kuraray

Noritake

PANAVIA™ SA Cement Universal

SUMMARY OF IN-VITRO AND IN-VIVO STUDIES

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EDITORIAL (R&D)

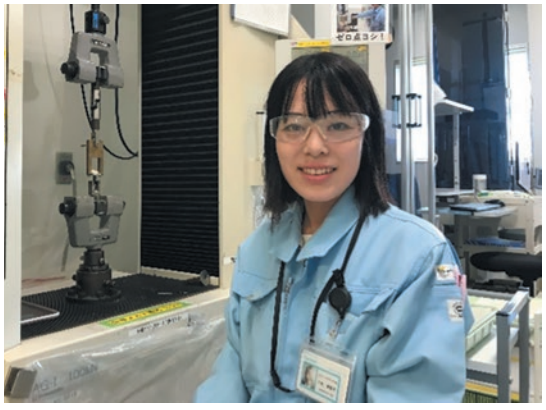
Creating additional value for users – this is the aim of every new product development project initiated by Kuraray Noritake Dental Inc. (Kuraray Noritake Dental). When PANAVIA™ SA Cement Universal was launched in 2019, several self-adhesive resin cements were already available. However, we had never provided our customers with a single-component solution for silica-based ceramics. Instead, it was necessary to treat silica-based ceramics with a primer containing a silane coupling agent before cement application.

With all-ceramic restorative materials on the rise, however, the R&D team at Kuraray Noritake Dental had identified the need for a dental resin cement that adheres to various restorative materials including the popular silica-based ceramics without the need for a separate primer. For this reason, we decided to develop a new universal self-adhesive resin cement that meets precisely this need. Our solution: the incorporation of an unreacted (long carbon-chain) silane coupling agent – the LCSi monomer – in a resin cement paste. The other paste contains the original MDP monomer, which is not only responsible for a strong chemical bond to tooth structure, metals, oxide ceramics (like zirconia) and composite resins, but also activates the LCSi monomer upon contact of the two pastes during mixing due to its acidity. Once activated, the LCSi monomer enables the material to adhere to silica-based ceramics without requiring primer treatment. And as the long carbon chain in the monomer molecule makes the adhesive interface hydrophobic, the hydrolysis of this chemical bond can be suppressed and long-term chemical adhesion can be expected.

The major benefit of this technology is obvious: The cementation procedure of silica-based ceramics is simplified. Users do not have to think about multiple steps and suitable material combinations, but simply apply a single component. This consistent single-step application also leads to a reduction of the technique sensitivity and treatment time.

So far, the ability to bond to silica-based ceramics without the need for a second component is a unique feature of PANAVIA™ SA Cement Universal. This might be due to the fact that it is quite challenging to incorporate a silane coupling agent in a resin cement paste, while maintaining the storage stability at room temperature. By using the proprietary LCSi monomer and carefully aligning the other components to the system, this mission has been successfully accomplished at Kuraray Noritake Dental.

On the following pages, mainly external scientific study results are presented that reveal why you may trust the innovative single-component cementation system.



Mariko Sugiura, Manager

INTRODUCTION

From mechanical retention to chemical adhesion: The widespread use of modern indirect restorative materials like ceramics and resins puts high requirements on cementation systems. Modern adhesive or self-adhesive resin systems need to support the aesthetics of the often highly translucent tooth-coloured restorative material over time and they need to establish a strong and long-lasting bond between the tooth structure and the restorative material for different reasons.
Reason # 1 is that minimally invasive restorations often lack sufficiently retentive elements. Reason # 2 is that even crowns with a sufficiently retentive preparation design may be at higher risk of losing retention when cemented with conventional materials[1]. And finally, reason # 3 is that materials with a flexural strength under 350 MPa are strengthened by an adhesive cementation system[2-4].

For these reasons, anyone planning to start working with a new self-adhesive resin cement or adhesive cementation system should gather information about its bonding behaviour. This bonding behaviour is best assessed in long-term clinical studies; however, a lot of time and work is involved in obtaining the desired clinical data. Laboratory testing, on the other hand, allows researchers to retrieve much more detailed information in a short time span. That is why a huge number of different in-vitro tests is usually carried out before and after a product's launch. For universal dual-cure self-adhesive resin cements like PANAVIA™ SA Cement Universal, these tests should shed light on bonding to different substrates, including enamel and dentin in different conditions (wet and dry), glass ceramics, resin-based materials and oxide ceramics (zirconia). In addition, the performance in the light-cure and self-cure mode needs to be tested and aging needs to be simulated to obtain information about the long-term bonding performance.

But what is the best test procedure that should be used to assess and compare the bonding performance of self-adhesive resin cements? In fact, different companies, universities and testing institutes have their own way of testing the materials. They make use of a selected shear or tensile bond strength test method, which may differ from each other with regard to the testing apparatus, the sample preparation, test geometry and many other factors. As a consequence, the determined values are never absolute, and performance comparisons should only be carried out within a single study. Inter-study comparisons, on the other hand, will most probably be misleading. For this reason, **we have compiled a collection of different in-vitro studies conducted by many different universities and testing institutes to provide for a solid data base that allow us to predict the clinical behaviour of PANAVIA™ SA Cement Universal** – used with diverse restorative materials and in different circumstances – always immediately and after some time in the oral cavity.

On top, we have summarized a clinical study – the first one with available data on zirconia crowns after two years in clinical service. The compiled data will give you an impression of how the material is going to behave in your dental office, so you can use it without any doubts.

IN-VITRO STUDIES

BONDING TO RESTORATIVE MATERIALS

Self-adhesive dual-cure resin cement, typically used without separate primers, needs to establish a strong and durable bond to tooth structure on one side and to the restorative material on the other. PANAVIA™ SA Cement Universal contains two specific monomers responsible for this: The Original MDP monomer establishing a particularly strong and long-lasting bond to enamel, dentin, metal and zirconia and the LCSi monomer, a long carbon-chain silane coupling agent. The latter monomer has been developed by Kuraray Noritake Dental Inc. to form a strong chemical bond with resin composite, porcelain and silica-type ceramics (like lithium disilicate), so that the need for a separate silane component (a primer or adhesive) is eliminated.

On the following pages, we will take a closer look on in-vitro studies analysing the bonding performance of PANAVIA™ SA Cement Universal to all kinds of restorative materials.

SILANE FUNCTION AND BONDING TO GLASS CERAMICS

The standard procedure recommended to optimize the bond strength of resin cements to silica-based (glass-based) restorative materials is etching of the intaglio surface with hydrofluoric acid followed by the application of a silane agent[5,6]. The hydrofluoric acid removes a part of the glassy matrix, which increases the surface available for bonding and enables micromechanical interlocking of the resin cement. Silanization of the etched surface is responsible for a coupling (chemical adhesion) between the inorganic phase of the ceramic and the organic phase of the resin. It increases the surface energy of the restorative material and the wettability of the resin cement[5,6].

PANAVIA™ SA Cement Universal has been developed to eliminate the need of a separate bottle of silane (glass ceramic primer). The key component that has been built into the resin cement for this purpose is the proprietary LCSi (long carbon-chain silane coupling agent) monomer.

