Lava™ Plus

High Translucency Zirconia System

Technical Product Profile

3M ESPE


My plus is clear:
True colors –
for true masterpieces

Table of Contents

1 Introduction to Lava™ Plus High Translucency Zirconia from 3M ESPE

In 2001, 3M ESPE launched one of the first zirconia CAD/CAM systems under the brand Lava™. Since then the system has spread very successfully across the globe and is now present in more than 40 countries. Lava™ looks back on over 11 years of clinical history and millions of units produced. There are over 200 scientific publications and more than 10 clinical studies completed or ongoing with Lava™ Zirconia from 3M ESPE.

Based on the proven success of Lava™ Frame Zirconia, 3M ESPE is now introducing Lava™ Plus High Translucency Zirconia which is designed to enable unprecedented Lava™ Zirconia esthetics with uncompromised strength.

Lava™ Plus is a complete system consisting of the new Lava™ Plus High Translucency Zirconia Mill Blanks with a comprehensive range of 3M™ ESPE™ Lava™ Plus High Translucency Zirconia Dyeing Liquids for excellent color match to the VITA® classical shade guide. Precise shading of the restoration can be achieved by using the new Lava™ Plus High Translucency Zirconia Color Markers by 3M ESPE. Finally the restorations can be individualized before sintering with the appropriate 3M™ ESPE™ Lava™ Plus High Translucency Zirconia Effect Shades.

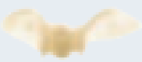
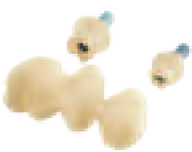
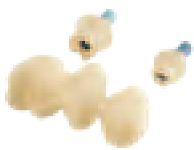
The precision of fit and the strength properties of Lava™ Plus High Translucency Zirconia remain the same as for Lava™ Frame Zirconia. This is backed-up by a 15 years limited warranty on the 3M ESPE Lava™ Plus Zirconia frameworks and Lava™ Plus All-Zirconia Monolithic restorations.*

Lava™ Plus Zirconia covers the full Lava™ Zirconia indication range for both, framework veneered restorations and all-zirconia restorations.

Fig. 1: Lava™ Plus Highly Translucent All-Zirconia Monolithic 3-unit bridge, with Effect Shade "white", stained and glazed.

*If fabricated by an Authorized Lava™ Milling Center on Lava™ Equipment in strict compliance with approved indications and instructions for use for Lava™ Crowns and Bridges. Only approved indications for Lava™ Zirconia are covered and the warranty does not cover any breakage resulting from accidents or misuse. Additional costs such as the cost of preparation and veneering are also not covered.

Lava™ Zirconia can be used for a wide range of indications

INDICATION	ZIRCONIA FRAMEWORK		ALL-ZIRCONIA RESTORATIONS	
		FOR FULL VENEERING 	AS FULL-CONTOUR OR PARTIALLY VENEERED 	
Crowns (anterior and posterior)		●	●	
Splinted crowns[1]		●	●	
3-4 unit bridges		●	●	
Long-span and curved bridges (up to 48 mm)[2]		●	●	
Cantilever bridges[3,4]		●	●	
3-unit Inlay and onlay bridges[4,5]		●	●	
Anterior adhesive bridges (Maryland bridges)[4,5]		●	●	
Primary Crowns		Veneering not necessary	●	
Crowns on implant abutments[4]		●	●	
3-unit bridges on 2 implants[4]		●	●	
Zirconia build-up for two-piece abutments		Veneering not necessary	●	

1. Splinted crowns up to 4 units
2. 5+ unit bridges (up to 48 mm) with a maximum of two pontics next to one another in the posterior area and a maximum of four pontics next to one another in the anterior area. Registration pending in Canada
3. With a maximum of 1 pontic at the position of a premolar or incisor
4. Contra-indicated for patients with bruxism
5. Tests have proven: Lava™ Zirconia shows a sufficient strength for this indication. However, this type of indication overall can have a higher failure risk due to adhesion failure and secondary caries regardless of manufacturer. Please refer to national and regional dental associations for more information

Fig. 2: Lava™ Zirconia and Lava™ Plus Zirconia indication list.

2 Lava™ Plus High Translucency Zirconia

Composition

Lava™ Plus High Translucency Zirconia is a tetragonal polycrystalline zirconia partially stabilized with 3mol-% Yttria engineered for high translucency and utmost strength. It has a lower Alumina content of 0.1% compared to Lava™ Frame Zirconia, optimally distributed within the material for maintaining aging stability. This composition enables the excellent features which are outlined in the following chapters.

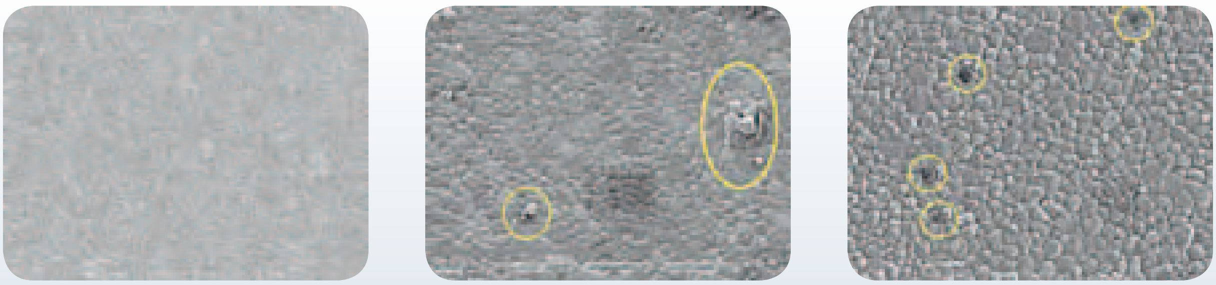
Translucency

Translucency is the physical property of allowing light to pass through a material. The translucency of zirconia materials is mainly determined by

- Density and grain size of the sintered material
- Presence of impurities and structural defects
- Alumina content and distribution

Impurities and structural defects like pores lead to light absorption and scattering which can reduce translucency. The high quality processing of Lava™ Plus Zirconia minimizes these effects (Fig. 3). This is in contrast to what was found for some other zirconia materials (Fig. 3).

Alumina is a dopent with many useful effects including increased aging stability of zirconia. However, alumina has a different refractive index and can segregate in the zirconia material (Fig. 3) which decreases translucency by scattering. To improve the translucent properties of Lava Plus Zirconia, the alumina content is lower than in Lava Zirconia. In order to maintain aging stability at the same level as Lava Zirconia, the alumina distribution was improved. (1)(2)



a) Lava™ Plus High Translucency Zirconia

b) Generic zirconia – highlighted impurity and pore

c) Branded competitive zirconia – highlighted segregated Alumina grains

Fig. 3: SEM images, Magnification 10,000 fold. (3M ESPE internal data.)

A common method to compare material translucency is to determine the contrast ratio (CR): The white light remission from a specimen placed over a standardized black (Yb) and white (Yw) background is determined. CR is calculated as CR = Yb/Yw. CR is ≤ 1, a CR value of 1 represents a completely opaque specimen. Translucency can be expressed by 1-CR.

The higher 1-CR, the higher is the translucency of a specimen.

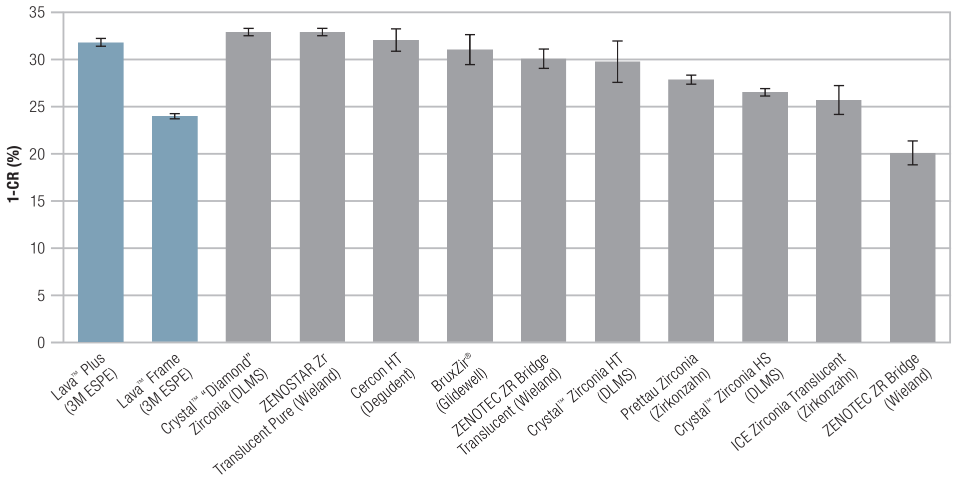


Fig. 4: Translucency (1-CR) of unshaded zirconia samples. (1 mm sample thickness, Color i7, 3M ESPE internal data, partially published (3))

3M™ ESPE™ Lava™ Plus High Translucency Zirconia offers excellent translucency due to the optimized distribution of alumina (Fig. 4).

In clinical use, zirconia is commonly shaded to match the intra-oral environment. The patented 3M ESPE ion dyeing technology allows higher translucency in the shaded state (Fig. 5).

