3M ESPE

All Ceramic System

technical product profile

Lava

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1. Introduction

Overview

The Lava All Ceramic System comprises a CAD/CAM procedure for the fabrication of all-ceramic crowns and bridges for anterior and posterior applications. The ceramic framework consists of zirconia supplemented by a specially designed overlay porcelain. The frameworks are fabricated using CAD/CAM manufacturing techniques (scanning, computer-aided design, computer aided manufacturing) for pre-sintered zirconia blanks. Sintering of the milled frameworks in a special high-temperature furnace, the size of which has been increased to compensate for the sintering shrinkage during sintering, leads to high-strength restorations with excellent fit.

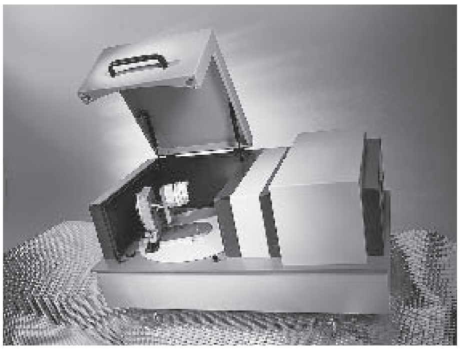


Figure 1. Lava™ Scan Optical 3D scanner

Figure 2. Lava™ Form Computer-aided milling machine

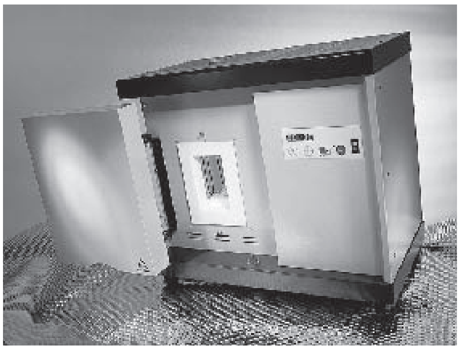


Figure 3. Lava™ Therm Sintering furnace

Figure 4. Lava™ Frame Zirconia framework

History

Porcelain restorations have been a fundamental component of dental care for many years. Reports dating from the seventeenth century recount the first successful attempts of a porcelain tooth replacement[1] (Duchateau and Dubois de Chemant, Paris).

At the beginning of the nineteenth century Charles Henry Land developed the porcelain jacket crown, based on a feldspathic composition, which is still used today in a slightly modified form. Fifty years later reinforcement of the jacket crown with aluminium oxide was achieved as a result of the work of McLean and Hughes[2].

Further materials developments, which concentrated on the inadequate fracture resistance of the shell ceramics, were based on increasing the crystalline content, for example leucite (Empress®), mica (Dicor®), hydroxyapatite (Cerapearl®) or glass infiltrated mixed (e.g. aluminum/ magnesium/zirconium) oxides (InCeram®).

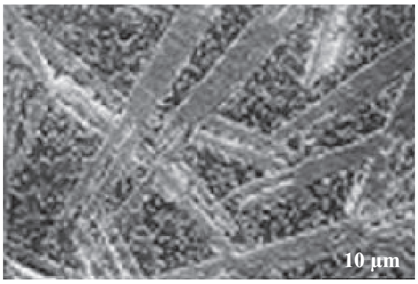


Figure 5. Glass ceramic (contains glass) e.g. Empress I/II

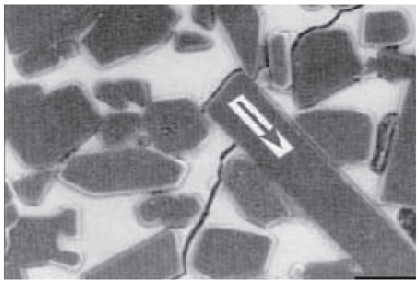


Figure 6. Infiltrated ceramic (contains glass) e.g. InCeram

Pure polycrystalline oxide ceramics (e.g. Procera®) have only been in clinical use for about 10 years.

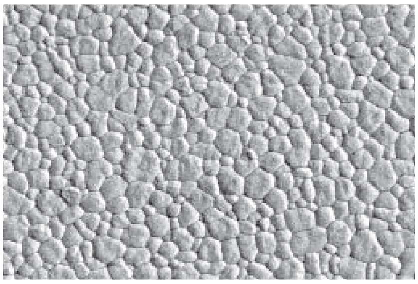


Figure 5. Polycrystalline ceramic (glass-free) e.g. Lava

Casting (Dicor), pressing (Empress) and grinding techniques (CEREC®) are all used to create morphology.

The idea of using CAD/CAM techniques for the fabrication of tooth restorations originated with Duret in the 1970s. Ten years later Mörmann developed the CEREC®-system first marketed by Siemens (now Sirona), which enabled the first chairside fabrication of restorations with this technology. There has been a marked acceleration in the development of other CAD/CAM laboratory systems in recent years as a result of the greatly increased performance of PCs and software.

Pressed ceramics, such as Empress have been used successfully for anterior crown applications for more than 10 years. InCeram crowns have also been used with long-term success for *anterior* tooth applications, though InCeram bridges and fixed partial dentures in *posterior* applications have not. In view of the success of porcelain fused to metal for over 30 years, any new all ceramic system must be comparable to this. A minimum survival rate of 85 % after 10 years in situ is required – even for posterior teeth[2a].

Crowns luted utilizing adhesive bonding have initially had favorable conditions for a high survival rate. The reason for this is a less critical stress situation, therefore a favorable situation with adhesive bonding of e.g. glass ceramics is achieved. The first published clinical results on Empress II are promising for bridges only up to the first premolar, but here again long-term results are not yet available.

Motivation

As a result of the requirement to provide patients with **excellent, aesthetic** and **biocompatible** prosthetic dental restorations, the search for ways to fabricate all-ceramic multi-unit bridges, offering **long-term stability** in posterior applications, has witnessed the limitations of glass ceramics and infiltrated ceramics.

Because of their material characteristics, frameworks based on polycrystalline ceramics are able to surmount these limitations. **Bridges for the posterior region** are also considered as an indication. It is zirconium oxide (zirconia), with its excellent **strength** and **biocompatibility** known from implant prosthetics, that makes it the framework material of choice. This type of framework can be fabricated by an automated process which supplies constant, monitored high quality and is designed to be as **flexible (in materials/indications)** as possible.

The zirconia framework also has to be the foundation of optimal esthetics (translucency & colorability), in combination with a perfectly matching overlay porcelain.

The enormous strength and natural esthetics of the framework mean that less tooth structure is removed during preparation. **Traditional cementation techniques,** as used in luting porcelain fused to metal, are possible.

Biocompatibility

All-ceramic tooth restorations are considered inert with respect to **oral stability** and biocompatibility. The **accumulation of plaque** is comparable to that on the natural tooth. Due to the low thermal conductivity of the ceramic, (unlike metal-supported units), sensitivity to temperature variation is no longer expected.

Long-term stability

The main concern centers on adequate **long-term strength** under functional stress in the specified range of indications. From the clinical point-of view, it is not the initial strength of the ceramic material itself that is of prime importance, but the time that the permanent restoration will last. In the case of ceramics containing glass, the type of **cementation**, adhesive bonding or conventional, is usually a decisive factor. It has a considerable effect on the stresses acting on the entire tooth preparation/restoration system. For the clinical use of porcelains adhesive bonding is required in the case of a **flexural strength** of around 100 MPa and a fracture toughness < 2 $MPa{\bullet}m^{1/2}$ (typical for glass ceramics). In the case of polycrystalline ceramic frameworks with considerably higher strength values, conventional cementation using glass ionomer cements may be recommended. Zinc phosphate cement is not indicated for aesthetic reasons.

The lack of **long-term strength** (subcritical crack growth, fatigue, stress corrosion) of the ceramic systems containing glass already on the market, as compared to the masticatory forces occurring in the mouth, is problematical. There is more noticeable loss of strength with glass containing systems due to the effect of oral moisture and **subcritical crack** growth (decreases to > 50% of initial strength). To guarantee successful, long-term restorations, an initial strength of more than 400 N is required for anterior restorations and more than 600 N for posterior applications. Values such as these (final strength of at least 500 N) are currently achieved only with alumina or zirconia bridges[2b].

Traditional Working Method

Ideally, the laboratory's dentist/customer needs a system that does not require him/her to change preparation and/or impressioning methods. The optimal system would use supragingival preparations where less tooth structure is removed, as compared with porcelain fused to metal restorations. Traditional luting, e.g. glass ionomer cements, would simplify the cementation process – and have the advantage of many years of success.

Range of indications

In modern clinical/materials scientific literature, currently available all ceramic systems (e.g. Empress and InCeram) are seen as being suitable for crowns in anterior and some posterior applications. Anterior bridges are indicated, but posterior bridges may be suitable only as far back as the first premolar (e.g. Empress II).[4] Clearly, a need for a reliable all-ceramic system designed for use in all posterior as well as anterior situations is needed.

Reliability

The literature describes other ceramic - specific parameters, such as fracture toughness and Weibull modulus. The Weibull modulus indicates the distribution of strength values. A high Weibull modulus (> 10) reflects a close distribution and is therefore advantageous, especially if the strength is low. However, for safety reasons a high Weibull modulus should be the goal even if there is high strength.