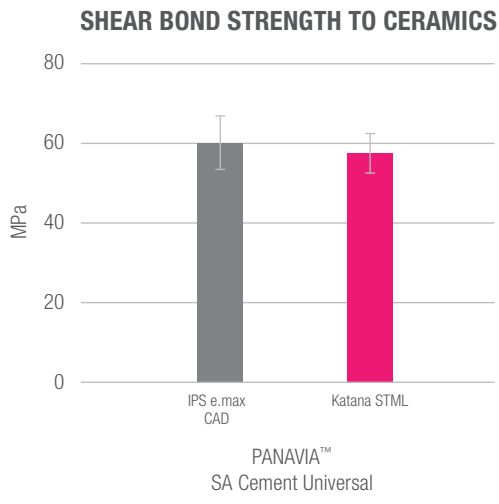
In order to find out if the formulation of PANAVIA™ SA Cement Universal is really capable of creating a strong bond to glass ceramics and lithium disilicate, different in-vitro studies have been conducted[6-10]. The results confirm that a high bond strength can be obtained without separate silane application and that an excellent long-term performance may be expected.

LITHIUM DISILICATE: HIGH INITIAL SHEAR BOND STRENGTH

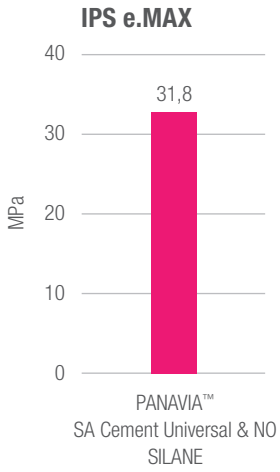
The DENTAL ADVISOR Biomaterials Research Center has performed laboratory testing to determine the shear bond strength of PANAVIA™ SA Cement Universal to lithium disilicate (as well as zirconia and dentin discussed in the respective sections) after 24 hours of storage in water[7]. The shear bond strength measured for PANAVIA™ SA Cement Universal (Kuraray Noritake Dental) used in the self-cure mode was high, although it was applied without a separate primer.

The researchers of the DENTAL ADVISOR came to the following conclusion: “PANAVIA™ SA Cement Universal with an incorporated silane primer has exceptional initial bond strength to dentin, lithium disilicate and zirconia.”[7]

Test conditions:
Bonded surface: Etched with 5% hydrofluoric acid gel
Storage in water (37° C) for 24 hours
Shear bond strength testing at a crosshead speed of 1 mm/min.
Universal testing machine: Instron model 5866



Even more different cementation systems were compared in a similar set-up[8]. Here, PANAVIA™ SA Cement Universal was applied in the self-curing mode, also without a separate primer. The results also show that the self-adhesive resin cement PANAVIA™ SA Cement Universal used without a separate primer performs very well.



Test conditions:
Bonded surface: Etched with hydrofluoric acid
Storage in water (37° C) for 24 hours
Shear bond strength testing

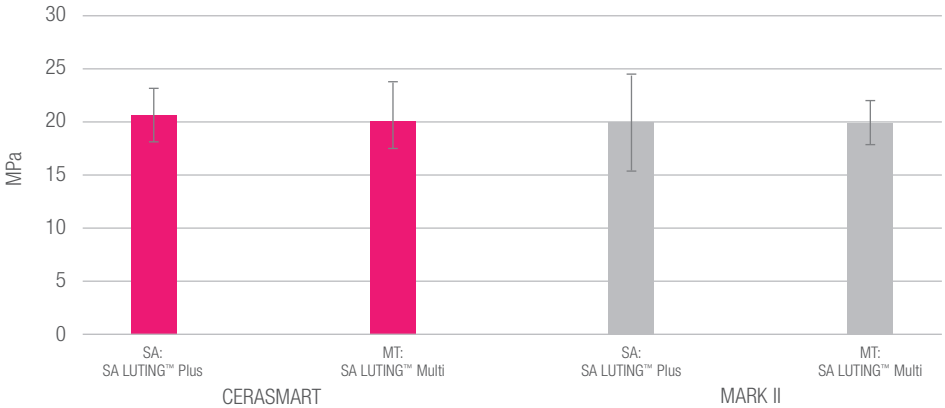
FELDSPATHIC CERAMICS: HIGH INITIAL TENSILE BOND STRENGTH

The fact that PANAVIA™ SA Cement Universal works well on feldspathic ceramic as well was confirmed in a second study conducted by a Japanese group of researchers[9]. Measuring the tensile bond strength of two resin cement systems used in the self-cure mode, they found that the obtained bond strength is at the same level.

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CURING MODE	CEMENT CATEGORY
SA LUTING™ Multi (Kuraray Noritake Dental)	--	Self-cure	Self-adhesive resin cement
SA LUTING™ Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS	Self-cure	Self-adhesive resin cement

RESULTS



Test conditions:
Bonded surface: Etched with hydrofluoric acid
200gf for 4 min
Storage in water (37° C) for 24 hours
Tensile bond strength testing

Products used in this research in Japan are equivalent of following ones in Europe:
SA LUTING™ Multi: PANAVIA™ SA Cement Universal.
SA LUTING™ Plus: PANAVIA™ SA Cement Plus.

LEUCITE REINFORCED GLASS CERAMICS: EFFICIENT SILANE COUPLING ABILITY

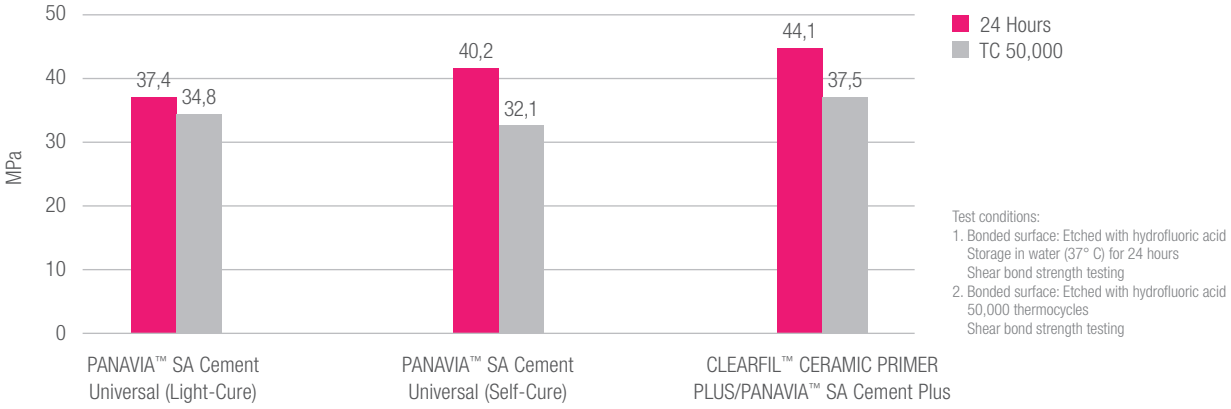
The laboratory testing carried out by a group of researchers from Japan and Belgium focused on the silane coupling ability of PANAVIA™ SA Cement Universal[10] – the property essential for bonding to glass ceramics. In one of various tests the group conducted, they determined the shear bond strength of the product after self-curing and after light-curing in comparison to a proven two-component system consisting of a self-adhesive resin cement plus primer immediately after bonding and after artificial aging.