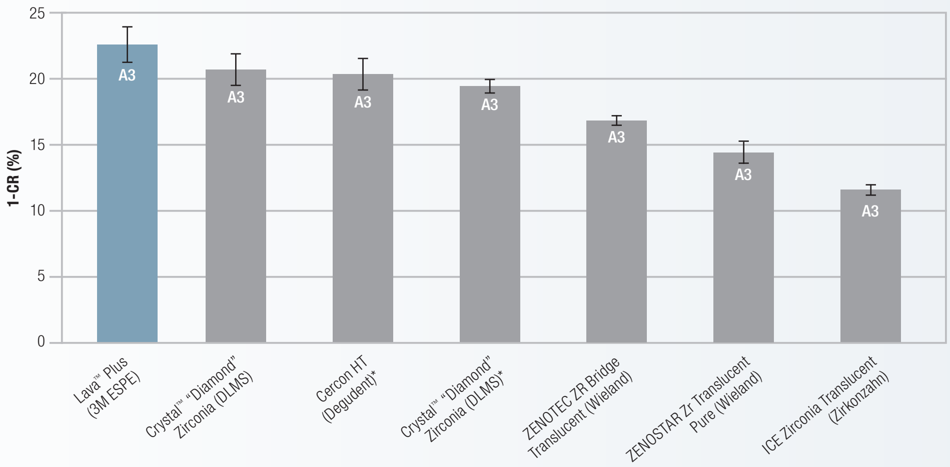


Fig. 5: Translucency (1-CR) of zirconia samples shaded with the manufacturers' A3 shading liquid. Except samples with "*" are shaded with Zirkonzahn Prettau Color Liquid A3. (1 mm sample thickness, Color i7, 3M ESPE internal data, partially published in (3))

The high level of translucency is achieved without compromising strength. This comparison shows that the strength of Lava™ Plus High Translucency Zirconia is comparable to Lava™ Zirconia. (Fig. 6).

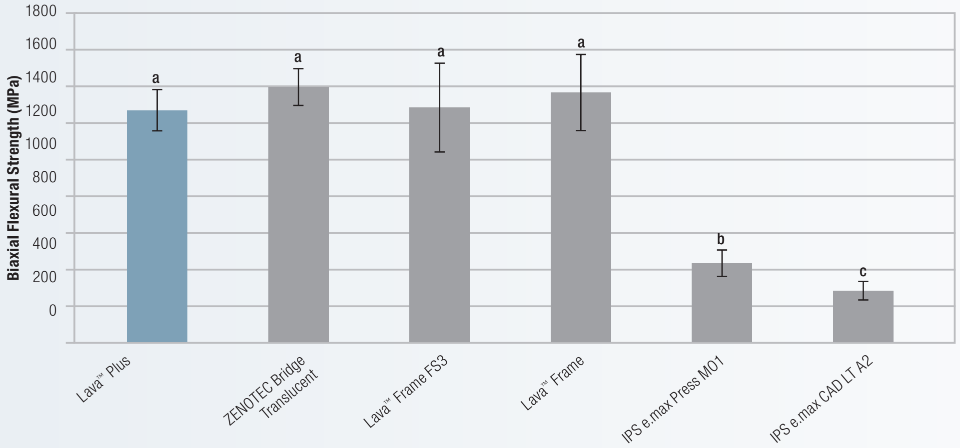


Fig. 6: Biaxial flexural strength of zirconia and glass ceramic materials. Bars with same letter indicate no significant difference. (P< 0.05) (4)

The high strength of zirconia allows thinner walled restorations. When comparing material translucencies for clinically placed restorations, the allowed minimal thickness should be taken into account. For example, when comparing minimum allowed occlusal thicknesses, A3 shaded Lava Plus High Translucency Zirconia has a similar translucency to IPS e.max CAD LT (Fig. 7).

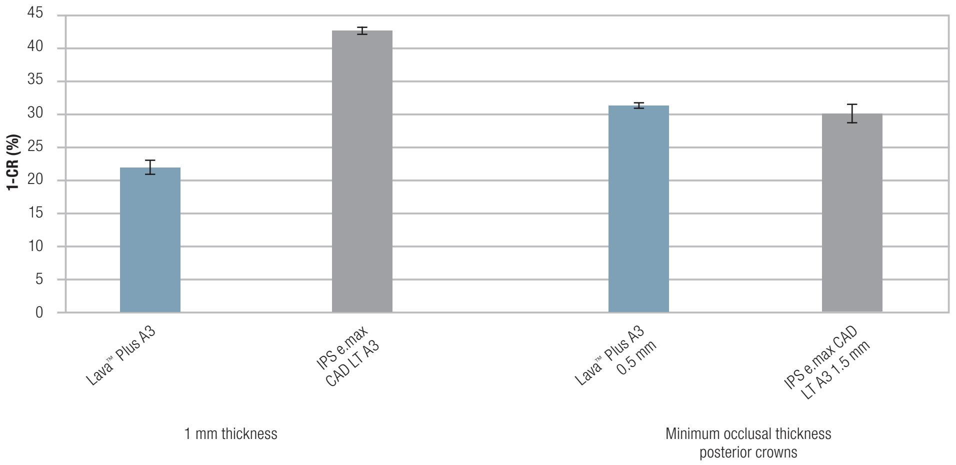


Fig. 7: Translucency (1-CR) of IPS e.max CAD LT A3 and Lava™ Plus Zirconia shaded A3 for a thickness of 1 mm and for the respective minimum occlusal wall thickness for posterior crowns. (Color i7, 3M ESPE internal data)

Strength

Y-TZP Transformation Toughening

Zirconium dioxide (ZrO2) exists in three crystalline states: monoclinic at room temperature, tetragonal above 1170 °C and cubic above 2100 °C. (5)(6) The "zirconia ceramic" used for dental applications is composed of zirconium dioxide crystals stabilized in the tetragonal state by addition of yttrium oxide. The tetragonal crystalline state is responsible for the high strength and fracture toughness of Y-TZP (Yttrium oxide partially stabilized Tetragonal Zirconium dioxide Polycrystals) materials. Once a crack propagates within a Y-TZP material the energy supplied by the crack can trigger the phase transformation of tetragonal to monoclinic in the surrounding grains. This phase transformation leads to a local compressive stress field caused by the change from a higher material density (tetragonal) to lower material density (monoclinic), that hinders further crack propagation (5)(6). It is well known (7)(8) that on Y-TZP material surfaces the phase transformation of tetragonal to monoclinic can also slowly occur by contact with water. The impact of this "low temperature degradation" (LTD) on the lifetime of a medical device can be very different depending on the application and on the material composition and processing. For dental applications the key learning is the importance of manufacturing process control.

Phase transformation properties strongly depend on the chemical composition of the raw material, the grain size, the amount and distribution of dopents, the production process (densification and sintering parameters) and the quality of process control. (5)

For Lava™ Zirconia efficient transformation toughening was demonstrated by space-resolved X-ray diffraction (XRD) analysis of fractured surfaces (9). These findings are in accordance with the consistently high strength of Lava™ Zirconia (Fig. 8).

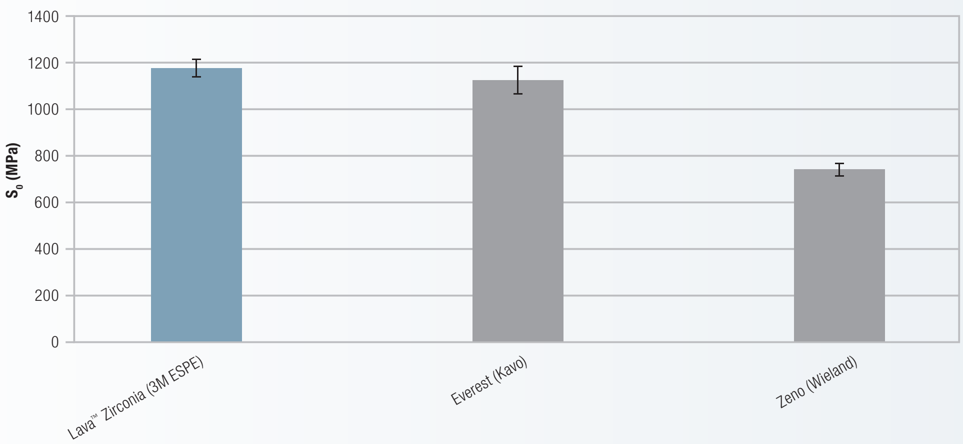


Fig. 8: Strength determined with 3-point bending of polished bars in water (Weibull). (10)

Fig. 9: Lava™ Plus High Translucency Zirconia Mill Blank, Multi L.

Influence of Water on Zirconia Surface State

Exposure of Lava™ Zirconia to water leads to a superficial phase transformation detectable by XRD. The changes in crystal phase composition do not result in a noticeable reduction in strength. Figure 10 summarizes the surface phase compositions of sintered Lava™ Zirconia samples after storage in air, water and autoclaving. The sintered surface contains initially no monoclinic phase.