Accuracy of fit

Not the least consideration, a good accuracy of fit is also a determining factor for clinical success. An accuracy at the crown margin of 50 µm - 100 µm is considered ideal. A clear definition of the term fit is important (see Holmes et. al[13]).

Summary

These requirements can now be achieved using precise scanning and milling technologies - coupled with accurate knowledge of the zirconia ceramics. The Lava All Ceramic System has been developed utilizing the accumulated knowledge of previously available materials and systems, and newly developed state-of-the art scanning and milling expertise – to provide the laboratory, dentist, and patient with the most durable and aesthetic all – ceramic restorations available today.

2. Indications

Due to its outstanding mechanical and optical properties, Lava All Ceramic System covers a wide range of **crown and bridge applications** for most **anterior and posterior prosthetic requirements.**

Figure 8. Lava anterior crowns

Figure 9. Lava posterior crown

Figure 10. Lava anterior bridge

Figure 11. Lava posterior bridge

Preparation

The optimal preparation is a shoulder or chamfered preparation with a circumferential step or chamfer which must be applied at an angle of $> 5º$ (horizontal). The angle of the preparation (vertical) should be 4º or larger. The inside angle of the shoulder preparation must be given a rounded contour. The dies should be ditched directly below the margin (see arrow).

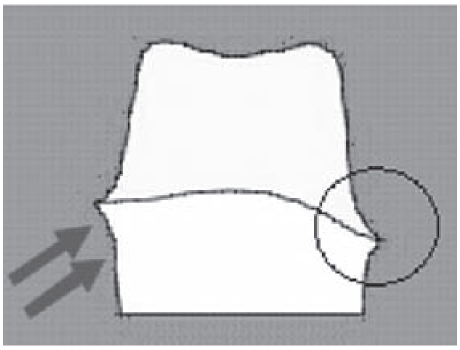


Figure 12. Chamfered preparation

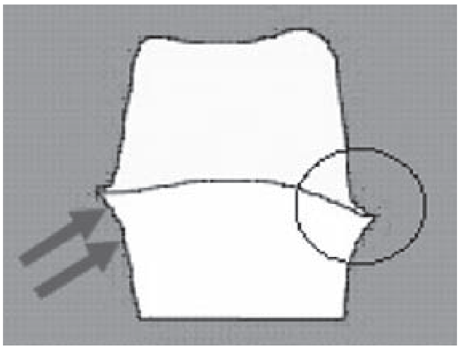


Figure 13. Shoulder preparation with rounded inside angle

Cementation

Permanent Cementation

The strength of Lava Frame frameworks is so high that adhesive cementation provides no additional advantages with respect to strength! The material can neither be etched nor directly silanized with silane coupling agent.

Conventional Cementation

For cementing use conventional glass ionomer cements, e.g. Ketac™ Cem, manufactured by 3M ESPE. The use of phosphate cements fail to provide the desired aesthetic results.

Figure 14. Cementation of an anterior bridge with Ketac Cem before the removal of excess material

Adhesive Cementation with RelyX™ Unicem

For adhesive cementation of the surfaces without silanization with the Rocatec System the new self-adhesive universal composite cement RelyX Unicem is suitable.
For adhesive cementation with silanization with the Rocatec System please proceed as described under point "Adhesive Cementation with Composites".

Adhesive Cementation with Composites

For the adhesive cementation with composite cements, the adhesive surfaces must be silicatized with Rocatec Soft or Cojet Sand for 15 sec and silanized with ESPE Sil. All products are manufactured by 3M ESPE. Soon thereafter, place in the mouth with composite cement, e.g. RelyX ARC, RelyX Unicem. If desired, a fit test has to be done before silicatization/silanization. For details on processing, please refer to the Instructions for Use of the Rocatec System or Cojet Sand.

3. Materials Science Background

Overview

The general term **all-ceramic dental materials** covers various oxide ceramic materials with very different material properties.

In addition to **glass ceramics** (reinforced by crystalline phases), two other currently available types are **glass infiltrated** and **polycrystalline** ceramics.

The first two groups are multi-phase materials and contain crystalline constituents (e.g. leucite crystallites) in addition to an amorphous **glass phase.**

Alumina and zirconia are the only two **polycrystalline** ceramics suitable for use in dentistry as framework materials, able to withstand large stresses in both anterior and posterior areas. These materials are shown to provide both necessary esthetics (tooth color, opacity) and material properties required of a modern tooth restoration.

Literature[6,7] indicates that 3-unit posterior bridges are clinically acceptable due to the high **fracture toughness** of InCeram® Zirconia, as recommended by the manufacturer VITA. It must be borne in mind, however, that finishing of sintered ceramics induces micro-defects. In addition to the defects introduced during fabrication, this may lead to a noticeable loss of strength even with high strength systems. In particular, the phenomenon of **subcritical crack growth** results in a poorer **long-term perspectice** for finished ceramic restorations. Generally speaking, the long-term strength of systems containing glass cannot be classified as completely without risk. Therefore the question of **long-term stability**, which is highly dependent on **subcritical crack growth** and **fatigue** is an exceptionally important aspect in the assessment of new all-ceramic systems. Subcritical crack growth refers to a continous fracture process in ceramics subjected to static and/or dynamic stress, whereby the crack may grow at a certain rate, until it results in a complete failure. The speed of crack growth also depends on the surrounding medium as well as the previously mentioned fracture toughness. H_2O in the saliva leads to so-called stress fatigue in systems containing glass. The water reacts with the glass causing corrosion of the latter; this leads to increased crack propagation velocities and consequently to long-term strength issues. On the other hand, systems having a polycrystalline microstructure such as ZrO_2 or Al_2O_3, and are to a great extent glass-free, display excellent long-term stability (see next chapter and Lit [6,7]).

The **preparation geometry** and wall thickness of framework and overlay porcelain are also decisive factors with regard to the strength of the permanent restorations . In the case of InCeram a chamfered preparation and framework wall thickness of around 0.8 mm is required for an optimal result. In the case of Empress the requirements are 1 mm of reduction in the body of the preparation and the shoulder. Lava Frame frameworks demonstrate the required strength at an overall thickness of only 0.5 mm.

Materials Science Aspects

Zirconia used in demanding environments is usually a tetragonal polycrystalline zirconia partially stabilised with yttria (Y-TZP = yttria tetragonal zirconia polycrystals) (addition of about 3 mol per hundred). This material is referred to as a transformation toughened material and it has the special property of a certain fracture inhibiting function. Tensile stresses acting at the crack tip induce a transformation of the metastable tetragonal zirconia phase into the thermodynamically more favourable monoclinic form. This transformation is associated with a local increase in volume. This results in localized compressive stresses being generated at the crack tip, which counteract the external stresses acting on the crack tip. This leads to a high initial strength and fracture toughness and, in combination with a low susceptibility to stress fatigue, to an excellent service life perspective for zirconia frameworks.

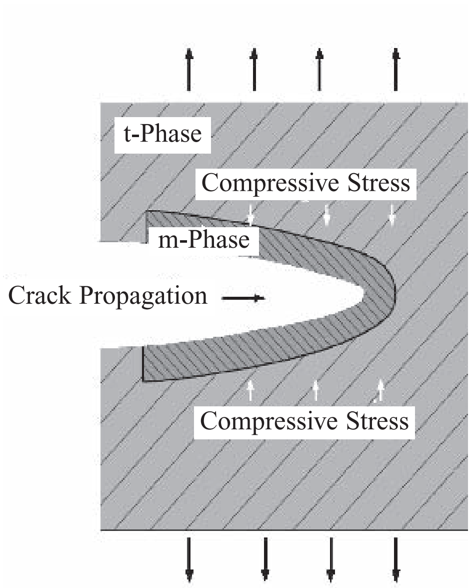


Figure 15. Fracture inhibition due to tetragonally stabilised zirconia

The frameworks may be fabricated by grinding dense sintered blanks (e.g. DCS, Celay®) or by milling pre-sintered porous zirconia blanks (e.g. Lava All Ceramic System). In the latter case, the **sintering shrinkage is compensated for with the aid of a powerful software.**

Because of the relatively low **coefficient of thermal expansion** (CTE) of zirconia (approx. 10 ppm), a special overlay porcelain (with the same or lower CTE) must be used.

In-vitro trials confirm the enormously high **fracture strength** of veneered 3-unit zirconia posterior bridges[8]. Values greater than 2000 N has been achieved, which exceeds the maximum masticatory load by a factor of 4. With this strength, bridges of this type demonstrate markedly better values than other all-ceramic bridges (e.g. Empress II: 650 N, InCeram® Alumina: 800 N). Consequently, zirconia can now be considered a suitable framework material for multi-unit bridges.

The strength values and high **fracture toughness** (resistance to crack propagation, K_{IC} about 10 MPa $m^{1/2}$ compared to aluminium oxide at about 5 MPa $m^{1/2}$) also enable a lower framework thickness than other all ceramic systems previously available. Instead of a coping thickness of 1 mm, a Lava framework/coping thickness of 0.5 mm is considered adequate. This permits **preparation** which encourages less aggressive tooth reduction than is the case with most systems currently on the market. The excellent esthetics of the zirconia framework (ideal translucency and coloration, see below) also enables the thickness of the veneer layer to be minimal, a result of which is a conservative preparation technique similar to porcelain fused to metal is possible.