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CURING MODE	CEMENT CATEGORY
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Light-cure	Self-adhesive resin cement
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Self-cure	Self-adhesive resin cement
PANAVIA™ SA Cement Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS	Light-cure	Self-adhesive resin cement

PANAVIA™ SA Cement Universal performed well in both curing modes:

IPS EMPRESS CAD SHEAR BOND STRENGTHS



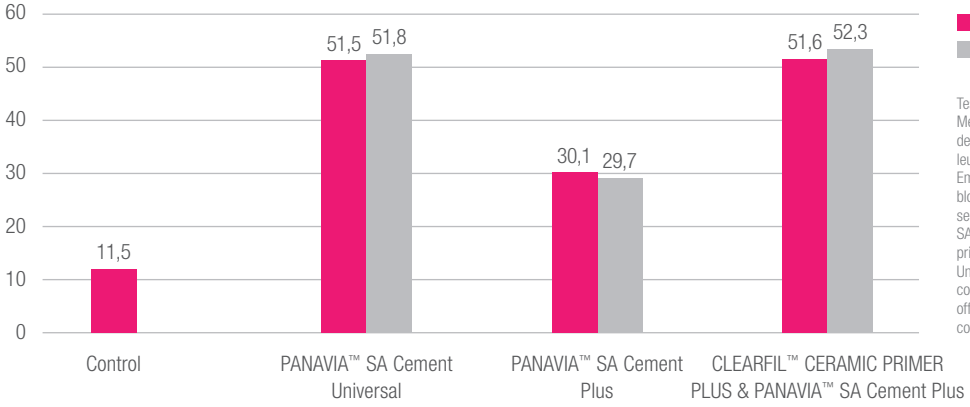
The results show that "the immediate & aged shear bond strength of PANAVIA™ SA Cement Universal (light-cure & chemical-cure) did not significantly differ from that of PANAVIA™ SA Cement Plus applied following a separate ceramic primer…".[10]

In order to find out more about the behaviour of the self-adhesive resin cement with built-in silane, the following additional laboratory tests were conducted by the group:

- **Contact angle of water (CA) of the treated ceramic surface**
  (revealing whether the cement or silane leaves a hydrophobic surface indicating efficient coupling ability of the incorporated silane)
- **Transmission electron microscopy (TEM)**
  (imaging technology used for a characterization of the resin cement-dentin interface)
- **X-ray diffraction (XRD)**
  (imaging technology used for a characterization of the resin cement-dentin interface)
- **29Si nuclear magnetic resonance (NMR)**
  (used for an analysis of the pastes prior to and during mixing)

The second test relevant for an evaluation of the bonding ability to glass ceramics is the contact angle of water test, which produced the following results:

CONTACT ANGLE OF GLASS SURFACE (DEGREES)



Test conditions:
Mean contact angles measured by deposition of a water drop onto the leucite-based glass-ceramic IPS Empress® CAD (Ivoclar Vivadent) blocks upon their exposure to the self-adhesive composite cements SAU and SAP, the latter also upon prior separate silanization (SAP CP). Untreated glass ceramic served as control. The cements were washed off using ethanol immediately prior to contact-angle measurement.

Based on these test results, the authors concluded that "the contact angle of PANAVIA™ SA Cement Universal treated glass ceramic did not significantly differ from that of PANAVIA™ SA Cement Plus treated glass ceramic that beforehand was pre-treated with a separate ceramic primer, but was significantly higher than the contact angle of PANAVIA™ SA Cement Plus treated glass ceramic."[10]

The analysis of the cement pastes sheds light on the mechanism of silane monomer activation. The paste-paste system contains the original MDP monomer plus hydrophilic monomers in one paste and the inactive LCSi monomer and hydrophobic monomers in the other. Upon mixing, the MDP monomer activates the silane essential for bonding to glass ceramics. The research summarizes their findings, concluding: "Si NMR revealed siloxane bonds after mixture, while only methoxy groups were detected before mixing, indicating that upon cement mixing hydrolysis and condensation of silane monomers occurred."[10]

Based on the complete data set obtained from the different tests, the authors stated that "the novel silane-containing, self-adhesive composite cement possessed an efficient silane-coupling ability onto glass ceramics …."[10]

BONDING TO RESIN BLOCKS

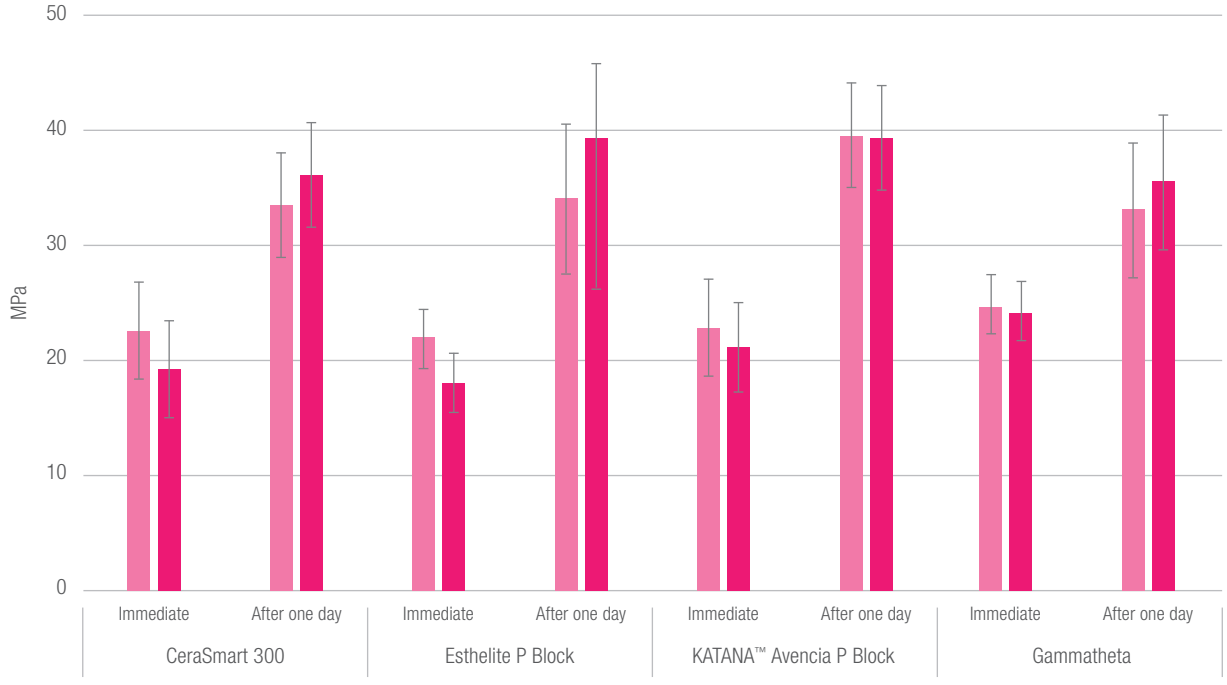
Highly filled resin composite blocks, also referred to as hybrid ceramics, are widely used for the production of single-tooth restorations. The materials are usually pre-treated by air-abrasion with alumina particles or by tribochemical silica coating. Afterwards, a silane primer should be used to obtain a strong and durable bond to materials of this class. As the incorporated LCSi monomer takes over the task of the bottle of silane, the separate silanization step is eliminated when using PANAVIA™ SA Cement Universal.