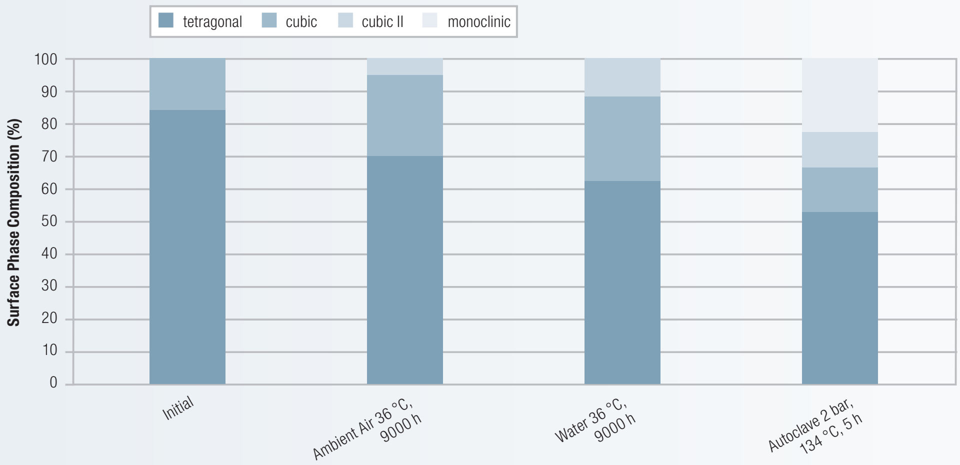


Fig. 10: Surface phase composition of as fired Lava™ Zirconia material initially and after storage at ambient air, storage in water and autoclaving. (10)

Figure 11 shows the importance of including the alumina dopents in the zirconia structure which greatly reduces phase transformation during accelerated aging.

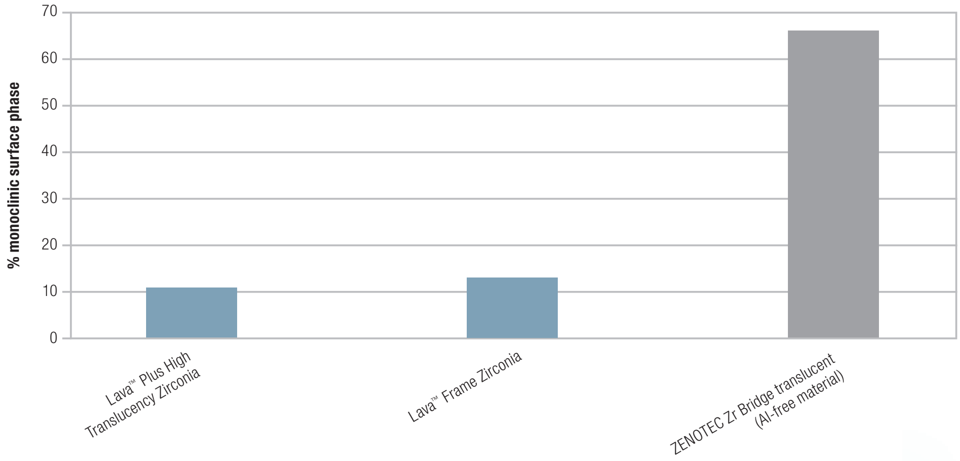


Fig. 11: Monoclinic surface phase content of polished samples after accelerated aging.
(30 hours autoclaving at 2 bars, 134 °C, 3M ESPE internal data)

Fig. 12: Lava™ Plus Highly Translucent All-Zirconia Monolithic crown.

It is well documented that the storage of Lava™ Zirconia samples in water does not lead to a significant decrease in strength. (12)(13)(14)(15) The hydrolytic stability proven for Lava™ Zirconia material is in contrast to glass ceramics containing a glass phase like e.g. Empress 2, IPS e.max CAD, Empress CAD and Inceram Alumina where a significant decrease in strength was observed. (12)(14)

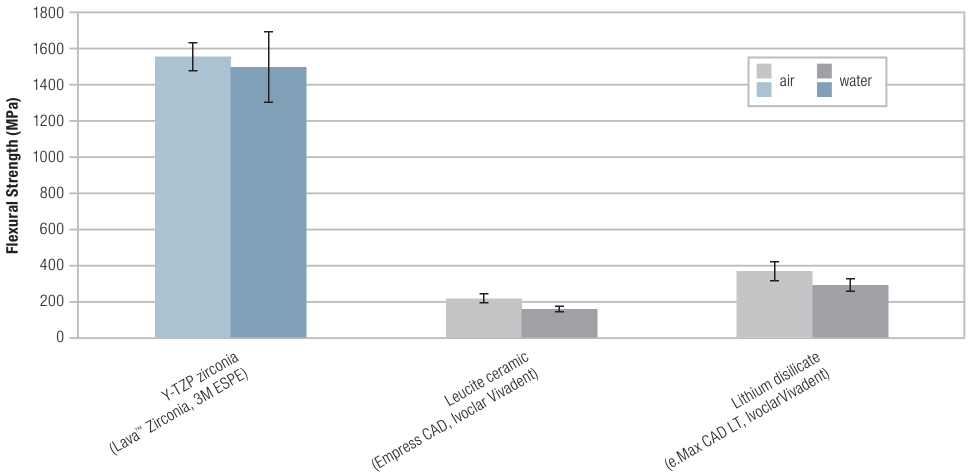


Fig. 13: Flexural Strength of Empress CAD, IPS e.max CAD and Lava™ Zirconia after 30 days storage and subsequent testing in water. The glass containing systems showed a significant decrease in strength of 28 % and 21 %, respectively. No significant influence was found for Lava™ Zirconia. (14)

The superficial phase transformation induced by autoclaving following the ISO 13356:2008 protocol has no significant influence on the bulk strength of Lava™ Zirconia samples (Fig. 13). (10)(15)(18)(19) In contrast the accelerated aging by autoclaving was found to increase the reliability factor (or Weibull module) m (10) and the fracture toughness (20), respectively (Fig. 14).

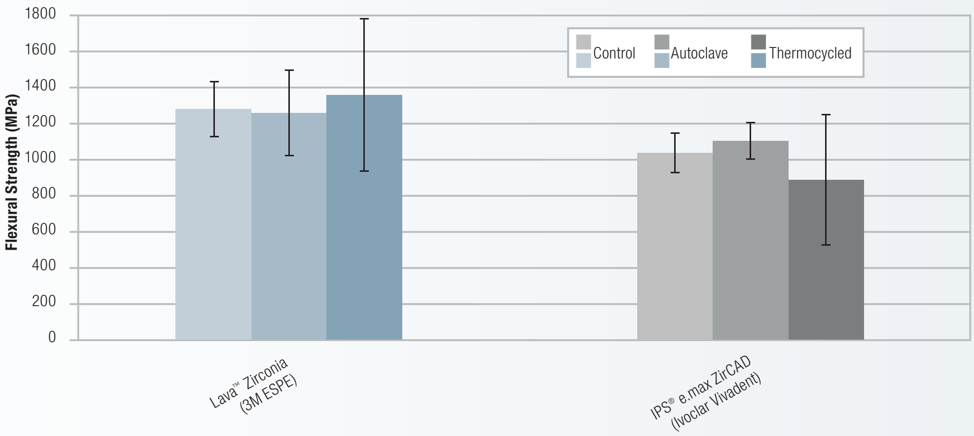


Fig. 14: Biaxial flexural strength of Y-TZP materials tested (Lava™ Zirconia, IPS® e.max ZirCAD) before and after thermo cycling and autoclaving, respectively. (19)

The high strength of Lava™ Zirconia allows thin walls of anterior and posterior monolithic restorations. This enables tooth – preserving preparations and the restoration of clinical situations with limited inter-occlusal space. The minimum occlusal wall thickness is 0.5 mm for Lava™ Zirconia posterior crowns as compared to 1.5 mm for lithium disilicate. Lava™ Zirconia withstood fracture loads of about 1500N with only 0.6 mm wall thickness, whereas lithium disilicate needed a wall thickness of 1.2 mm to withstand the same load (Fig. 15). (36)

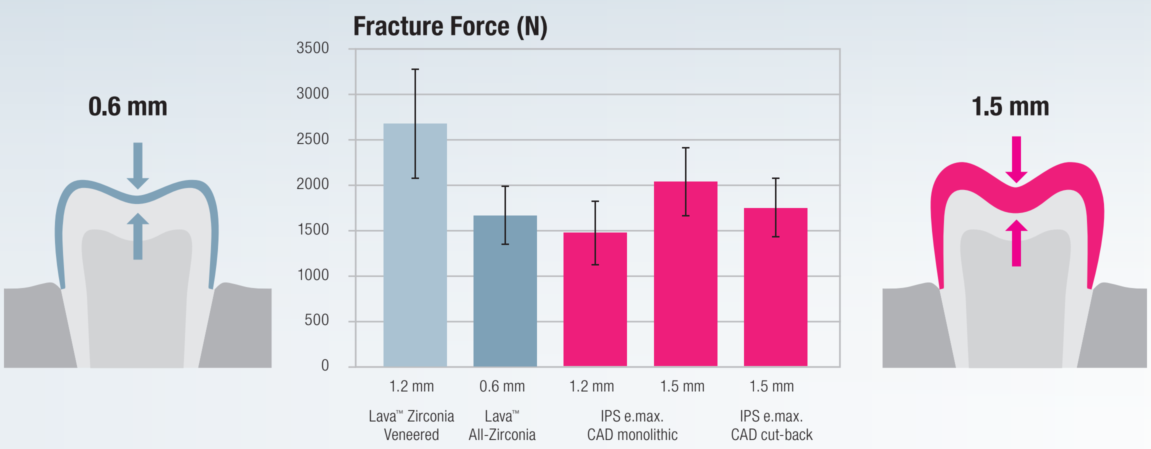


Fig. 15: Fracture strength of all-ceramic restorations after fatigue loading. (36)

Please note, restoration strength will also be dependent on framework design and finishing technique. In summary, Lava™ Plus High Translucency Zirconia offers uncompromized aging stability similar to clinically proven Lava™ Zirconia.