The **surface finishing** of ceramic materials has a decisive effect on the material's flexural strength. The grinding and milling of sintered ceramics usually leads to a reduction in strength (micro-defects on the surface). The finishing, by grinding or milling, of sintered zirconia frameworks (either by means of the fabrication process, such as DCS, or finishing in the dental laboratory) may lead to a **loss of strength** compared to finishing in the green, or pre-sintered state (Lava System, 3M ESPE techniques). The finishing of sintered frameworks using grinding or milling tools is contra-indicated in the connector area. (enhanced tensile stress). The milling procedure sufficiently 'roughens' the internal surface of the crown for retention of cement. Adhesive bonding can be accomplished with the aid of the Rocatec bonding system or Cojet bonding system, which add a silicate coating to the internal surface of the framework, followed by a dual cure bonding resin, such as RelyX ARC (see Chap. 2 "Indications – Cementation").

Zirconia posterior bridges fabricated according to similar procedures in Zurich have been in use in a clinical trial since 1998. Results so far are extremely positive[9a, 9b].

4. Properties

Overview

Zirconia has proved itself as a **biocompatible** material in implant surgery for many years. Lava Frame zirconia demonstrates no measurable solubility or water absorption and shows an excellent long term stability. Therefore the strength of this material is maintained, even after a long period in the mouth. Lava Frame zirconia has no allergenic potential and is very biocompatible. Lava™ Ceram overlay porcelain has all the familiar advantages of a feldspathic **overlay porcelain** with respect to **biocompatibility** and **abrasion characteristics.**

Zirconia withstands many times the load level occurring in the mouth (loads measured for: anterior teeth up to 250 N, posterior teeth up to 450 N). Its strength is considerably higher than other all-ceramic materials. Unlike infiltrated or glass ceramics, Lava Frame zirconia is particularly suitable for posterior bridge frameworks and for long **spans.**

Mechanical Properties

Material specifications

1. Lava Frame Framework Ceramic

Density (ρ):	6.08 g/cm^3
Flexural strength (σ_B) (punch-on-three-balls) (#121473):	>1100 MPa
Fracture toughness (K_{IC}):	10 MPa $m^{1/2}$
(Youngs) Modulus of elasticity (E):	210 GPa
CTE:	10 ppm
Melting point:	2700 °C
Grain size:	0.5 µm
Vickers hardness (HV 10):	1250

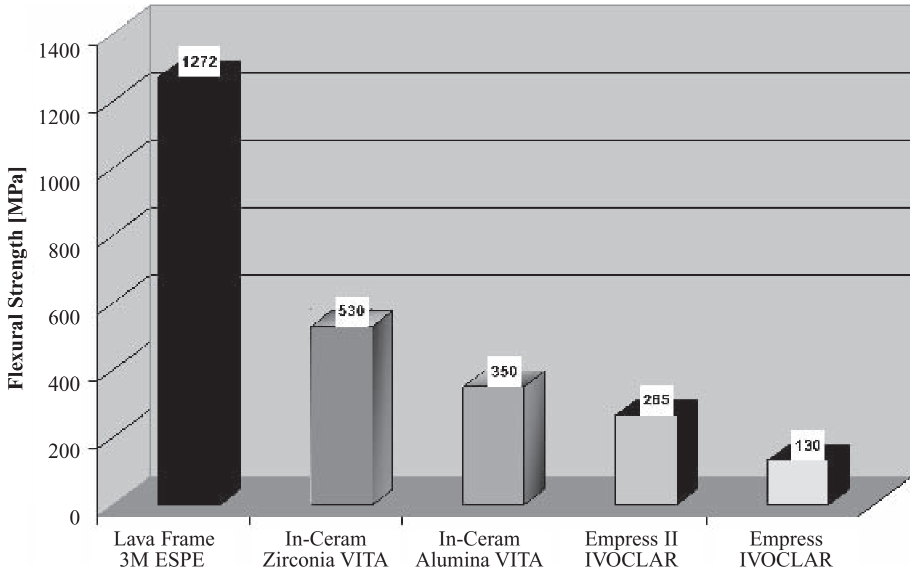
2. Lava Ceram Overlay Porcelain

Density (ρ):	2.5 g/cm^3
Flexural strength (σ_B) (3-point):	> 85 MPa
Fracture toughness (K_{IC}):	1.2 MPa $m^{1/2}$
(Youngs) Modulus of elasticity (E):	80 GPa
CTE:	10 ppm
Firing temperature:	810 °C
Grain size (d_{50}):	25 µm
Vickers hardness (HV 0.2):	530

Data in accordance with standard ISO 6872 (dental ceramics)

1. Lava Frame Framework Ceramic

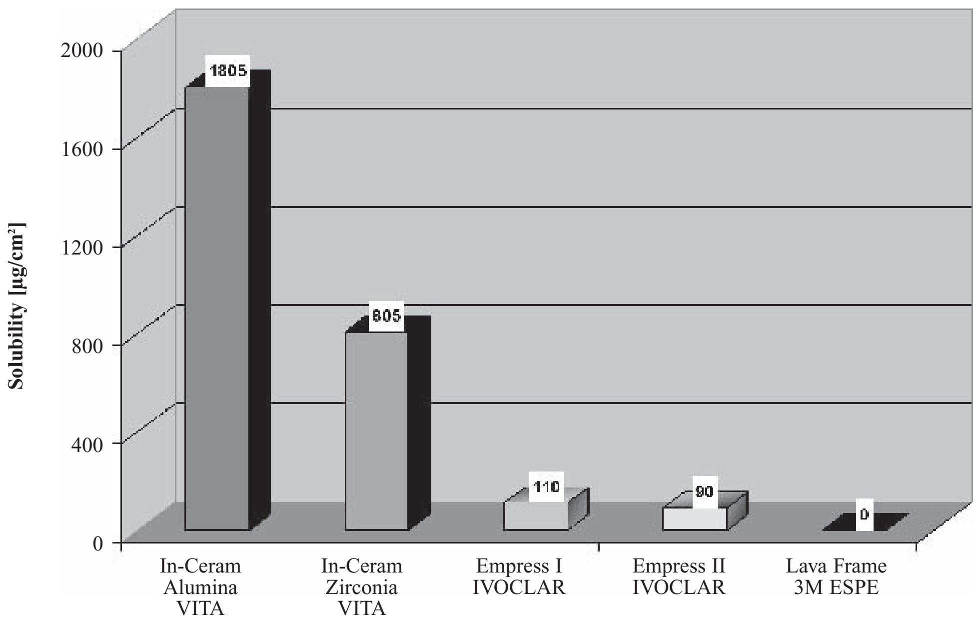
Flexural Strength (punch-on-three-balls) (ISO 6872)



A competitive product, InCeram Zirconia, which is a glass-infiltrated ceramic based on a zirconia and aluminium oxide combination, has only about half the flexural strength of Lava, but has been indicated for bridges in posterior applications.

The flexural strength (ISO 6872) in the 3-point bending test was also determined by Dr. Simonis (Berlin)[10] (1625 MPa).

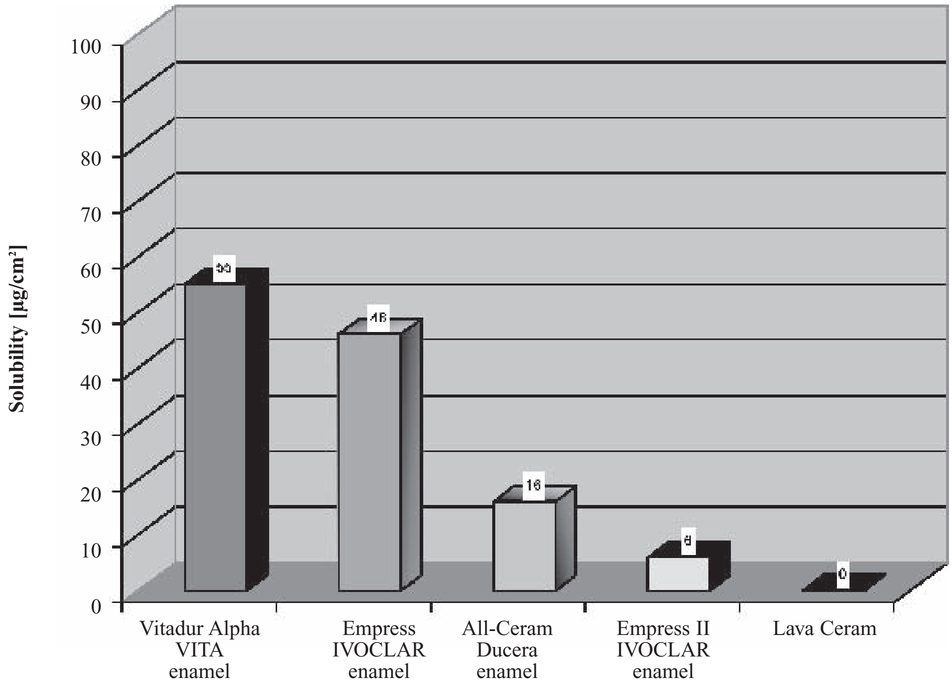
Chemical Solubility



The fact that there is no detectable solubility of the Lava zirconia framework is an indication of its high biocompatibility.

2. Lava Ceram Overlay Porcelain

Chemical Solubility



As with the framework ceramic, here too the solubility cannot be measured. This is an indication of excellent biocompatibility.