Different in vitro studies have been conducted in order to find out if PANAVIA™ SA Cement Universal works well with various types of resin-based CAD/CAM blocks as a single-component self-adhesive resin cement.

RESIN BLOCKS: HIGH INITIAL SHEAR BOND STRENGTH WITHOUT THE USE OF A PRIMER

The shear bond strength to four different block types, CeraSmart 300 (GC), Estelite P Block (Tokuyama Dental), KATANA™ Avencia P Block (Kuraray Noritake Dental) and KZR-CAD HR 3 GAMMATHETA (Yamakin) was determined in an in-vitro study from Japan[11]. The researchers determined both, the immediate shear bond strength and the shear bond strength obtained after 24 hours storage in water, for six different resin cement systems. PANAVIA™ SA Cement Universal was the only product used without a separate primer.

THE RESULTS OF THE STUDY ARE SHOWN IN THE FOLLOWING CHART



Test conditions:
1. Bonded surface: #600 polished surface, sandblasted. Curing
   Shear bond strength testing
2. Bonded surface: #600 polished surface, sandblasted
   Storage in water (37° C) for 24 hours. Shear bond strength testing

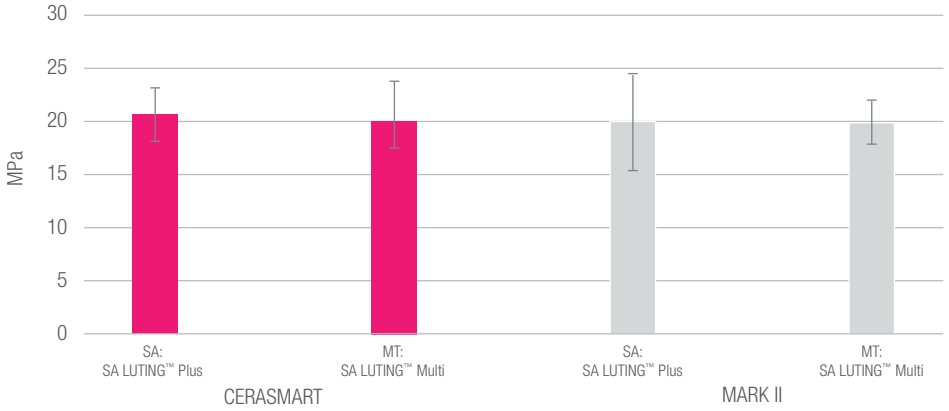
For all four different block types, the shear bond strength of PANAVIA™ SA Cement Universal was on a high level.

The excellent bonding to CERASMART (GC) was confirmed in another in-vitro study comparing two systems.[12] Here, the tensile bond strength was measured after 24 hours of water storage.

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CEMENT CATEGORY
SA LUTING™ Multi (Kuraray Noritake Dental)	--	Self-adhesive resin cement
SA LUTING™ Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Self-adhesive resin cement

RESULTS



Test conditions:
Bonded surface: Etched with hydrofluoric acid 200gf for 4 min
Storage in water (37° C) for 24 hours
Tensile bond strength testing

Products used in this research in Japan are equivalent of following ones in Europe:
SA LUTING™ Multi: PANAVIA™ SA Cement Universal.
SA LUTING™ Plus: PANAVIA™ SA Cement Plus.

The determined bond strength was high and comparable to the multi-component system tested.[12]

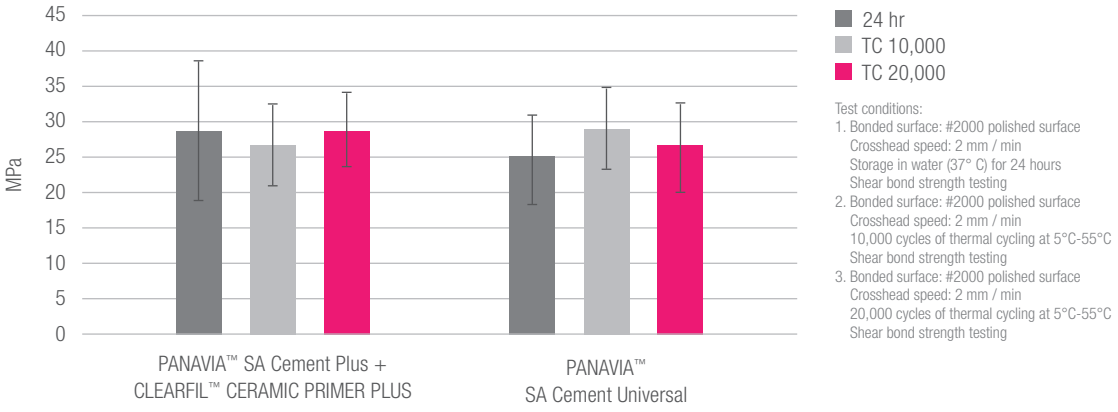
RESIN BLOCKS: EXCELLENT BOND STRENGTH AFTER ARTIFICIAL AGING

The fact that the bond strength remains high after artificial aging was confirmed in a laboratory study using polished samples of KATANA™ AVENCIA™ P Block.[13] The shear bond strength of two cements was determined immediately and after artificial aging (10,000 and 20,000 cycles).

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CEMENT CATEGORY
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Self-adhesive resin cement
PANAVIA™ SA Cement Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Self-adhesive resin cement

RESULTS



No significant differences between the two resin cements were found. Based on their measurements, the researchers concluded that "it is clear that the new SAU (PANAVIA™ SA Cement Universal) exhibits bond strength to CAD/CAM resin blocks comparable to that of conventional SA with primer (PANAVIA™ SA Cement Plus and CLEARFIL™ CERAMIC PRIMER PLUS), even without a silane coupling agent."[13]