Wear Behavior

Lava™ Plus Highly Translucent All-Zirconia monolithic restorations

All-zirconia restorations, if made of Lava™ Plus Zirconia, give the clinician a biocompatible, tooth-colored and highly-durable alternative to metal restorations. Lava™ Plus Zirconia can also be covered with a thin glaze layer only or it can be simply polished in direct occlusal contact. The monolithic Zirconia indication raises new questions:

Are Lava™ Plus All-Zirconia Monolithic restorations antagonist friendly? What needs to be considered in treatment planning? How can I adjust and polish Lava™ Plus All-Zirconia Monolithic restorations?

Antagonist wear of Lava™ All-Zirconia

Zirconia is a hard material. One might intuitively derive abrasiveness from hardness. However, abrasiveness is mainly determined by material smoothness (21). A smooth surface will not lead to excessive antagonist abrasion because there will be little mechanical interlocking between the two wear bodies. Polished Lava™ Zirconia was found less abrasive to enamel compared to veneering porcelain and a pressed glass ceramic in the OHSU 3-body Oral Wear Simulator (Fig. 16). (22)

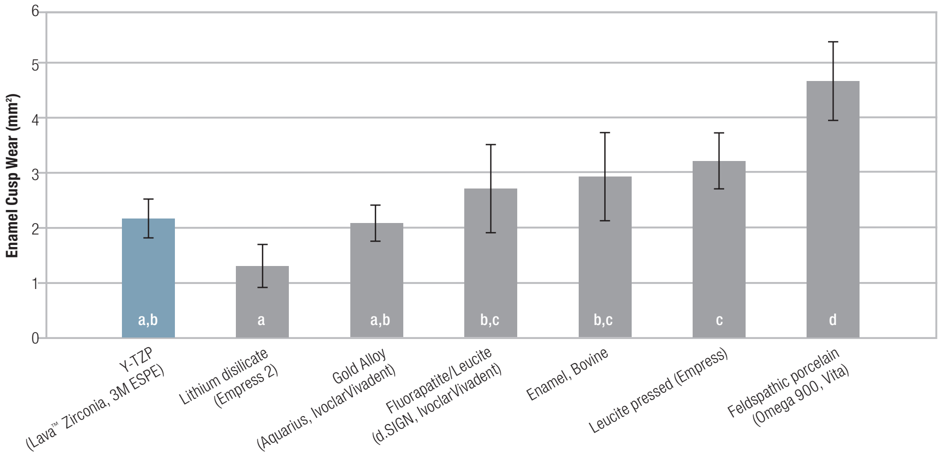


Fig. 16: Mean human enamel cusp wear against polished material in an abrasive medium
(OHSU 3-body Oral Wear Simulator). **(22)**

Long-term enamel wear behavior of Lava™ Zirconia material after accelerated aging was investigated at the University of Alabama at Birmingham (Fig. 17). The study revealed that: "Aged zirconia had similar roughness and produced similar wear of opposing enamel as polished zirconia. Both zirconia groups produced less enamel wear than the veneering porcelain or natural enamel." (23)

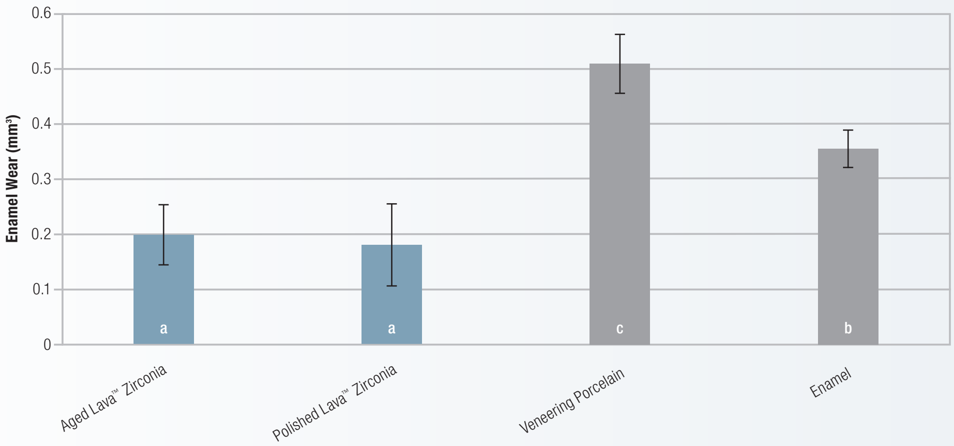


Fig. 17: Volumetric human enamel wear to Lava™ Zirconia (polished or polished and aged by autoclaving for 5 h at 135 °C, 2 bars), human incisor enamel and a veneering porcelain (Modified Alabama wear testing device). **(23)**

Lava™ Plus Zirconia shows equivalent wear behavior to Lava™ Frame Zirconia (Fig. 18).

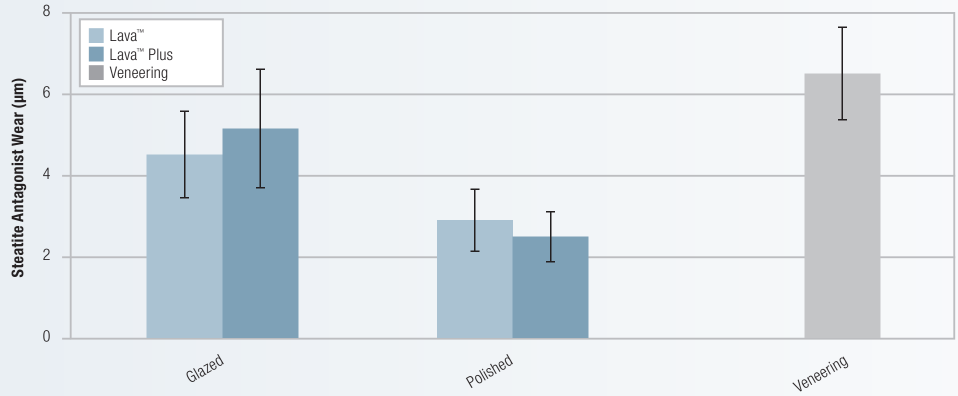


Fig. 18: Steatite (29) antagonist wear behavior of Lava™ Zirconia and Lava™ Plus Zirconia when veneered, glazed or polished only (24)(25).

Extensive aging does not affect the smoothness of Lava™ Zirconia. The smooth surface provides low wear against the antagonist (Fig. 19). (1)(2)

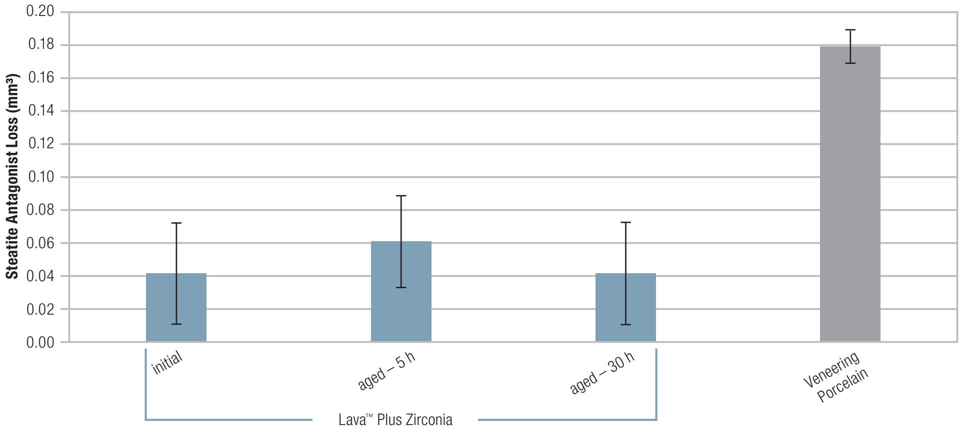


Fig. 19: Wear of enamel model substance Steatite to Lava™ Plus High Translucency Zirconia (polished or polished and aged at 135 °C, 2 bars) and veneering porcelain. (2)

Fig. 20: Lava™ Plus Highly Translucent All-Zirconia Monolithic 6-unit bridge.

Zirconia Material Wear

Lava™ All-Zirconia Monolithic restorations show no notable self abrasion – they will maintain their anatomic shape over time. (1)(2) Lava™ Plus All-Zirconia Monolithic restorations behave similar to non-precious metal materials like cobalt chrome (Fig. 21).