Long-Term Strength

Table 1: Characteristic material values of various dental ceramics

Ceramic	Weibull strength σ_0 [MPa]	Weibull-modululus m [-]	Fracture toughness K_{IC} [MPa√m]	Crack growth coefficient n [-]	Crack growth coefficient B [MPa^2sec]
Lava Frame	1345	10,5	9,6	50*	-
InCeram Alumina	290	4,6	5	18	$6,0 \cdot 10^1$
Cerec (VITA® Mark II)	88	24	1,3	26	$1,8 \cdot 10^1$
Dicor	76	6	0,8	25	$2,9 \cdot 10^1$
Empress I	89	9	1,2	25	$5,8 \cdot 10^1$
Empress II	289	9	2,5	20	$2,3 \cdot 10^3$
HiCeram®	135	9	2,5	20	$1,2 \cdot 10^3$
Hydroxylapatite	114	6	0,9	17	$2,2 \cdot 10^2$
VITA® Omega Opaker	69	12	1,4	21	$7,2 \cdot 10^1$

The data were ascertained by Prof. Marx and Dr. Fischer, Aachen [19].
** = 3M ESPE measurement*

Estimate of long-term strength of Lava Frame
(peripheral conditions: 60 % atmospheric humidity, 22°C, static continuous load)

A mathematical estimate of the service life time (maximum static continuous loading, with 2% failure rate after 5 years) can be made using a so-called SPT diagram (SPT: Survival-Probability-Time):

Table 2: Long - term flexural strength (static continuous load)

	Lava Frame	Empress II	In-Ceram Alumina	VITA® Mark II
$\sigma_{2\%/\ 5\ Jahre}$ [MPa]	615	80	125	30*

Source: Prof. Marx and Dr. Fischer, Aachen and internal measurements

The table must be interpreted in the following way: if a Lava Frame test specimen is subjected to a load of 615 MPa in moisture for 5 years, a failure rate of 2% may be expected. The same failure rate is obtained by Empress II at a continuous load of only 80 MPa.

Strength and Real Geometries

Fracture strength of 3-unit posterior bridges (patient models) before and after masticatory simulation (Munich, Prof. Pospiech PD, Dr. Nothdurft, Dr. Roundtree)[10, 11]

Resiliently mounted after cementation with Ketac Cem (mean values of 8 bridges)
a) initially after 24 h: **approx. 1800 N**
b) after 1.2 million masticatory load cycles (50N) and 10.000 thermocycles (5°/55°C): **approx. 1450 N**

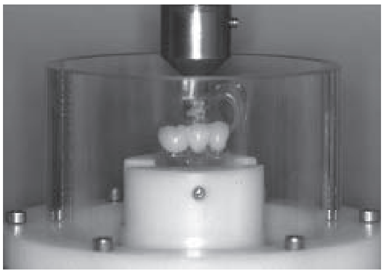


Figure 16. Set-up for masticatory simulation and thermocycle

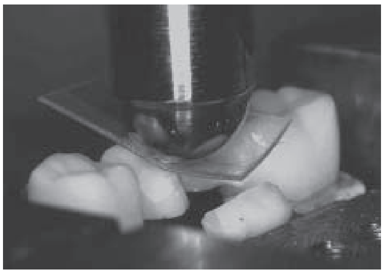


Figure 17. Fracture test

The slight decrease in the values combined with exceeding the maximum masticatory loading for posterior teeth of approx. 450 N (see above) after simulated 5 years of wear suggests an excellent probability of survival.

Fracture strength and long-term strength of 3-unit anterior bridges before and after masticatory simulation (Kiel, Prof. Ludwig)[10]
Resiliently mounted after cementation with glass ionomer.
6 bridges (11-22) were loaded from an angle of 30° until fracture occurred.

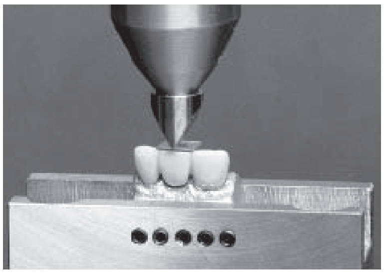


Figure 18. Measurement of static fracture load

a) Initially (24 h storage in water): static fracture load: **1430 N**

b) Long-term strength after masticatory simulation (1.2 million cycles - corresponding in clinical terms to approx. 5 years of wear, at 250 N, incl. thermocycling 5°/ 55°C): **no fracture**

Prof. Ludwig's conclusion based on the maximum masticatory force on the anterior teeth of 180 N: Lava anterior bridges can be assumed to be clinically resistant to fracture in long term usage.

Abrasion

In a masticatory simulator in Erlangen (U. Lohbauer), hemispheres made from the overlay porcelains under examination were tested against bovine enamel. Lava Ceram was compared with Empress II and VITA® Omega 900 (spherical) against bovine enamel (ground flat), and also Lava Ceram against itself.

The analyses were carried out using a scanning electron microscope (SEM) both for the spheres and the specimens, and volumetric surveys were conducted.

The wear values after 200,000 cycles with a load of 50 N and a further 1,500 cycles under thermocycle (5°C and 55°C) likewise with a load of 50 N resulted in a mean wear of 10^{-3} mm^3 for all overlay porcelains.

Other findings:

- Differences between the individual groups cannot be established to a significant degree.
- The abrasion of two ceramic surfaces in contact is higher in comparison with the bovine enamel.
- The traces of abrasion on the spheres are very slight and lie within the same ranges of size amongst the groups.
- Fractures which can be detected on the enamel samples on the SEM images are natural fractures in the enamel and are not attributable to the abrasion process.

The Lava Ceram overlay porcelain displays no fundamental differences from other commercially available products examined as far as abrasion is concerned.

Optical Properties/Aesthetics

The Lava Ceram overlay porcelain components are optimal matching the range of shades which can be applied to the framework made from Lava Frame. This results in a harmonic color appearence and natural blending into the oral environment.

The ideal translucency results from the material properties and the low wall thickness of the sintered zirconia. No light-absorbent opaquer or opaque dentine layers are necessary for the build-up of Lava all ceramic restorations.

Moreover, the relatively thin framework permits optimal modelling even in difficult situations. An appropriate selection of unique modifiers completes the Lava Ceram set.

The framework can be colored in 7 shades in the VITA® Classic shade system and is therefore ideal for a natural-looking build-up.

Figure 19. After the coloring of the frameworks (the first bridge has not been colored)

The relative translucency of a Lava framework and an Empress® II framework is comparable even in view of the wall thicknesses recommended by the manufacturers (Lava: 0.5 mm; Empress® II: 0.8 mm).

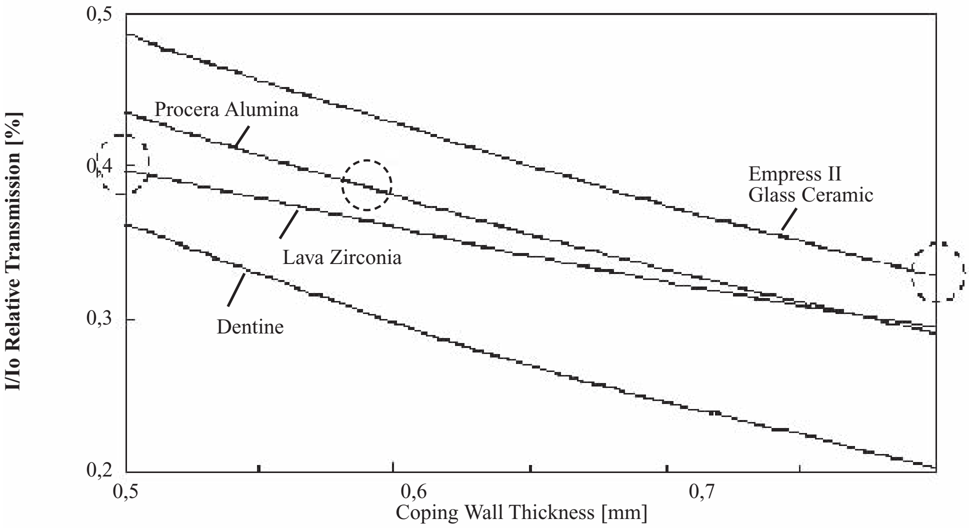


Figure 20. Comparison of translucency as a function of wall (coping) thickness

Any tooth shade can be reproduced without difficulty using the traditional range of 16 shades. Effect material and extrinsic colors provide necessary individuality.

Figure 21. Lava anterior bridge from tooth 11 - 13

Accuracy of Fit

Lava crowns and bridges have excellent accuracy of fit. The Lava Form milling unit operates on a high accuracy level.

In the Lava procedure the crown or bridge framework is milled from a so-called pre sintered state. This blank is made from presintered zirconia and is therefore considerably softer than dense and fully sintered material. Milling is thus performed quickly, accurately and economically before the extreme strength is achieved during the final sintering.

Excellent fit is achieved due to the high milling accuracy and the possibility of accurate calculation of the sintering shrinkage via the software package. The cement gap can be adjusted to the individual requirements.

Control of this procedure provides one of the fundamental innovations of the Lava technique. Specific 3M ESPE know-how and sophisticated production processes for the presintered blanks ensure accuracy of fit. The dimensions of the marginal gap easily achieve values comparable to those of porcelain fused to metal.