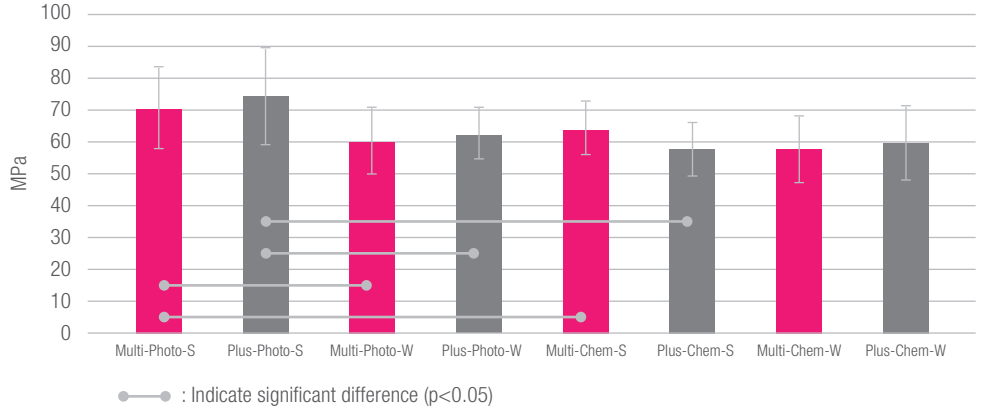
RESIN BLOCKS: EXCELLENT BOND STRENGTH IN EVERY CURING MODE

As a dual-cure resin cement, PANAVIA™ SA Cement Universal may be light-cured or self-cured. In order to assess whether a sound bonding performance may be expected independent of the curing mode, an in-vitro study was carried out in Japan.[14] In this study, polished samples of KATANA™ AVENCIA™ P Block were luted with two different systems involving two curing modes and the microtensile bond strength was determined immediately and after artificial aging.

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CURING MODE	CEMENT CATEGORY
SA LUTING™ Multi (Kuraray Noritake Dental)	--	Light-cure	Self-adhesive resin cement
SA LUTING™ Multi (Kuraray Noritake Dental)	--	Self-cure	Self-adhesive resin cement
SA LUTING™ Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Light-cure	Self-adhesive resin cement
SA LUTING™ Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Self-cure	Self-adhesive resin cement

MICRO-TENSILE BOND STRENGHT



SA LUTING™ Multi
CLEARFIL™ CERAMIC PRIMER PLUS + SA LUTING™ Plus

KATANA™ AVENCIA™ P Block
Polished (15 micron meter)
Water rinse
Photo: Dual cure
Chem: Self cure
S: immediately
W: after one week

Test conditions:
1. Bonded surface: Polished (15 µm)
   Rinsed with water
   Storage in water (37° C) for 24 hours
   Micro-tensile bond strength testing

2. Bonded surface: Polished (15 µm)
   Rinsed with water
   One week of simulated aging
   Micro-tensile bond strength testing

Products used in this research in Japan are equivalent of following ones in Europe:
SA LUTING™ Multi: PANAVIA™ SA Cement Universal.
SA LUTING™ Plus: PANAVIA™ SA Cement Plus.

The graph shows that the obtained bond strengths are high in both curing modes as well as before and after artificial aging.

BONDING TO ZIRCONIA

The popularity of zirconia as a restorative material is increasing ever since the introduction of highly translucent, pre-shaded material variants. They allow for a monolithic use that offers the benefit of reduced minimal wall thicknesses promoting less invasive tooth preparations and therefore fit the contemporary philosophy of conserving healthy tooth structure very well.

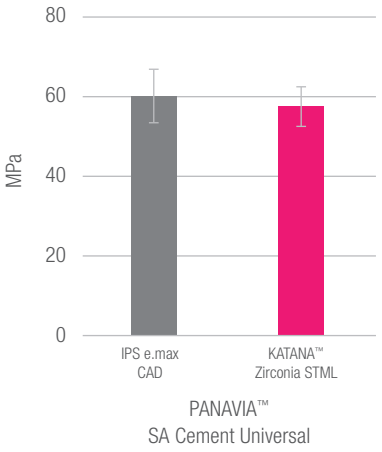
When it comes to luting zirconia restorations, the procedure is somewhat different from silica-based ceramics, as zirconia is a polycrystalline material lacking a glassy matrix. Hence, etching of the surface with hydrofluoric acid is ineffective. Nevertheless, it is possible to establish a strong and long-lasting bond to zirconia with (self-)adhesive resin cement systems. In order to create surface conditions favourable for bonding, sandblasting with alumina particles or tribochemical silica coating is usually recommended[15-18]. This measure has a similar effect as the etching of silica-based ceramics: A micro-retentive surface is created.

While sufficiently retentive crown and bridge preparations do not per se require adhesive luting, more modern preparation designs lacking retentive elements require excellent chemical adhesion. In these cases, the use of (self-) adhesive resin cements is required, while in many other situations, it is highly recommended for aesthetic reasons.

HIGH-TRANSLUCENCY ZIRCONIA: HIGH IMMEDIATE SHEAR BOND STRENGTH

PANAVIA™ SA Cement Universal contains the original MDP monomer responsible for the establishment of a high bond strength to zirconia. In order to find out if this proven monomer works well in the formulation, the shear bond strength to KATANA™ Zirconia STML was measured in an in-vitro study conducted in the DENTAL ADVISOR Biomaterials Research Center.[19] Used in the self-cure mode, PANAVIA™ SA Cement Universal achieved a high shear bond strength to KATANA™ Zirconia STML.

SHEAR BOND STRENGTH TO CERAMICS

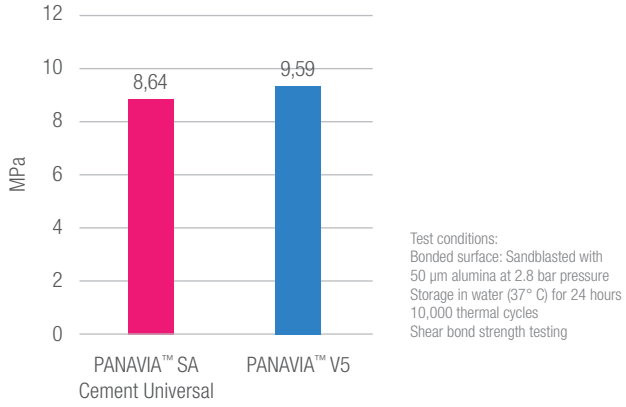


Test conditions:
Bonded surface: Sandblasted with 50 µm alumina at 3 bar pressure
Storage in water (37° C) for 24 hours
Shear bond strength testing

HIGH-TRANSLUCENCY ZIRCONIA: HIGH SHEAR BOND STRENGTH AFTER ARTIFICIAL AGING

The fact that a resin cement performs well immediately after cementation makes it impossible to draw conclusions about the material's long-term behaviour. Therefore, a group of researchers from the University of Pennsylvania measured the shear bond strength of PANAVIA™ SA Cement Universal and one adhesive cementation system (control) to KATANA™ Zirconia after 10,000 thermal cycles.[20] PANAVIA™ SA Cement Universal showed an excellent performance:

SHEAR BOND STRENGTH TO KATANA STML ZIRCONIA AFTER 10,000 THERMALCYCLES



The researchers came to the conclusion that "In routine clinical application, self-adhesive resin cements can be a user-friendly, less technique sensitive alternative for bonding zirconia restorations following the APC concept."[20]

BOND STRENGTH TO TOOTH STRUCTURE

On the side of the tooth structure, the resin cement has to deal with different substrates (enamel and different types of dentin). A factor that may affect the bonding performance of a self-adhesive resin cement to dentin is the level of moisture. A high-performance self-adhesive universal resin cement should be moisture-tolerant and able to adhere to all the different types of tooth structure that a dentist has to deal with during cementation equally well. Moreover, a high bond strength should be obtained independent of the curing mode (light-cure versus self-cure).