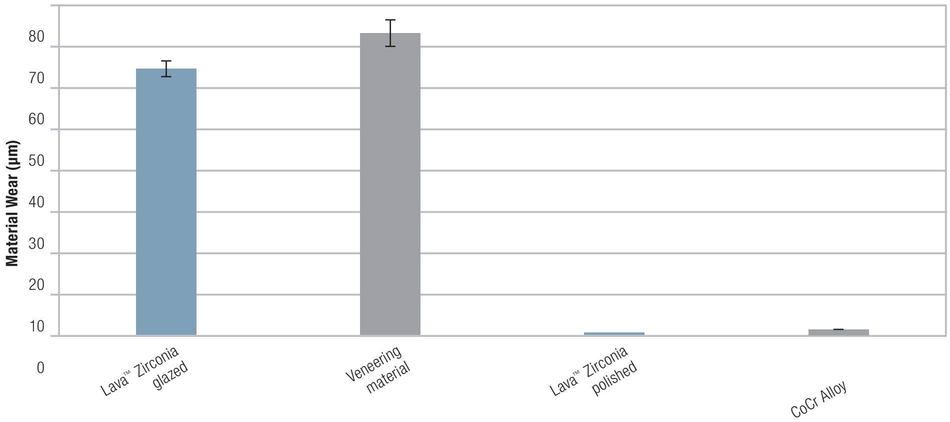


Fig. 21: Material wear of polished and glazed Lava™ Zirconia, a veneering material and non-precious metal CoCr alloy after abrasion in with a Steatite sphere at 25 N load. (3M ESPE internal data, method published in (28))

Zirconia Material Handling

Due to the fact that zirconia occlusal surfaces are not subject to appreciable abrasive wear, therapy planning has to be considered carefully. Special attention must be paid to the design of the occlusal surface so that dynamic and static occlusion is correct. This should be checked regularly by a dentist.

If minor intra-oral adjustments are necessary, use a fine diamond bur with water-cooling and continue with a standard rubber polisher set for ceramic materials.

Several In vitro-test results demonstrated that Lava™ All-Zirconia has antagonist preserving wear properties and is not abraded or roughened under occlusal load in water. Polished Lava™ Zirconia is even more antagonist friendly than veneering porcelains. The antagonist friendliness is preserved with aging.

3 Lava™ Plus High Translucency Zirconia Dyeing Liquids

3M™ ESPE™ invented dental zirconia shading. Lava™ Plus is a complete system, offering a high translucency zirconia which is combined with a tailored shading solution for full color control. Each Lava™ Plus High Translucency Dyeing Liquid by 3M ESPE is a fine-tuned mixture of three ionic components. The result is a full offer of 18 dyeing liquids covering the 16 VITA classical A1 – D4 shades plus two bleach shades.

How does zirconia shading work?

Lava™ Plus High Translucency Zirconia Dyeing Liquids from 3M ESPE are applied after milling to the porous pre-sintered zirconia (Fig. 22). Through this dyeing process, the coloring ions are built into the zirconia crystalline structure where they produce the desired color.

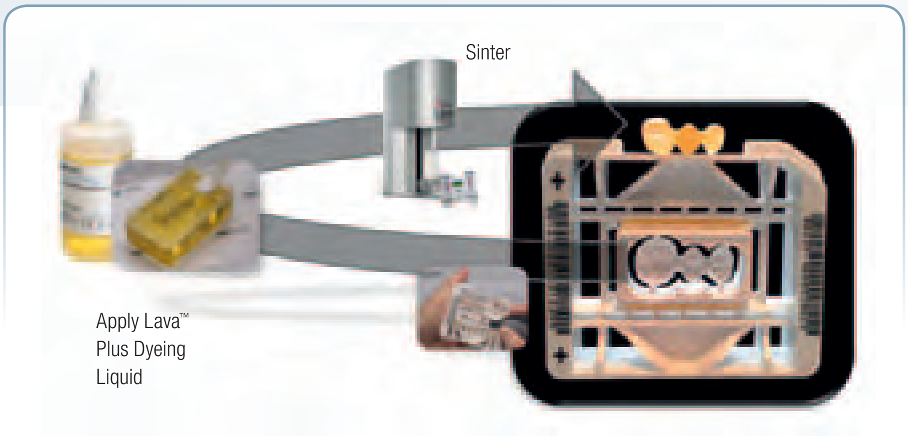


Fig. 22: Zirconia shading process.

Where does the color come from?

3M ESPE developed the shading liquids to work specifically with Lava™ Plus Zirconia. The liquids utilize proprietary technology based on three different ions: for yellow, red and grey colors (Fig. 23). Lava Plus Dyeing Liquids are Cobalt and Chrome free.

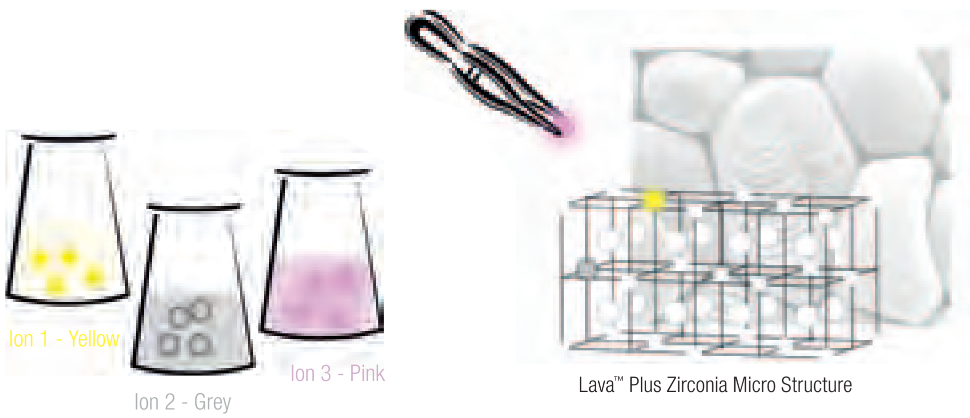


Fig. 23: 3-Ion shading principle of Lava™ Plus High Translucency Zirconia.

Each Lava™ Plus Dyeing Liquid is a fine-tuned mixture of these three ionic components. A special organic additive in the Lava™ Plus Dyeing Liquids ensures uniform distribution of the ions within the pre-sintered material and ensures the ions remain in the zirconia crystal lattice during drying. In the sintering process step, the organic compound is completely burned out. Lava™ Plus Dyeing Liquids offer true colors with an excellent color match to VITA® classical Shade Guide (Fig. 24).

Fig. 24: Color match comparison of A4 shaded 3-unit bridge frameworks cut through the connector. From left to right: Crystal™ Zirconia HS, Colour Liquid A4, Prettau; VITA™ In-Ceram® YZ, VITA™ In-Ceram® YZ, Coloring Liquid LL5; Lava™ Plus High Translucency Zirconia, Lava™ Plus High Translucency Zirconia Dyeing Liquid A4; VITA classical shade guide.

The ions built into the zirconia crystal lattice absorb part of the white light spectrum to achieve color. Lava™ Plus Dyeing Liquids transform the pure white pre-sintered Lava™ Plus Zirconia into a beautiful restoration with a warm, natural intrinsic tooth color (Fig. 25).

Fig. 25: Lava™ Plus Highly Translucent All-Zirconia Monolithic crown custom shaded with Lava™ Plus Dyeing Liquids.

Comparing the transmission spectra of different shaded zirconias reveals a clear difference between the Lava™ Plus System and other zirconias (Fig. 26). The unique technology employed for 3M™ ESPE™ Lava™ Plus High Translucency Zirconia Dyeing Liquids shows two distinct absorption peaks with a transparency window in the green to yellow range.

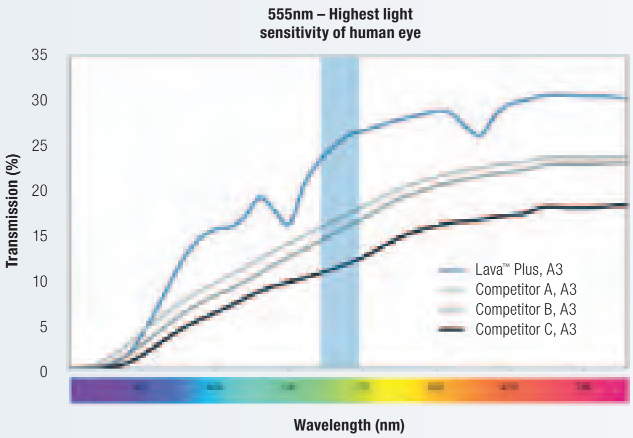


Fig. 26: Transmission spectra of shaded, polished zirconia discs with 1 mm thickness
(Color i7, 3M ESPE internal data).