Studies of marginal gap measurements produced values (average) of 40 µm and 70 µm for MO and AMO[12a] respectively.

Figure 22. Light-optical microscope exposure: cross-section of a 3-unit bridge from 35 - 37

Figure 23. Detail enlargement 37 buccal

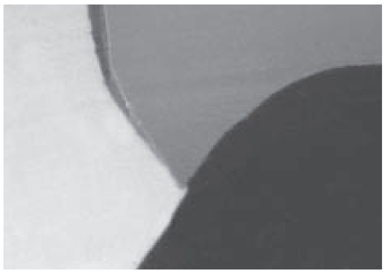


Figure 24. Detail enlargement 37 mesial

MO (marginal opening) can be interpreted as the distance between the framework and the stump close to the crown margin. AMO (absolute marginal opening) also includes possible contouring work above and below and measures the distance between the end of the crown margin and the preparation margin[13].

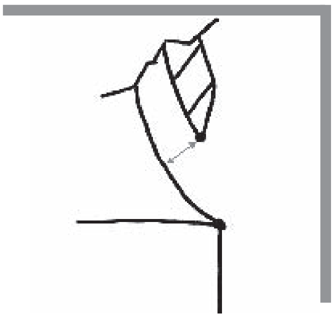


Figure 25. MO with under-extension

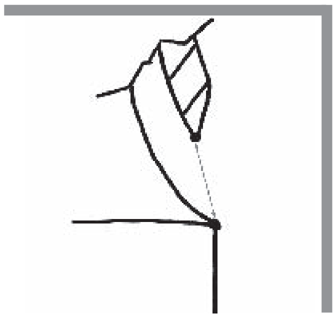


Figure 26. AMO with under-extension

Biocompatibility

Another remarkable feature of zirconia, in addition to its extraordinary chemical stability, is its very high level of biocompatibility. For this reason it has already been in use for more than a decade as a material for surgical implants, such as hip joints. The zirconia utilised, and likewise the overlay porcelain, manifests no measurable solubility or allergy potential and produces no irritation of the tissue.

The lower thermal conductivity provides comfort for the patient. Moreover, the material does not contribute to galvanic processes in situ.

5. Clinical Results

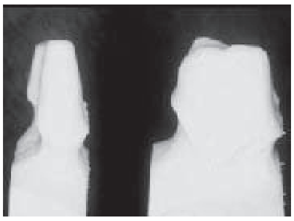
More than 15.000 units of fixed dental prosthetic work utilizing Lava All Ceramic System materials were placed in the anterior and posterior region between December 1999 and August 2003 (crowns, 3- and 4-unit bridges).

Some patients were treated in the company's own dental practice (Seefeld Center). The majority of the clinical work was carried out in various 3M ESPE consultant laboratories and tested on their dentist/clients (40 dentists in total) with very satisfactory results. The esthetics, precision fit and suitability for simple conventional cementation were found to be particularly impressive.

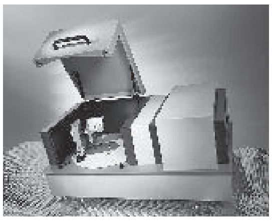
In addition to this, Dr. Peter Pospiech, senior physician and professor of dentistry at the University of Homburg/Saar has been conducting a clinical survey according to EN 540 (ISO 14 155) since summer 2000 (the longest running Lava study so far). In this survey, 35 patients fitted with posterior bridges are being monitored for a period of 5 years.[14]

Figure 27. 3-unit posterior bridge 25 - 27 (Source: G. Neuendorff, Filderstadt)

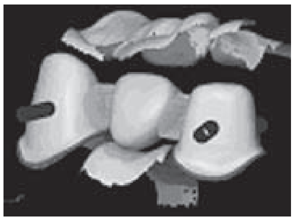
6. Technical Overview



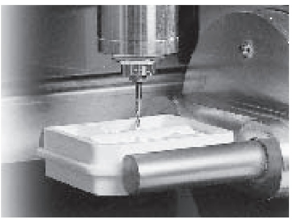
Working model



Scanning

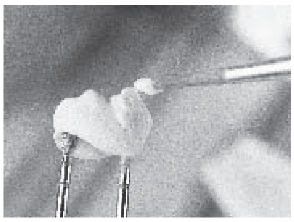


Designing



Milling

Sintering



Veneering

Scanning with Lava Scan:
The unit consists of the non-contact, optical scanning system Lava Scan (white light triangulation), a PC with monitor and the Lava™ CAD software.

When the sectioned model has been positioned in the scanner, individual preparations and the ridge are recorded automatically and displayed on the monitor as a three-dimensional image (recording of the model situation including preparations, gingiva and occlusal record). The preparation margins are scanned and displayed automatically.

CAD modelling with Lava CAD:
The design of the framework onscreen, e.g. the insertion of a pontic (from a library) or the design/modelling of the connections is done with the keyboard, mouse and software support. No special knowledge is necessary. The data is then used for the calculation of the milling path.

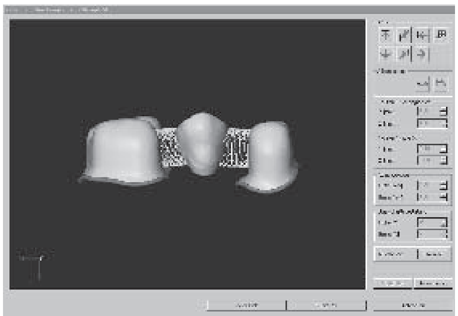


Figure 28. Design of connectors and pontic on the screen

Milling with Lava Form:
The 3D shape is milled from a pre-sintered ZrO_2 blank using hard metal tools. The average milling time for a crown is 35 minutes, for a 3-unit bridge about 75 minutes. The machine has a magazine capacity of 21 blanks; new blanks can be inserted and finished frameworks removed while milling continues. Different frameworks can be milled automatically, even overnight, thanks to the automatic tool changer.

Sintering in Lava Therm:
Manual finishing can be carried out before sintering takes place. The coloring of the frameworks also takes place before the sintering process according to the prescribed shade (7 possible shades, keyed to VITA Classic). The fully-automated, monitored sintering process then takes place with no manual handling in a special furnace, the Lava Therm (approx. 11 hours incl. heating and cooling phases).

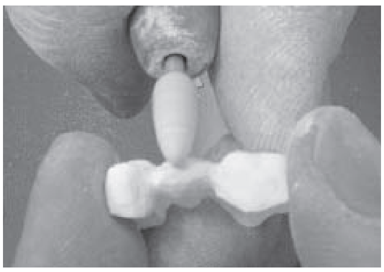


Figure 29. Manual finishing before sintering

Veneering with Lava Ceram:
The coefficient of thermal expansion (CTE) of the specially developed, integrated overlay porcelain has been matched closed (-0,2 ppm) to that of zirconia. The 16-shade layering system is based on the VITA® Lumin range. Very aesthetic characterising possibilities are provided by various additional individual components. The natural translucency harmonises ideally with the translucent zirconia framework.

7. Instructions for Use

The Framework Ceramic

Lava Frame

Zirconia Blanks for Framework Production with Lava Form

Product Description

Lava Frame, manufactured by 3M ESPE, is a set of Zirconia mill blanks for fabrication of all-ceramic restorations. The blanks are processed in the Lava Form CAD/CAM unit, manufactured for 3M ESPE. After milling and before sintering, the frameworks are dyed with one of 7 available Lava Frame Shade dyeing liquids as required to achieve the desired tooth color. The dyed frameworks are then sintered using the specialized program of the Lava Therm sintering furnace, manufactured for 3M ESPE.
Instructions for Use should not be discarded for the duration of the product use.

- For details on all mentioned products, please refer to the respective Instructions for Use.

Areas of Application

- Perfectly fitting restorations can be manufactured only in compliance with the preparation guidelines. For pertinent information, please refer to the Lava All Ceramic System's Instructions for Use.
- Fabrication of all-ceramic crowns and 3-unit bridge frames for anterior and posterior teeth.

Model Preparation

- It is recommended to use a light plaster (white, beige, light grey, light blue, ISO 6873, Type 4) without polymer additions and free of silicone oil residue (e.g. from doubling or bite registration).
- All segments of the saw cut model have to be removable and secured against rotation (double pin or block pin).
- The model base should be smooth at the bottom and have no split cast guidances. When using a conventional split cast model system, an appropriate holder must be used.
- The die needs to have a sharp undercut underneath the margin. It may not be pretreated (no marked margin, no varnishing or hardening).
- Undercuts (after notification of the dentist) and defects are blocked out with a light wax.
- In the case of distinct bifurcations, it is possible, that, in rare cases, there will be an insufficient detection of the preparation margin. Such areas should be blocked out preventively with a light wax and fitted afterwards with a diamond tool.
- Reflecting areas on the die are detrimental for the scanning procedure. Tarnish eventually with titanium dioxide spray (e.g. Developer D70, Met-L-CHEK).

Scanning

Crowns and bridges are designed after the scanning procedure with the Lava Scan Computer, manufactured for 3M ESPE.

The strength of the restoration and perfect milling results depend on the design of the bridge elements, the crown margins, and proper positioning of the holding pins.

- When entering data into the Lava Scan computer, please observe the design guidelines described in the Operating Instructions of the Lava All Ceramic System!