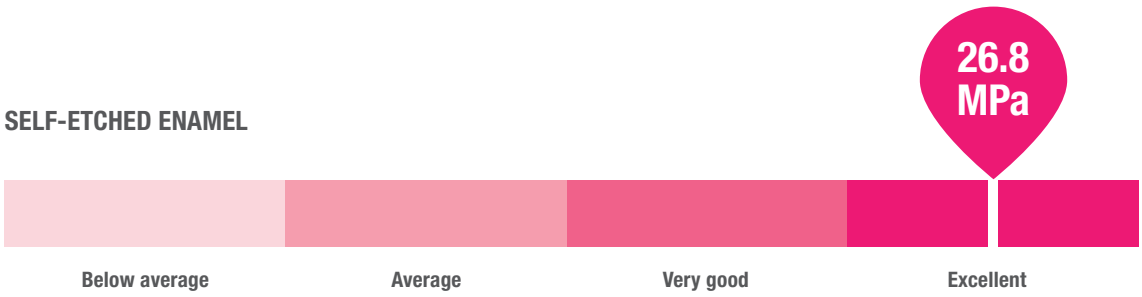
The following study results confirm that PANAVIA™ SA Cement Universal offers the properties needed to perform well in diverse settings and even in the long term.

BONDING TO ENAMEL

The restoration margin of most indirect restorations is positioned in enamel, while some minimally invasive tooth preparations end up with a bonding surface mainly or completely made of enamel. In all these situations, it is essential that the resin cement used establishes a strong bond to enamel that is stable over time and a good sealing ability. PANAVIA™ SA Cement Universal performs well in this respect.

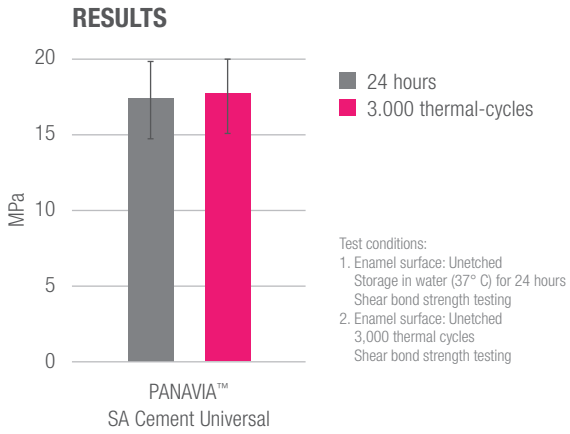
ENAMEL: EXCELLENT INITIAL SHEAR BOND STRENGTH

The DENTAL ADVISOR Biomaterials Research Center has already determined the shear bond strength to tooth structure and different restorative materials. Based on the collected data, the researchers have developed a rating scale with four different categories (from below average to excellent).
The values they determined for PANAVIA™ SA Cement Universal on self-etched enamel were so high that they were rated "excellent"[21]:



ENAMEL: EXCELLENT BONDING EVEN AFTER ARTIFICIAL AGING

The fact that the bond strength to enamel remains high after artificial aging was confirmed in-house study conducted at the research laboratory of Kuraray Noritake Dental in Japan.



CONCLUSION

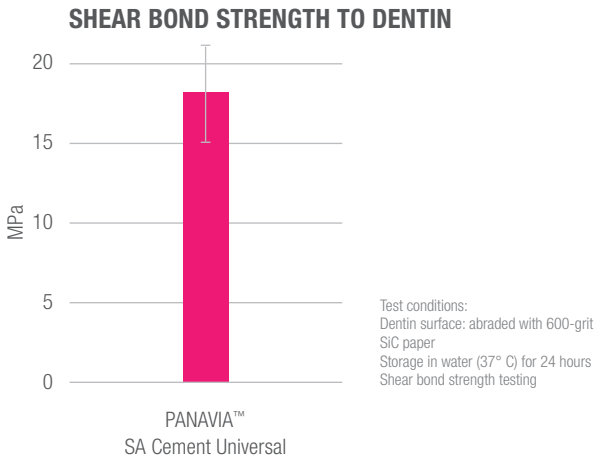
The results show that the shear bond strength of PANAVIA™ SA Cement Universal was on the same high level before and after simulated aging, which may be an indicator for excellent bonding to the substrate also in the long term.

BONDING TO DENTIN UNDER DIFFERENT CONDITIONS

Often, the largest part of an indirect restoration has to be luted to dentin. Therefore, the creation of a strong bond to this substrate is essential for the success of a restoration. But how well does PANAVIA™ SA Cement Universal bond to dentin? And is the self-adhesive resin cement moisture tolerant so that it performs well even under difficult clinical conditions? Various in-vitro studies have been conducted at different research institutes and universities to shed light on this topic. All of them produced very good results.

BONDING TO DENTIN: HIGH IMMEDIATE BOND STRENGTH

According to an in-vitro study conducted at the DENTAL ADVISOR Biomaterials Research Center, the immediate shear bond strength of PANAVIA™ SA Cement Universal to dentin is exceptionally high.[22]



BONDING TO DRY AND WET DENTIN: GREAT LONG-TERM PERFORMANCE

The fact that a product performs well under ideal conditions and immediately after its application does not tell users much about its clinical long-term potential. In order to find out more about the moisture tolerance of PANAVIA™ SA Cement Universal and its bonding performance over time, a group of researchers and a dental practitioner from Okayama, Japan, conducted a more extensive in-vitro study.[23]

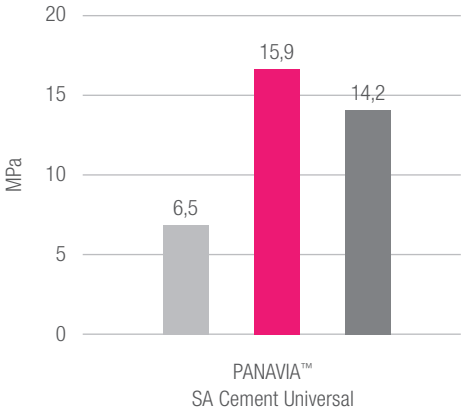
THE GROUP DETERMINED

- the **immediate** shear bond strength on **dry** dentin
- the shear bond strength on **dry** dentin after **24 hours** of water storage
- the shear bond strength on **dry** dentin after **20,000 thermocycles**

- the **immediate** shear bond strength on **wet** dentin
- the shear bond strength on **wet** dentin after **24 hours** of water storage
- the shear bond strength on **wet** dentin after **20,000 thermocycles**

