.e., A2, Bleach, Opaque, Translucent), along with corresponding try-in pastes, to accommodate all aesthetic cementation requirements—was extruded directly into the crown.

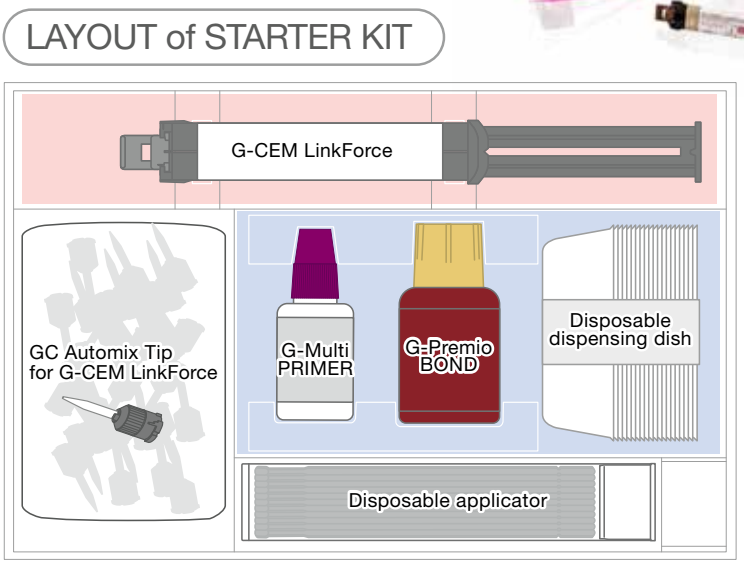


The crown was immediately seated onto the preparation, and pressure was maintained to allow extrusion of excess cement.

Postoperative view of the restoration cemented with G-CEM LinkForce universal adhesive resin cement. All excess of G-CEM LinkForce could be removed atraumatically from gingival and interproximal areas, maintaining a healthy gingiva and long-lasting functionality.