Preparation of the Milling Unit

- To mill frameworks with the Lava Form CAD/CAM unit, use burrs of type 4 (rough milling), type 5 (finishing), and type 6 (fine-finishing) only; see also Lava Form Operating Instructions.
- Prior to processing Lava Frame frameworks, clean the milling chamber of the Lava Form milling unit and make sure that no oil remains on or is fed to the cutting spindle and all metal or plastic dust is removed.

Processing After Milling

Caution: Aspirate all dust and air with a fine dust filter commonly used in the dental lab (ceramic dust). Use protective goggles in all framework processing work.

In order to prevent contamination, the blank must not be exposed to water or any other liquids, fats (hand lotion) or oils during processing!

Removal of the Milled Framework from the Holding Device

We recommend the use of a turbine handpiece to remove the framework due to the lower degree of vibration as compared to other handpieces! If no turbine is available, fine cross-cut tungsten carbide mills can also be used - rotary speed 20.000 rpm/min!

- First, notch all holding links on their top as close as possible to the crown from the occlusal side and then carefully extend the notches from the opposite side to separate the framework. Use as little pressure as possible in removing the framework and let it gently slip into the hand or onto a soft pad!

Finishing of the Blank Surface

Compared to finishing already sintered frameworks, shape correction and surface smoothing of the green body (non-sintered framework) is not only simpler but also a more reliable procedure. Grinding sintered frameworks may cause damage invisible to the naked eye. As a consequence, corners, edges, joints of the holding pins, and all other non-smooth areas on the surface should be smoothed out prior to sintering such that the preparatory work on the framework is completed prior to sintering and only the copings need to be fitted after sintering.

Caution: The presence of notches and sharp edges or damage on the bottom side of the interdental connections may substantially reduce the stability of the sintered framework. Thus, it is essential to render the framework surface smooth especially in these areas in the green state!

Use Universal Polishers from Brasseler (Type Komet #9557) for finishing only - rotary speed 10.000-20.000 rpm/min!

- Start with the joints of the holding pins and then fit all edges outside of the crown margin to the desired contour.
- Take care not to damage the crown margin when finishing the outer contour in the vici nity of this area.

Cleaning of the Framework

- Touch the framework only with clean, non-oily hands. The framework surface must remain uncontaminated by oils.
- Thoroughly clean the entire surface of the framework including the internal surfaces of the coping from all milling dust, e.g. with a disposable applicator.
  To ensure even coloring, the framework must be clean, free of oils and completely dry prior to dyeing!

Dyeing of the Framework

Preparation of the Dyeing Liquid/Dyeing Process
All immersion containers for the framework must be dry, clean and free from residual dyeing liquid to ensure that there are no changes in color!

- Select a suitably sized immersion container for coloring of the crown or bridge, as required, such that the framework is easy to remove and does not get jammed.
- Select the suitable Lava Frame Shade dyeing liquid for the desired tooth color:

Lava Frame Shade Dyeing liquid	300 ml-bottles FS 1	FS 2	FS 3	FS 4	FS 5	FS 6	FS 7
Coordinates with Vita Classic Colors	A1 B1	B2 C1	A2 A3	A3,5 A4	B3 B4	C2 C3 C4	D2 D3 D4

- Shake up the Lava Frame Shade dyeing liquid prior to use!
- Pour a sufficient amount of dyeing liquid into the container to ensure that the framework is covered by some 3 mm of liquid.
- Reseal the bottle immediately after use to ensure that the concentration of the liquid does not become altered.

Dyeing Process

- Use plastic forceps to place the framework in the container. The framework must be completely covered by the dyeing liquid!
- Carefully rock the container to allow any air bubbles trapped inside a coping to escape.
- Put the container with the framework into an empty standard commercial pressure pot and pressurize up to 3-6 bar. Keep the framework in the container under pressure at room temperature in the pot for 1 min, this will ensure optimal infiltration of the pore structure of the Lava framework.

- Color only once!
- To ensure even coloring, any excess dyeing liquid must be aspirated from the coping and the interdental connections, e.g. with an absorbent paper towel.
  Make sure that no lint from the paper towel remains on the framework.
- After dyeing and suctioning of the framework, place it on a carrier for sintering (please refer to Positioning for Sintering) and put it into the furnace within 3 hours. The temperature of the furnace may not be above 25°C/77°F. The furnace dries the framework in an optimal time after pressing the Start button (please refer to Sintering).
- The dyeing liquid can continue to be used for daily production of frameworks within 24 hours if covered immediately after use and stored in a cool place protected from sunlight.
  If these precautions are not observed, there is a risk of the following:
  Discolorations of the framework
  Sintering changes, e.g. increased sintering time
  Reduction in useful life
- Dilute the dyeing liquid with copious amounts of water and dispose of in the sewage.

Direct exposure of skin and eyes to Lava Frame Shade dyeing liquid may lead to irritation. Wear suitable protective gloves and goggles. Do not swallow the dyeing liquid.

Error	**Cause**	**Solution**
Framework shows spots after dyeing.	Dyeing liquid did not dry evenly.	All excess dyeing liquid must be removed very carefully.
Coping breaks during removal from the holding structure.	Holding pin was separated off too far from the object.	Separate off closer to the object to reduce vibrations.
	Handpiece wobbles.	Check the handpiece. Use a turbine, if available.
	Bur is blunt.	Use a new cutter.
Framework does not fit.	Erroneous positioning of crowns and bridges during sintering.	Ensure proper positioning during sintering as described under “Positioning for Sintering”.
	Die was not placed placed in the correct position on the model during scanning.	Prior to scanning, check the proper position of the die on the model.
Contamination apparent on the coping surface.	Dyeing liquid is contaminated due to repeated use.	Use dyeing liquid only 1x!
Whitish spots apparent on the coping surface.	Milling dust was not removed.	Carefully remove all milling dust prior to dyeing.

Incompatibilities
Sensitisation to the product in susceptible individuals cannot be ruled out. Use of the product should be discontinued and the product completely removed, if allergic reactions are observed.

Storage and Shelf-Life

Do not store Lava Frame Shade dyeing liquid above 25°C/77°F. Avoid direct exposure to sunlight.
Do not use after the expiration date.

Customer Information
No person is authorized to provide any information which deviates from the information provided in this instruction sheet.

Sintering of the Framework

Positioning for Sintering

The framework shrinks by approx. 20-25% (linear) during the sintering process and, as a consequence, it is essential to position the framework such that its movement is not restricted. The framework must be positioned such that it cannot tip over and does not touch neighboring frameworks or is freely suspended relative to the sintering tray to ensure that it does not change shape during the sintering process.

- Place the pegs or wires on the honeycomb-like sintering tray as fits the framework geometry such that the framework can make any movement induced by shrinking.
- Attach no more than one sintering peg or wire to the sintering tray for each honeycomb section.

Positioning of Copings for Sintering

- Depending on type, use 1 to max. 4 pegs per coping.

	Number of sintering pegs
Front tooth	1
Premolar	2 – 3
Molar	3 – 4

Positioning of Bridges for Sintering

- Be sure to provide for longitudinal shrinking of bridges by correct placement of sintering pegs or wires!
- Position bridges perpendicular to the furnace insertion direction.

Anterior Bridges:

- Position bridges always on one peg per coping.
- The pegs have to be positioned close to the coping wall facing the bridging unit without touching them.

Posterior Bridges:

- Generally position bridges on two wires in the connector area (one per connector).
- Generally position bridges with the occlusal side up.

Caution: In order to ensure free movement of the wires, they must be positioned without tension in the honeycomb sections.

Sintering

For information on the operation of the sintering furnace, please refer to the Operating Instructions of the Lava Therm unit!

- For an optimal use of space, the furnace can be loaded with two sintering trays on top of each other. Close the door afterwards.
- Once the Start button is pressed, the sintering program starts up automatically and heats the furnace after the 3 1/2 hours drying period to 1,500°C/ 2,732°F. The sintering including the drying time is approximately 11 hours. The furnace is automatically unlocked once the temperature drops below 250°C/452°F during the cooling phase of the furnace. *Caution when opening furnace door: Burn hazard!* If the temperature is above 250°C/452°F, do not force the furnace door open since the resulting extreme drop in temperature may destroy the furnace and the frameworks!
- Use tongs or another suitable tool to remove the sintering tray from the furnace. Place the sintering tray on a refractory surface and allow the frameworks to cool down slowly on the sintering tray.

Veneering

For veneering use Lava Ceram veneer ceramic, manufactured by 3M ESPE, a product specially developed for use with this Zirconia framework material. Please comply with the Instructions for Use of Lava Ceram when processing!

Cementing

There is no need to roughen the internal surfaces of crowns by mechanical means.

Do not use light-curing glass ionomer cements, as these are capable of absorbing water and swelling!

For detailed information on the products mentioned in the following, please refer to the corresponding Instructions for Use!

Temporary Cementation

If a composite cement is used for permanent cementation:

- For temporary cementation use an eugenol-free luting cement (e.g. RelyX™ Temp NE, manufactured by 3M ESPE).
  Residual eugenol-containing products inhibit the setting of composite cement during the permanent cementation process!

If a conventional cement is used for permanent cementation:

- Use a common commercial temporary luting cement, e.g. RelyX™ Temp NE or RelyX™ Temp E, manufactured by 3M ESPE.