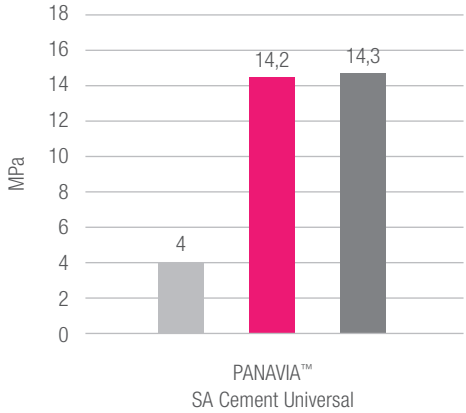
- the **immediate flexural strength**
- the **flexural strength** after **24 hours** of water storage
- the **flexural strength** after **20,000 thermocycles**

SHEAR BOND STRENGTHS ON DRY DENTIN AT 3 TIMES



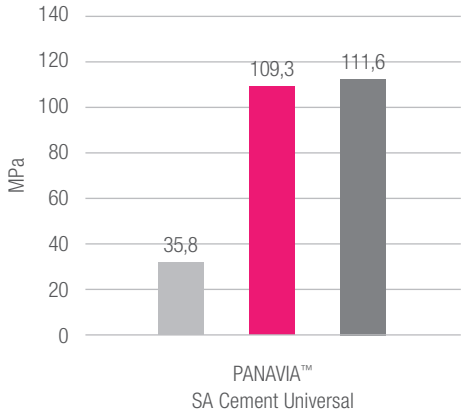
Test conditions:
Specimens were determined at three time periods: immediately after light activation, one day after distilled water storage at 37°C, and after 20,000 thermocycles (thermal stress between 5 and 55°C; 1 min dwell time).
Shear stress was applied at a crosshead speed of 0.5 mm/min.

SHEAR BOND STRENGTHS ON WET DENTIN AT 3 TIMES



Test conditions:
Specimens were determined at three time periods: immediately after light activation, one day after distilled water storage at 37°C, and after 20,000 thermocycles (thermal stress between 5 and 55°C; 1 min dwell time).
Shear stress was applied at a crosshead speed of 0.5 mm/min.

FLEXURAL STRENGTHS - 3 POINT BENDING TEST



Test conditions:
Flexural strength was measured at three different time periods, as in the above test. 3-point bending test with a 20-mm span and a load speed of 0.5 mm/min, as outlined in ISO 9917-2 (1996).

These results reveal that the lowest bond strength and flexural strength was measured immediately after cementation, whereas the values increased after 24 hours of water storage and remained on a higher-than-initial level after thermocycling. The bond strength measured for PANAVIA™ SA Cement Universal on dry and on wet dentin was on a similar level, PANAVIA™ SA Cement Universal showed no decrease in bond strength or flexural strength after thermocycling. This may be an indicator of a great long-term performance of PANAVIA™ SA Cement Universal.

BONDING TO DENTIN: EXCEPTIONAL PERFORMANCE INDEPENDENT OF THE CURING MODE

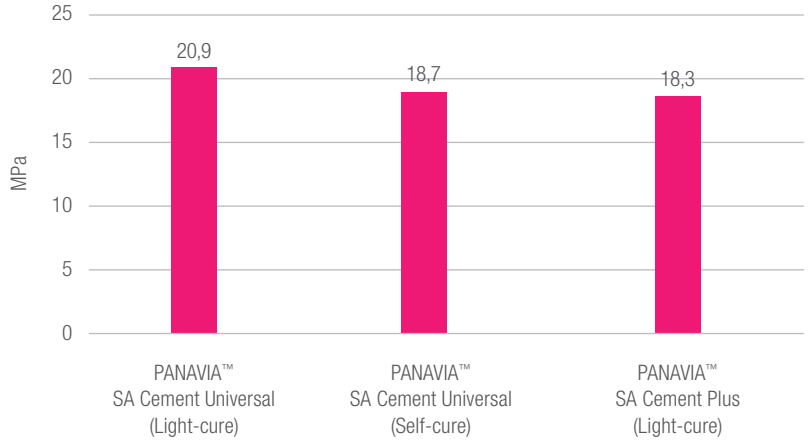
Due to the translucency of the restorative material or the wall thickness of the indirect restoration, it is not always possible to light-cure the cement under a restoration. With PANAVIA™ SA Cement Universal, the clinical performance of the restoration should not be affected by this factor. This is the result of an in-vitro study comparing the shear bond strength of PANAVIA™ SA Cement Universal to dentin achieved in the light-cure and self-cure mode.[24] In addition, the group conducted a resin cement-dentin interface analysis using transmission electron microscopy (TEM) and X-ray diffraction (XRD).

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CURING MODE	CEMENT CATEGORY
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Light-cure	Self-adhesive resin cement
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Self-cure	Self-adhesive resin cement
PANAVIA™ SA Cement Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Light-cure	Self-adhesive resin cement

In the shear bond strength test, great results were obtained:

SHEAR BOND STRENGTHS



Test conditions:
Surface was polished using 600-grit SiC paper. Shear bond strength testing after 24-h storage in water at 37°C, following a light-curing protocol and a chemically curing protocol.

Based on these test results and the characterization of the interface, the researchers concluded that "the shear bond strength of PANAVIA™ SA Cement Universal (light-cure & chemical-cure) on dentin did not significantly differ from that of PANAVIA™ SA Cement Plus. PANAVIA™ SA Cement Universal produced a tight interface with dentin and formed nano-layering 10 MDP-Calcium Salts."[24] This confirms an effective dentin bonding ability.

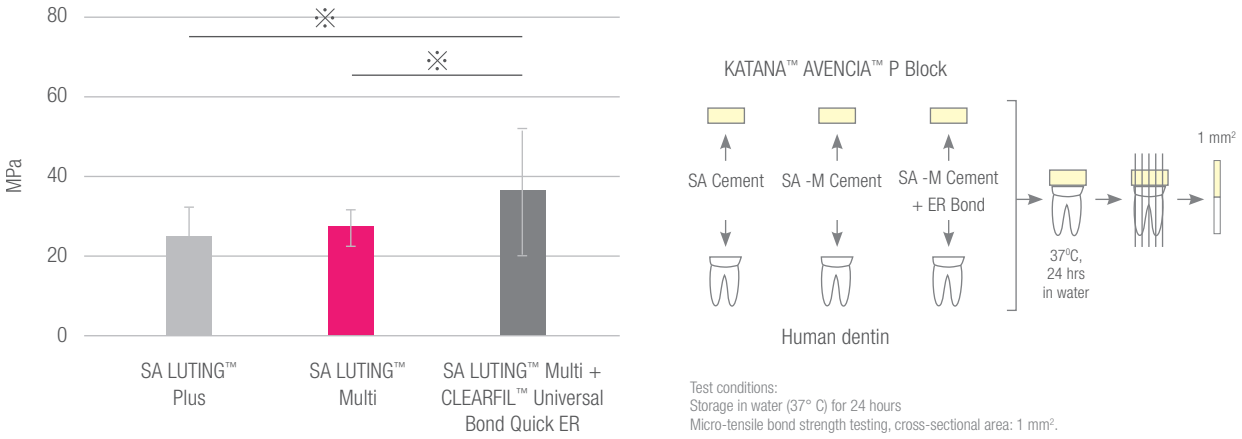
BOOSTING THE BOND STRENGTH TO DENTIN

While the dentin bond strength of PANAVIA™ SA Cement Universal is already high, it may be maximized in challenging situations with CLEARFIL™ Universal Bond Quick applied as a separate adhesive. The effect of this measure was determined with the aid of micro-tensile bond strength testing.[25]