This transparency window is of special importance for the warm, natural appearance of Lava™ Plus Zirconia which leads the eye to perceive life-like esthetics of shaded Lava Plus Zirconia restorations. This unique feature of the Lava™ Plus Dyeing Liquids also helps to better maintain the translucency after shading (Fig. 27). (3)

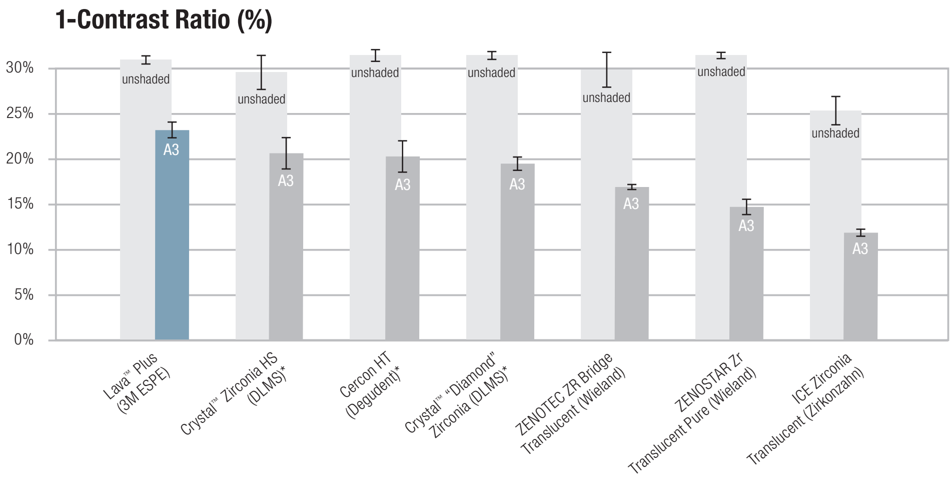


Fig. 27: Contrast ratio of uncolored and colored zirconia materials. (3)
* No dedicated shading solution – shaded with Zirkonzahn Prettau Color Liquid A3

4 Lava™ Plus High Translucency Zirconia Effect Shades

Fig. 28: Lava™ Plus High Translucency Zirconia Effect Shades.

In addition to the dyeing liquids the Lava™ Plus system offers 8 effect shades (Fig. 28). The effect shades employ the same shading principles as the dyeing liquids in that the color ions are incorporated into the zirconia crystal lattice.

The effect shades allow unprecedented customization of Lava™ Plus Zirconia:

- **White** can be used punctually to mimic small, opaque white spots
- **Yellow, Orange, Brown** e.g. to provide stain into fissures and at crown collar
- **Purple** and **Grey** to increase vitality of cusps and incisal edges
- **Pink** to better blend into gingival tissue at crown margins, bridge connectors and zirconia build-ups for 2-piece abutments.
- **Fluorescence**

Besides translucency and color, fluorescence is an important parameter determining the esthetics of a restorative material. Human teeth are fluorescent (Fig. 29). Dentin has a higher fluorescence than enamel. To mimic the optical properties of a tooth it is important to provide fluorescence from within the whole restoration material. With the Lava™ Plus Fluorescent effect shade it is possible to incorporate fluorescence into the Zirconia core, e.g for Zirconia build-ups for two-piece abutments and into monolithic restorations. Lava™ Plus Effect Shade Fluorescence can be used with lighter restoration shades. (W1, W3, A1, B1, C1, unshaded).

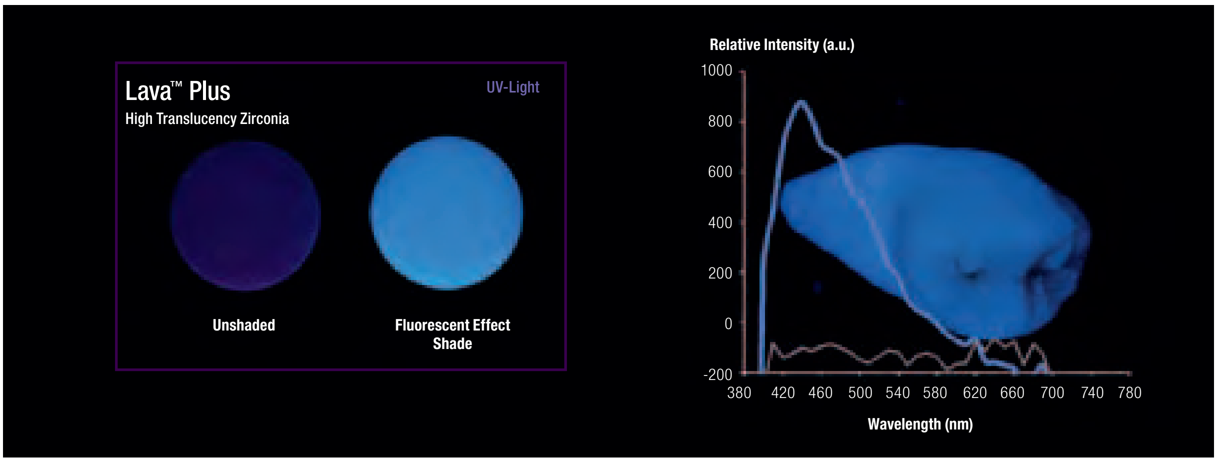


Fig. 29: All images are taken under UVA light exposure. Left: Lava™ Plus Disk; Middle: Lava™ Plus + Fluorescent effect shade Disk; Right: Emission spectrum Lava™ Plus and Lava™ Plus + Fluorescent Effect shade when irradiated with UVA.

5 Lava™ Plus High Translucency Zirconia – Shading and Finishing

For more information, see video:

The Lava™ Plus system allows many shading and finishing options (Fig. 30).

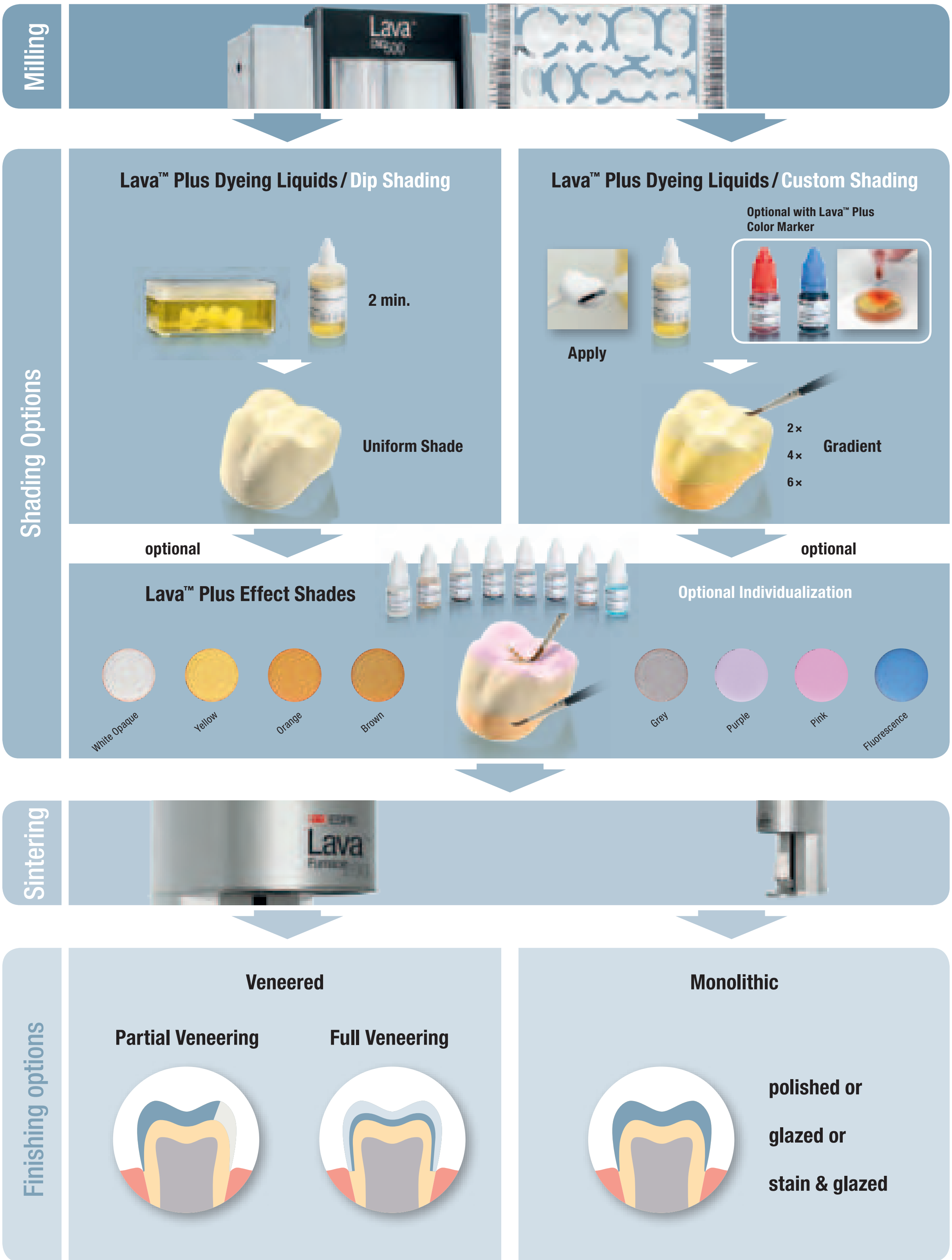
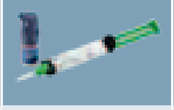
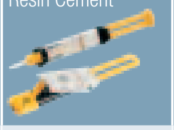
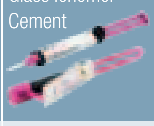
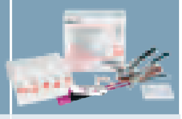
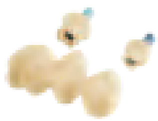


Fig. 30: Shading and Finishing Options of Lava™ Plus High Translucency Zirconia.