Permanent Cementation

The strength of Lava Frame frameworks is so high that adhesive cementation provides no additional advantages with respect to strength! The material can neither be etched nor directly silanized with silane coupling agent.

Conventional Cementation

For cementing use conventional glass ionomer cements, e.g. Ketac Cem, manufactured by 3M ESPE. The use of phosphate cements fail to provide the desired aesthetic results.

Adhesive Cementation with RelyX Unicem

For adhesive cementation of the surfaces without silanization with the Rocatec System the new self-adhesive universal composite cement RelyX Unicem is suitable.
For adhesive cementation with silanization with the Rocatec System please proceed as described under point “Adhesive Cementation with Composites”.

Adhesive Cementation with Composites

For the adhesive cementation with composite cements, the adhesive surfaces must be silicatized with Rocatec Soft or Cojet Sand for 15 sec and silanized with ESPE Sil. All products are manufactured by 3M ESPE. Soon thereafter, place in the mouth with composite cement, e.g. RelyX ARC, RelyX Unicem. If desired, a fit test has to be done before silicatization/silanization. For details on processing, please refer to the Instructions for Use of the Rocatec System or Cojet Sand.

Removal of a Seated Lava Restoration

- To remove a seated restoration, use common rotating instruments to introduce a slit using water cooling and then extend the slit with the leverage of an instrument and/or use common office instruments to pull off the restoration.

The Overlay Porcelain

Lava Ceram

Overlay porcelain for Lava Frame zirconia frameworks

Product Description

Lava Ceram overlay porcelain and Lava Frame mill blanks, both manufactured for or by 3M ESPE respectively, are both components of the Lava All Ceramic System for fabrication of all-ceramic restorations. These overlay porcelains and mill blanks are specially designed to be used in combination and cannot be combined with other overlay porcelains.
Lava Ceram overlay porcelains are available in 16 VITA colors; the color range consists of the following components: 7 shoulder ceramic porcelains, 16 framework modifiers, 16 dentine porcelains, 10 Magic intensive shades, 4 enamel porcelains, 2 enamel effect porcelains, 4 transparent-opal porcelains, 1 transparent-clear porcelain, 10 stains, 1 glaze, and the corresponding mixing liquids.

Instructions for Use should not be discarded for the duration of product use.

Areas of Application
Veneering of Lava Frame zirconia framework

Preparation

Preparation of the Framework

- After dyeing and sintering, clean the framework in an ultrasonic bath or by briefly using a steam cleaner.
  The framework must be absolutely clean and free of grease!

Color Selection

Combination Table for VITA Classic Colors
VITA Classic Colors

VITA Classic Farben	A1	A2	A3	A3,5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
7 Schulter-massen	SH1	SH3	SH3	SH4	SH4	SH1	SH2	SH5	SH5	SH2	SH6	SH6	SH6	SH7	SH7	SH7
16 Gerüst-modifier	MO A1	MO A2	MO A3	MO A3,5	MO A4	MO B1	MO B2	MO B3	MO B4	MO C1	MO C2	MO C3	MO C4	MO D2	MO D3	MO D4
16 Gerüst-modifier	D A1	D A2	D A3	D A3,5	D A4	D B1	D B2	D B3	D B4	D C1	D C2	D C3	D C4	D D2	D D3	D D4
4 Schneide-massen	E2	E2	E3	E3	E4	E1	E1	E3	E3	E4	E3	E3	E4	E4	E3	E3

Color Table

Shoulder-materials:	SH 1 – SH 7	**Framework modifiers:**	MO A1 – MO D4	**Dentine materials:**	D A1 – D D4
Incisal-materials:	E 1 – E 4	**Enamel effect-materials:**	E 5 Polar E 6 Sun	**Transparent-Opal materials:**	T 1 neutral T 2 yellow T 3 blue T 4 grey
Magic Intensive-materials:	I 1 Ocean blue I 2 Atlantis I 3 Chestnut I 4 Havanna I 5 Orange I 6 Khaki I 7 Vanilla I 8 Honey I 9 Gingiva I 10 Violet	**Extrinsic colors:**	S 1 Ocean blue S 2 Atlantis S 3 Chestnut S 4 Havanna S 5 Orange S 6 Khaki S 7 Vanilla S 8 Honey S 9 Gingiva S 10 Violet	**Glaze material:** **Transpa-Clear:**	G CL

- Keep on hand appropriate porcelains that match the color of the teeth.

Veneer Production

Mixing

The following mixing liquids are available:
- Modeling liquid
- Shoulder ceramics liquid
- Stain/Glaze liquid

- Mix the ceramic powders and the appropriate liquid with a glass or agate mixing spatula until a creamy consistency is attained. The mixing ratio is 2.5 g powder to 1 g liquid.

Layering of Shoulder Porcelain

A ceramic shoulder is to be baked to the framework, if the cervical area of the framework was reduced for the purpose of shoulder porcelain baking or if the preparation edge was inadvertently damaged.

- Select the appropriate color to match the color of the tooth and mix with shoulder ceramics liquid.
- Insulate the plaster model with a commercial insulating liquid - plaster against ceramics.
- Place the framework on the model.
- Apply the shoulder porcelain to the framework and shape down to the preparation edge of the die, then blot the liquid off.
- Remove the framework from the model and fire the shoulder as described under “Baking procedure”.
- Compensate any shrinking during the sintering process by another step of shoulder porcelain baking. Then continue the processing by applying framework modifier.

Application of Framework Modifier

The framework modifier is what gives the framework its basic color.

- Mix the framework modifier with modeling liquid.
- Apply a thin coat (0.1-0.2 mm) to the entire surface to be veneered.
- For adequate wetting, vibrate well and then blot off the liquid in order to prevent air inclusion and bubble formation.
- As an option, a thin layer of Magic intensive shade can either be applied as such to the framework using a wet brush or, alternatively, after mixing with framework modifier.
- The framework modifier should be fired separately – using the same procedure as for "Initial dentine and enamel baking" – or the dentine layer should be directly applied onto the framework modifier.

Layering of Dentine/Enamel Porcelain

- Mix the dentine, enamel, and "transpa" porcelain with modeling liquid and build up the restoration.
- To adapt the procedure to the individual needs of the patient, you may wish to mix-in some Magic intensive shades into the dentine, enamel or transpa porcelain and apply a layer of these mixtures in particular locations.
  – The Magic shades are very intense so that the materials should be used in small amounts only.
- Working with bridges, separate the teeth all the way down to the framework prior to initial baking, using a flexible instrument.
- Initial baking should be done in accordance with the baking table; please refer to "Baking procedure".
  – After baking there is no need to roughen or blast the surface of the ceramic.
- Shape corrections, if any, can be done with fine-grained diamonds at low pressure.
  – Never damage the framework when separating the veneer ceramic interproximally!
- Complete modeling the restoration with dentine or enamel porcelain.
- Close interdental spaces and separate again, if required.
- Correction baking must be done in accordance with the baking table; please refer to "Baking procedure".

Finishing

Caution! Ceramic dust is a health hazard! Use a common suction device for laboratory use with fine dust filter while processing ceramic materials.

- Finish with fine-grain diamonds at low pressure.
- Make sure to separate only the veneering ceramics with the diamond discs without affecting the framework!

  – The framework must not be damaged interdentally as this may give rise to fractures in the future!
- Fine-shape the surface with rotating instruments.

Either:
Mix stains with stain/glaze liquid and apply special color effects.
Or:
Mix glaze with stain/glaze liquid and apply in a very thin layer.
Or:
Glaze bake without stain or glaze.
E Subsequently, glaze bake in accordance with the baking table; please refer to "Baking procedure".

Firing Procedure

	Start temp.	Drying time	t ↗ under vacuum	t ↗ without vacuum	Final temp.	Hold time under vacuum	Hold time without vacuum
1. Shoulder material firing	450°C	4 min	45°C/min	./.	840°C	1 min	./.
2. Shoulder material firing	450°C	4 min	45°C/min	./.	830°C	1 min	./.
Initial dentine- and enamel porcelain baking	450°C	6 min	45°C/min	./.	810°C	1 min	./.
Second dentine- and enamel porcelain baking (correction bake)	450°C	6 min	45°C/min	./.	800°C	1 min	./.
Glaze baking with glaze or stain	480°C	2 min	./.	45°C/min	790°C	./.	1 min
Glaze baking without glaze or stain	480°C	2 min	./.	45°C/min	820°C	./.	./.

Intraoral Veneer Repair

Veneers of cemented restorations can be repaired with the Cojet™ system, manufactured by 3M ESPE, and a filling composite.

• For further details, please refer to the Instructions for Use of the Cojet™ system.

Prevention of Processing Errors

Bubble Formation in the Veneer

Bubble formation may be caused by the usual factors, such as contaminants unintentionaly introduced into the porcelain. But it can also be due to inappropriate application of the framework modifier, i.e. the framework modifier did not sufficiently wet the framework and air became trapped between the modifier and the framework.

• To provide for adequate wetting, vibrate well and then blot the liquid off.

Incompatibilities

In susceptible individuals, sensitization to the product cannot be excluded. Use of the product should be discontinued and the product completely removed, if allergic reactions are observed.

Storage and Stability

Do not store the liquids above 25°C/77°F.