CEMENTATION SYSTEMS TESTED

CEMENT	PRIMER	CEMENT CATEGORY
SA LUTING™ Multi (Kuraray Noritake Dental)	--	Self-adhesive resin cement
SA LUTING™ Multi (Kuraray Noritake Dental)	CLEARFIL™ Universal Bond Quick (Kuraray Noritake Dental)	Self-adhesive resin cement
SA LUTING™ Plus (Kuraray Noritake Dental)	PANAVIA™ V5 Tooth Primer (Kuraray Noritake Dental)	Self-adhesive resin cement

RESULTS



Test conditions:
Storage in water (37° C) for 24 hours
Micro-tensile bond strength testing, cross-sectional area: 1 mm².

Products used in this research in Japan are equivalent of following ones in Europe:
SA LUTING™ Multi: PANAVIA™ SA Cement Universal.
SA LUTING™ Plus: PANAVIA™ SA Cement Plus.
CLEARFIL™ Universal Bond Quick ER: CLEARFIL™ Universal Bond Quick.

The results show that the already high bond strength values obtained with both self-adhesive resin cements are increased when PANAVIA™ SA Cement Universal is combined with CLEARFIL™ Universal Bond Quick.[25]

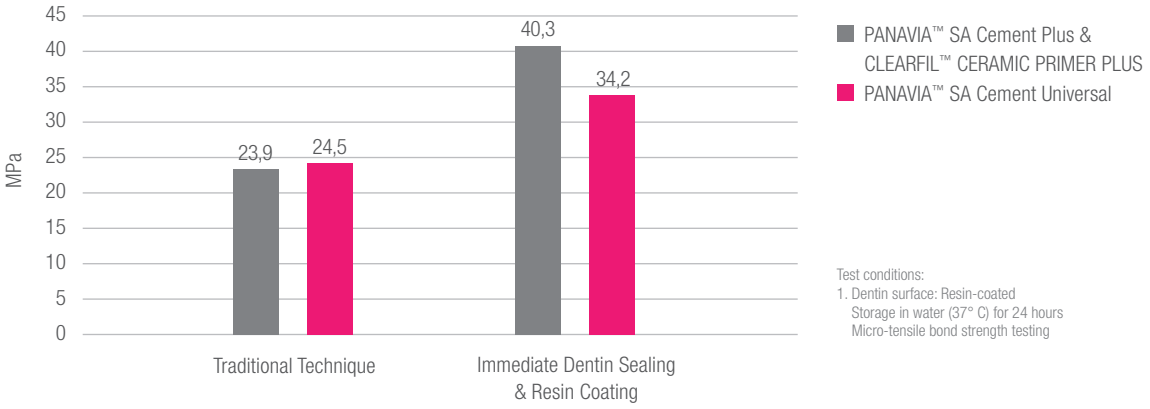
BONDING TO DENTIN TREATED WITH THE RESIN COATING TECHNIQUE

The term resin-coating technique describes the coating of a prepared dentin surface prior to the placement of an indirect restoration. Typically, a specific thin-film coating material or a flowable composite bonded with a self-etch adhesive is used for this purpose. The aim of the technique is to protect the dentin-pulp complex of vital teeth and to prevent the negative consequences of coronal leakage after endodontic obturation. The technique is also said to improve the bond strength between the tooth structure and the resin cement.

In order to find out whether resin coating does affect the bond strength of PANAVIA™ SA Cement Universal to tooth structure, an in-vitro study was conducted in Japan.[26] The researchers determined the micro-tensile bond strength of two different resin cement systems – PANAVIA™ SA Cement Plus combined with CLEARFIL™ CERAMIC PRIMER PLUS and PANAVIA™ SA Cement Universal used without a primer – on resin-coated dentin.

CEMENT	PRIMER	CURING MODE	CEMENT CATEGORY
PANAVIA™ SA Cement Universal (Kuraray Noritake Dental)	--	Light-cure	Self-adhesive resin cement
PANAVIA™ SA Cement Plus (Kuraray Noritake Dental)	CLEARFIL™ CERAMIC PRIMER PLUS (Kuraray Noritake Dental)	Light-cure	Self-adhesive resin cement

MICRO-TENSILE BOND STRENGTHS OF KATANA™ AVENCIA™ TO DENTIN



Conclusion

The test results show that resin coating increases the bond strength of PANAVIA™ SA Cement Universal to dentin. This positive effect was obtained for both self-adhesive resin cements tested. Based on this set of data, the researchers conducting the study concluded that "Resin coating and light curing are encouraged for predictable bonding performance of dual-cured self-adhesive resin cements in single-visit CAD/CAM resin restorations."[26]

CLINICAL STUDY

Clinical studies are the real-life proof of a product's clinical performance. It is usually impossible, however, to provide long-term data at a material's launch already, and some of the dental materials are already outdated by the time relevant clinical data becomes available. Luckily, this is not the case for PANAVIA™ SA Cement Universal.

The first two-year clinical evaluation was published in 2022, and it confirms the clinical performance expected on the basis of the promising in-vitro study results. That being said, Kuraray Noritake Dental Inc. recognizes the need for more in-vitro studies and continues to collect post-launch clinical data, to improve the understanding about the clinical performance of the material.

BONDING TO ZIRCONIA

Modern, high-translucency zirconia with a multi-layered colour structure is becoming increasingly popular as a restorative material. The option of placing restorations made of this material with a single-component self-adhesive resin cement is very attractive as the procedure is straightforward and efficient. But how does the product perform in the clinical environment?

To answer this question for the popular material combination KATANA™ Zirconia STML and PANAVIA™ SA Cement Universal, a clinical study was initiated at the University Complutense of Madrid, Spain, shortly after the introduction of the resin cement[27]. The group produced 30 monolithic posterior crowns made of KATANA™ Zirconia STML for a total of 24 patients. The restorations were placed with PANAVIA™ SA Cement Universal after try-in, air-abrasion of the intaglio surface with 50 µm alumina particles at 1 bar pressure and ultrasonic cleaning.

At a clinical evaluation performed after 24 months in clinical service, all 30 restorations were assessed using the California Dental Association (CDA) quality evaluation system. It takes into account the surface and colour of the restoration, its anatomical form and – decisive for an evaluation of the resin cement's performance – the marginal integrity. All 30 crowns were still intact and in place after 24 months. They all received the highest possible rating (Score 4 – excellent) for the parameter marginal integrity. With regard to the other two parameters, they were also rated satisfactory (Score 3 or 4). No biological or mechanical complications had occurred during the 24 months.

Based on these findings, it can be concluded that the performance of the material combination is promising. The researchers state, however, that "A long-term study is necessary to confirm this short-period study."[27]

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