6 Lava™ Plus High Translucency Zirconia – Cementation Options

Lava™ Plus Highly Translucent Zirconia restorations from 3M ESPE can be placed using a variety of different cements. We recommend the use of the following cements for the following indications:

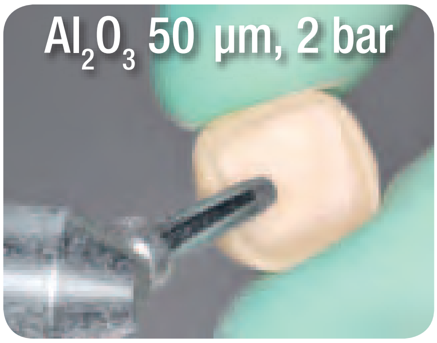
INDICATION	++ Highly recommended + Recommended - Not indicated	**RelyX™ Ultimate** Adhesive Resin Cement 	**RelyX™ Unicem / RelyX™ U100 and RelyX™ Unicem 2 / RelyX™ U200** Self-Adhesive Resin Cement 	**Ketac™ Cem Plus / RelyX™ Luting Plus / RelyX™ Luting 2** Resin Modified Glass Ionomer Cement 	**Ketac™ Cem** Glass Ionomer Cement 
Crowns (anterior and posterior)		+	++	+	+
Splinted crowns[1]		+	++	+	+
3-4 unit bridges		+	++	+	+
Long-span and curved bridges (up to 48 mm)[2]		+	++	+	+
Cantilever bridges[3,5]		+	++	+	+
3-unit Inlay and onlay bridges[4,5]		++	+	-	-
Anterior adhesive bridges (Maryland bridges)[4,5]		++	+	-	-
Primary Crowns		+	++	+	+
Crowns on implant abutments[5]		+	++	++	+
3-unit bridges on 2 implants[5]		+	++	++	+
Zirconia build-up for two-piece abutments		-	++	-	-

1. Splinted crowns up to 4 units
2. 5+ unit bridges (up to 48 mm) with a maximum of two pontics next to one another in the posterior area and a maximum of four pontics next to one another in the anterior area. Registration pending in Canada.
3. With a maximum of 1 pontic at the position of a premolar or incisor
4. Tests have proven: Lava™ Zirconia shows a sufficient strength for this indication. However, this type of indication overall can have a higher failure risk due to adhesion failure and secondary caries regardless of manufacturer. Please refer to national and regional dental associations for more information
5. Contra-indicated for patients with bruxism

Fig. 31: Cementation Options for Lava™ Plus Zirconia and Lava™ Zirconia.

For detailed information, please check the Instructions for Use of the respective cements.

Regardless of the cement, extra-oral sandblasting of the cementation area of the Lava™ Zirconia or Lava™ Plus Zirconia restoration is mandatory. We recommend aluminium oxide with grain sizes ≤ 50 µm and 2 bar pressure (Fig. 32). This allows efficient surface roughening while maintaining material strength. (10)(31)(32)(33)(34)



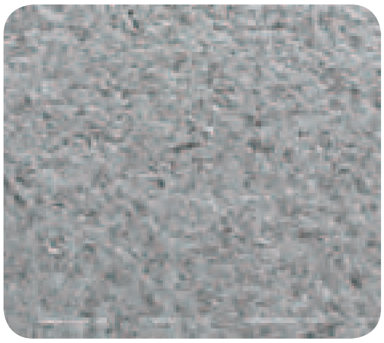


Fig. 32: Left: SEM picture of polished Lava™ Zirconia, Middle: Sandblasting of inner Lava™ restoration surface, Right: SEM picture of roughened Lava™ Zirconia (Magnification 500fold).

Cement adhesion to Zirconia is highly effective via phosphate functionalized monomers. The working principle of 3M™ ESPE™ Scotchbond™ Universal Adhesive and 3M™ ESPE™ RelyX™ Unicem Self-Adhesive Resin Cement is presented in figure 33. RelyX™ Unicem contains phosphate functional group monomers which bond to the zirconia surface. RelyX™ Ultimate Adhesive Resin Cement is used with Scotchbond™ Universal Adhesive as the primer and adhesive. Scotchbond™ Universal Adhesive also contains MDP monomers provide chemical bonding through phosphate functional chemistry.

The use of hydrofluoric acid does not have any effect whereas the use of phosphoric acid even leads to a negative impact on effectiveness of phosphate monomers.

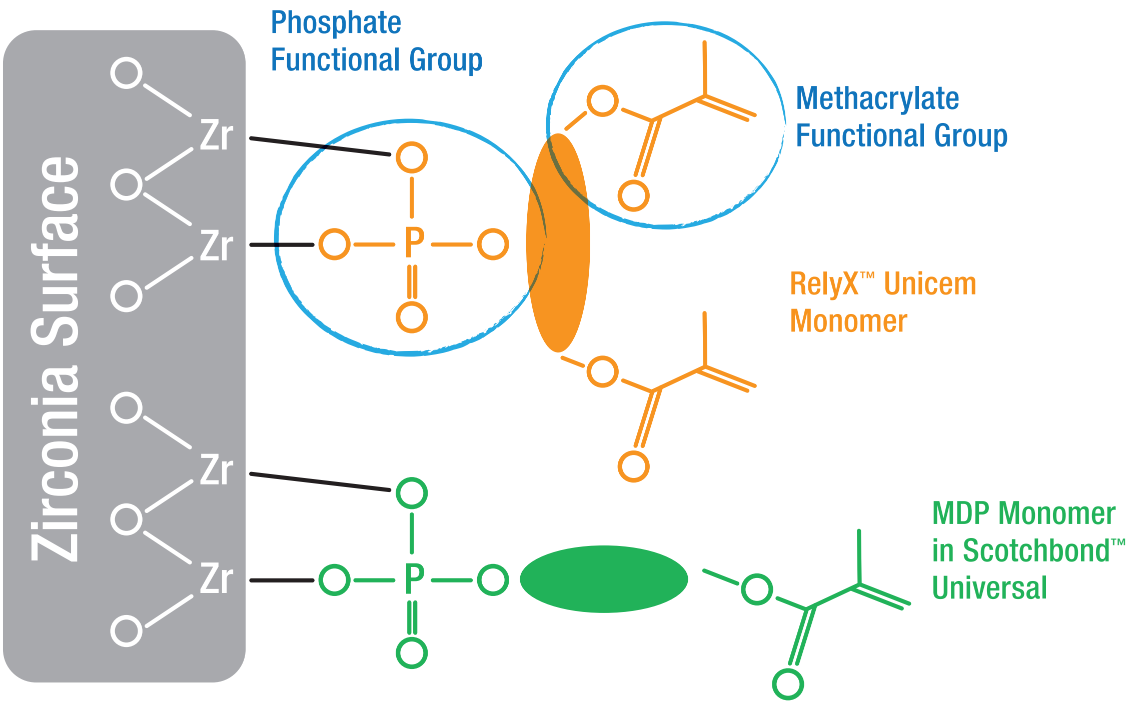


Fig. 33: Adhesion mechanism to zirconia of phosphate functionalized monomers as contained in RelyX™ Unicem Cement and Scotchbond™ Universal Adhesive.

RelyX™ Unicem 2 Automix Self-Adhesive Resin Cement shows excellent adhesion to Zirconia without the need for a separate primer (Fig. 34).

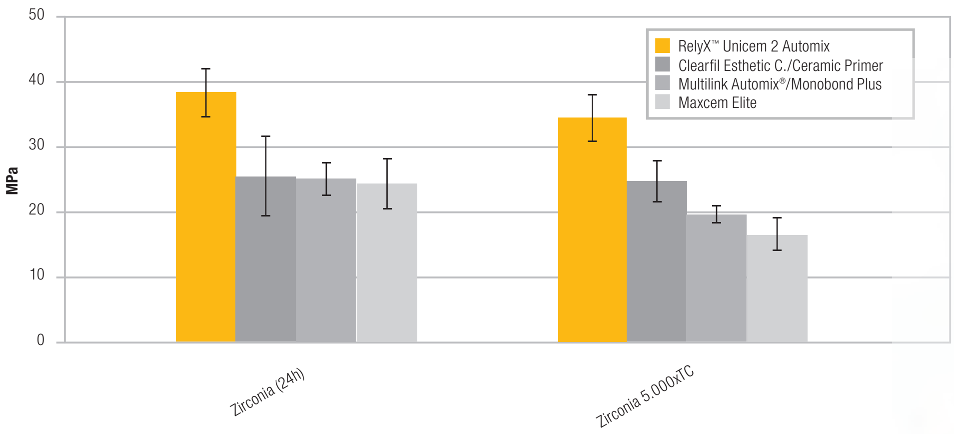


Fig. 34: Shear bond strength of RelyX™ Unicem 2 to Lava™ Zirconia before and after aging. Results cited in parts from (37).