7 Packaging

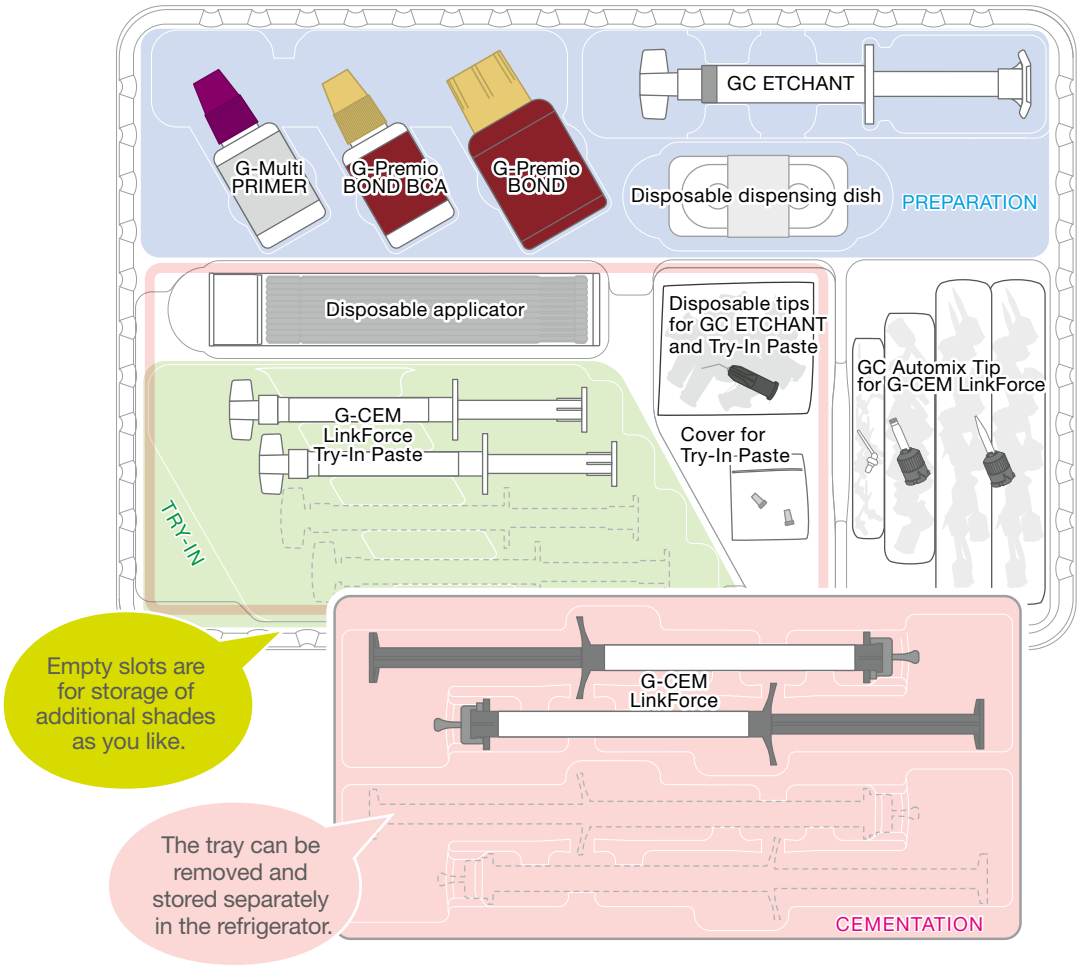
7.1 Starter Kit



ART NUMBER	DESCRIPTION	CONTENT
009542	GC G-CEM LinkForce Starter Kit A2	G-CEM LinkForce A2 8.7g (5mL) x 1 G-Premio Bond Bottle 5mL x 1 G-Multi PRIMER Bottle 5mL x 1 GC Automix Tip Regular x 20 Disposable dispensing dish Disposable applicators
009543	GC G-CEM LinkForce Starter Kit TR	G-CEM LinkForce TR 8.7g (5mL) x 1 G-Premio Bond Bottle 5mL x 1 G-Multi PRIMER Bottle 5mL x 1 GC Automix Tip Regular x 20 Disposable dispensing dish Disposable applicators

7.2 System Kit

LAYOUT of SYSTEM KIT



ART NUMBER	DESCRIPTION	CONTENT
009540	GC G-CEM LinkForce System Kit	G-CEM LinkForce A2 8.7g (5mL) x 1 G-CEM LinkForce TR 8.7g (5mL) x 1 G-CEM Try-In Paste A2 1.5g (1.2mL) x1 G-CEM Try-In Paste TR 1.5g (1.2mL) x1 G-Premio Bond Bottle 5mL x 1 G-Premio Bond DCA Bottle 3mL x 1 G-Multi PRIMER Bottle 5mL x 1 GC Etchant GC Automix Tip Regular x 20 Dispensing tips for GC Etchant and Try-In Paste x 20 Disposable dispensing dish Disposable applicators Light protective cover

7.3 Refills

ART NUMBER	DESCRIPTION	CONTENT
009544	G-CEM LinkForce Cement Refill A2	G-CEM LinkForce 8.7g (5mL) x 1 GC Automix Tip Regular x 20
009545	G-CEM LinkForce Cement Refill TR	
009546	G-CEM LinkForce Cement Refill Opaque	
009547	G-CEM LinkForce Cement Refill Bleach	
009548	G-CEM Try-In Paste A2	
009549	G-CEM Try-In Paste TR	G-CEM LinkForce Try-In Paste 1.5g (1.2mL) x 1 Dispensing Tip Needle Type x 3 Dispensing Cover x 1
009550	G-CEM Try-In Paste Opaque	
009551	G-CEM Try-In Paste Bleach	
009036	GC G-Premio BOND, 5mL Bottle Refill	G-Premio Bond Bottle 5mL x 1
009552	G-Premio BOND DCA 3mL Refill	G-Premio Bond DCA Bottle 3mL x 1
009553	G-Multi PRIMER 5mL	G-Multi PRIMER Bottle 5 mL x 1

8 References

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