The excellent bond strength of RelyX™ Ultimate Cement to Lava™ Zirconia was demonstrated in various internal and external studies. Retention of zirconia crowns bonded with adhesive resin cements was measured after thermocycling and fatigue (Fig. 35). RelyX™ Ultimate Cement performed superior to competitive cement systems. (35)

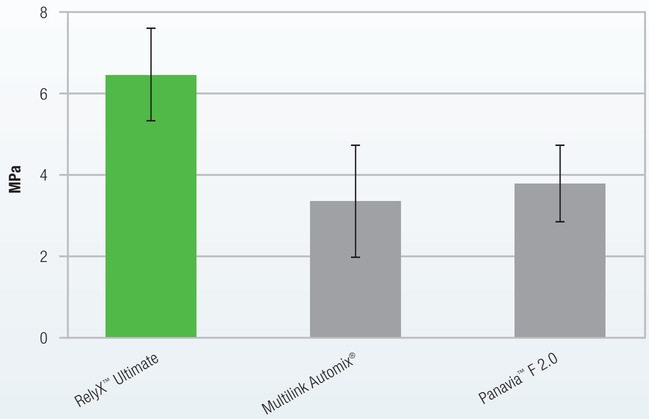


Fig. 35: Zirconia crown pull-off strength of resin cements after artificial aging.

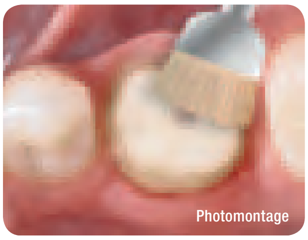
For more detailed information on scientific data of RelyX™ Unicem 2 and RelyX™ Ultimate, please refer to the corresponding Technical Product Profiles (www.3MESPE.com).

Lava™ Plus High Translucency Zirconia – Step-by-step Cementation Guide

RelyX™ Unicem Self-Adhesive Resin Cement and RelyX™ Unicem 2 Self-Adhesive Resin Cement are highly recommended for the cementation of Lava™ Zirconia and Lava™ Plus Highly Translucent Zirconia Crowns and Bridges (Fig. 36):

Try-in of Lava™ or Lava™ Plus Zirconia restoration

- Try-in restoration to check fit and color match.
- Carefully mark contacts.
- Remove undesired contacts with red ring diamond if necessary. (30 µm grain, water cooling and turbine)

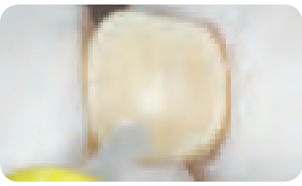


Cleaning Step Intraorally

- Clean the prepared abutment/cavity thoroughly with pumice slurry, rinse with a water spray and lightly air dry or use cotton pellets to dry it off. Do not over dry.
- Do not use H_2O_2 (hydrogen peroxide) or substances such as desensitizers, disinfectants, astringents, dentin sealants, rinsing solutions containing EDTA, etc., after the final cleaning with pumice slurry and water.
- Take care for adequate blood and saliva control. Do not use ferrous liquids for blood control.

Sandblasting and Cleaning Step Extraorally

- Sandblast inner zirconia restoration with aluminum oxide AL2O3 ≤ 50 µm, 2bar.
- Clean inner zirconia restoration surface with alcohol and dry with water-free and oil-free air.



Application of RelyX™ Unicem or RelyX™ Unicem 2 Self-Adhesive Resin Cement

- Apply according to *Instructions for Use.*

Excess Removal

- Remove excess cement after brief light exposure (“tack cure”, < 2 sec with a conventional polymerization device) or during self-hardening in the gel phase (starting 2 min [2:30 min. for RelyX™ Unicem 2 Automix Self-Adhesive Resin Cement] after beginning of mixing).
- During excess removal use a suitable instrument to hold restoration in place.

Curing Step

- Light- or self-curing according to the *Instructions for Use.*

Polishing Step

- Finish and polish the marginal area with diamond polishing devices, aluminum oxide coated discs (e.g. 3M™ ESPE™ Sof-Lex™ Discs), and polishing paste.
- If occlusion was adjusted, polish these areas with ceramic rubbers, polishers, ceramic polishing paste and adequate brush to a smooth and shiny surface.

Fig. 36: Step-by-step cementation guide

Pictures by Dr. Carlos Eduardo Sabrosa, Rio de Janeiro, Brazil.

7 Clinical Applications / Cases

Metal-free and tooth-colored esthetics:

Clinical case with pure monolithic, glazed-only 3M™ ESPE™ Lava™ Plus Highly Translucent Zirconia Restorations.

Fig. 37: Case 1 Initial situation: Insufficient full-cast metal crowns at teeth 26 and 27; insufficient composite filling at teeth 23, 24 and 25.

Final result: Monolithic Lava™ Plus Highly Translucency Zirconia Single Crowns at teeth 25, 26 and 27; teeth 23 and 24 restored with Filtek™ Supreme XTE.

Uncompromized esthetics:

Clinical case with veneered Lava™ Plus Highly Translucent Zirconia Restoration.

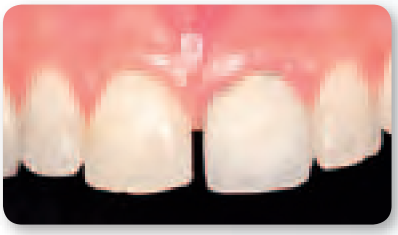
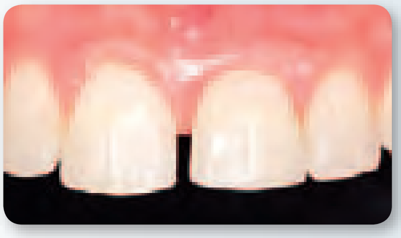


Fig. 38: Case 2 Initial situation: Insufficient PFM crown at tooth 21.



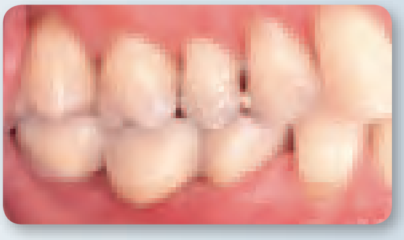
Final result: Tooth 21 restored with Lava™ Plus Highly Translucent Zirconia crown veneered with Vita™ VM 9.

Chip-free and tooth-colored esthetics:

Clinical case with only little inter-occlusal space. Monolithic, 3-unit Lava™ Plus Highly Translucent Zirconia Bridge, individualized with Effect Shades and glazed only. Minimum wall thickness at contact points 0.5 mm.

Fig. 39: Case 3 Initial situation: Insufficient provisional at 45 to 47.

Prep situation: Little inter-occlusal space at 45 to 47 – Monolithic restoration indicated.



Final result: Monolithic Lava™ Plus Highly Translucent Zirconia bridge at 45 to 47.

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9 Summary of Physical and Mechanical Properties

Property	Lava™ Plus High Translucency Zirconia Mill Blank	Lava™ Frame Zirconia Mill Blank
Flexural strength (Punch Test) (ISO 6872)	> 1100 MPa	> 1100 MPa
Young's modulus (Modulus of elasticity)	210 GPa	210 GPa
Fracture toughness (KIC SEVNB, ISO 6872 Annex)	5-10 MPa $m^{1/2}$	5-10 MPa $m^{1/2}$
Coefficient of thermal expansion (25 °C – 500 °C) (ISO 6872)	10,5 ± 0,2 1/K	10,5 ± 0,2 1/K
Vickers hardness (HV 10)	> 1200	> 1200
Melting point	2700 °C	2700 °C
Average grain size	0,4 µm	0,5 µm
Density (ISO 13356)	6,08 g/cm^3	6,06 g/cm^3
Solubility (ISO 6872)	< 0,01 $µg/cm^2$	< 0,01 $µg/cm^2$
Opacity (Contrast Ratio of 1 mm disk measured in remission)	69 %	76 %
Dyeing Procedure	18 Dyeing liquids, 2 Color markers, 8 Effect shades	7 Frame shades

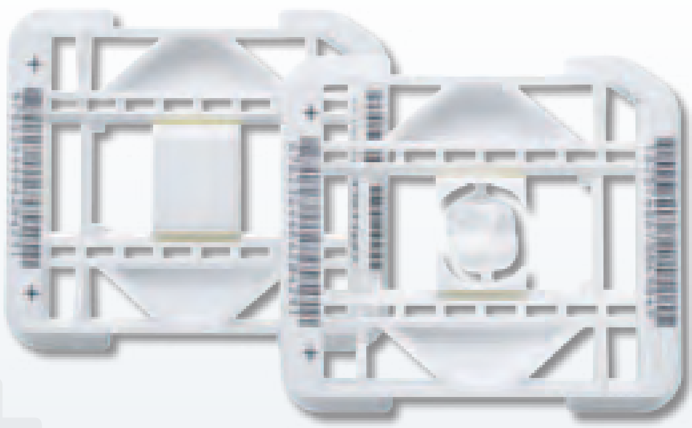

Fig. 40 Lava™ Plus High Translucency Zirconia Mill Blanks 20. With and without milled single unit crown.

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