Customer Information
For questions or comments in U.S.A. or Canada please call toll-free 1-800-634-2249.
No person is authorized to provide any information which deviates from the information provided in this instruction sheet.

Date of the information: 03/02

8. Questions and Answers

How comprehensive is the clinical experience with the Lava All Ceramic System?
The first fixed prosthetics utilizing Lava zirconia were cemented by the end of 1999. By August 2003 there were more than 15.000 units in situ. But it must be remembered that this is the first time that an all ceramic system of such high strength has been available. Laboratory simulation experiments verify a unprecedented long-term strength. There is now every indication that Lava may be used for metal-free prosthetics in both posterior and anterior regions!

What distinguishes Lava from the other all ceramic systems and what is its composition?
Lava is based on a framework made from zirconia (Lava Frame) and a feldspathic overlay porcelain (Lava Ceram), which has been specially designed to meet the requirements of the framework. The zirconia ceramic is a tetragonal polycrystalline zirconia partially stabilised with yttria (admixture of approx. 3 mol-%) (Y-TZP = Yttria Tetragonal Zirconia Polycrystals).

How does the accuracy of fit compare with typical porcelain fused to metal?
Literature indicates a theoretically required accuracy of 50 - 100 µm for crowns & bridges. Internal and external investigations verify an accuracy of fit of 30 - 100 µm with crowns and bridges designed and fabricated using the Lava All Ceramic System.[12a, 12b]

Is Lava really sufficiently strong for posterior bridges?
With zirconia frameworks strengths that exceed the maximum masticatory load (450 N) several times, posterior applications are possible for the first time. Internal and external investigations confirm that 3-unit bridges after artificial ageing (simulation of 5 years carrying time) in the mastication simulator (1.2 million cycles) with simultaneous thermocycling (10.000 x 5°-55°C) have a strength of 1.450 N to 1.200 N for 3- or 4-unit bridges, respectively.

How aesthetic are the results with Lava? Is zirconia white(-opaque)?
The Lava zirconia framework is ideally translucent due to its high density (no residual porosity) and homogeneity - no longer white-(opaque), as we know it from the past technical/medical applications. Interestingly, the framework wall thickness of 0.5 mm, which is possible due to the high strength of zirconia provides ample opportunity for aesthetic layering with the overlay porcelain. There is the unique option of coloring the zirconia framework in 7 VITA Classic shades. The veneer system provides a range of intensive and characterizing materials, in addition to 16 VITA Classic shades.

What are the preparation requirements for a successful long-term restoration?

In principle, many of the requirements for a porcelain fused to metal restoration can be applied to the Lava All Ceramic System. Fabrication of a Lava restoration requires a preparation having a circumferential chamfer or shoulder. The preparation angle should be 4° or greater. The inside angle of the shoulder preparation must have a rounded contour. The preparation for the Lava all ceramic restoration can be done with removal of less tooth structure thanks to the framework's thin wall thickness of only 0.5 mm. Supragingival preparations are possible due to Lava's excellent fit characteristics and optical properties.

Why don't Lava restorations have to be luted using adhesive?
Which cement is recommended?

Permanent Cementation

The strength of Lava Frame frameworks is so high that adhesive cementation provides no additional advantages with respect to strength! The material can neither be etched nor directly silanized with silane coupling agent.

Conventional Cementation

For cementing use conventional glass ionomer cements, e.g. Ketac Cem, manufactured by 3M ESPE. The use of phosphate cements fail to provide the desired aesthetic results.

Adhesive Cementation with RelyX Unicem

For adhesive cementation of the surfaces without silanization with the Rocatec System the new self-adhesive universal composite cement RelyX Unicem is suitable.
For adhesive cementation with silanization with the Rocatec System please proceed as described under point "Adhesive Cementation with Composites".

Adhesive Cementation with Composites

For the adhesive cementation with composite cements, the adhesive surfaces must be silicatized with Rocatec Soft or Cojet Sand for 15 sec and silanized with ESPE Sil. All products are manufactured by 3M ESPE. Soon thereafter, place in the mouth with composite cement, e.g. RelyX ARC, RelyX Unicem. If desired, a fit test has to be done before silicatization/silanization. For details on processing, please refer to the Instructions for Use of the Rocatec System or Cojet Sand.

Glass ceramics are frequently luted with adhesive bonding, to enhance esthetics and increase the strength of the entire tooth/restoration system. This no longer applies with polycrystalline oxide ceramics (Lava). This method of cementation will not result in any further increase in strength.

9. Summary

With the Lava All Ceramic System 3M ESPE presents the new, innovative CAD/CAM technology for all-ceramic crowns and bridges on a zirconia base.

Due to the remarkable strength and stability of zirconia, Lava restorations are now indicated for posterior crowns & bridges. Excellent fit is guaranteed by a perfectly coordinated system.

Preparation can be achieved with removal of less tooth structure, and cementation can be carried out according to proven conventional techniques.

The aesthetic capability and biocompatibility of Lava restorations represents the optimum in all ceramic systems. Colorable frameworks of ideal translucency and thin coating thickness to which color can be applied ensure a natural appearance due to the wide scope for characterization.

The milling of zirconia frameworks in the pre sintered state prevents damage to the microstructure of the material, and ensures an excellent long-term perspective for Lava restorations.

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11. Technical Data

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Lava Frame Framework Ceramic

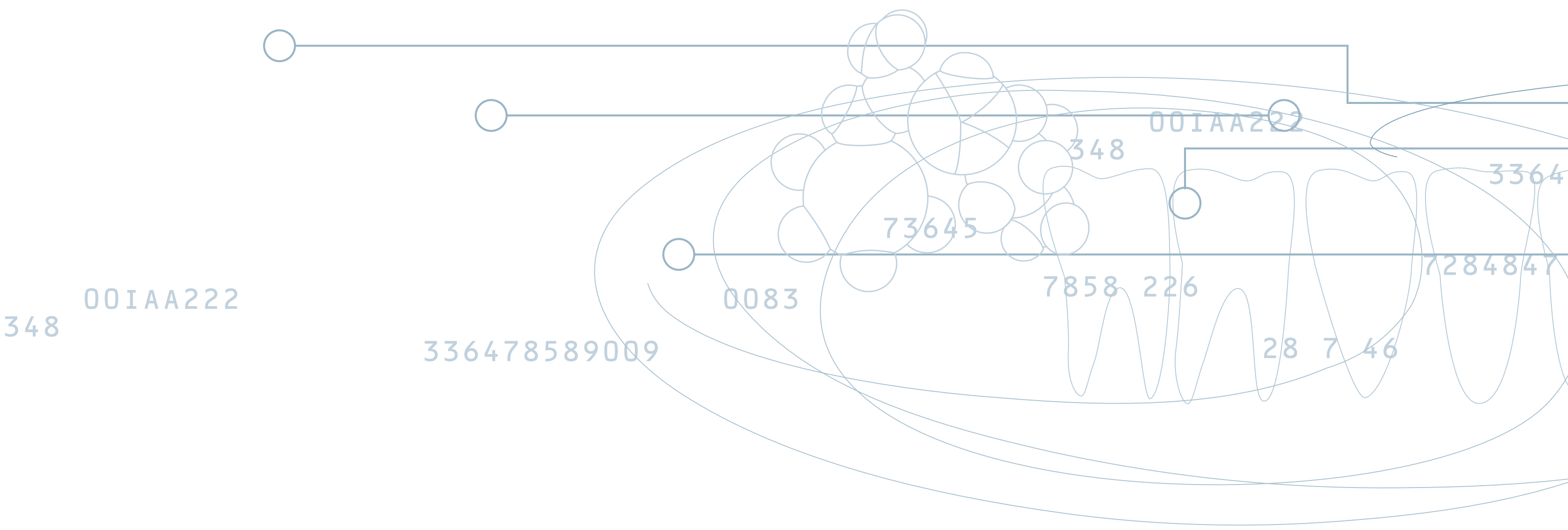
Flexural strength (sB) (punch-on-three-balls) (ISO 6872)	> 1100 MPa
Flexural strength (sB) (3-point) (ISO 6872)	1625 MPa
Weibull strength (s0) (3-point)	1345 MPa
Stress resistance (2% / 5 years)	615 MPa
(Youngs) Modulus of elasticity (E)	210 GPa
Weibull modulus (m)	10.5
Crack growth parameter (n)	50
Fracture toughness (KIC)	10 MPa m_
CTE	10 x 10^{-6} 25-500°C
Vickers hardness (HV 10)	1250
Melting point	2700 ºC
Grain size	0.5 µm
Density (r)	6.08 g/cm_
Solubility (ISO 6872)	0 µg/cm^2

Lava Ceram Overlay Porcelain

Flexural strength (sB) (3-point) (ISO 6872)	> 85 MPa
(Youngs) Modulus of elasticity (E)	80 GPa
Fracture toughness (KIC)	1.2 MPa m_
CTE	10 x 10-6 25-500°C
Vickers hardness (HV 0.2)	530
Firing temperature	810 ºC
Grain size (d50)	25 µm
Density (r)	2.5 g/cm^3
Solubility (ISO 6872)	0 µg/cm^2
Wear/abrasion	state-of-the-art

Lava clinically relevant real geometry

Fracture strength 3-unit. **Posterior** bridge a) initial	approx. 1800 N
b) after mastication simulation and thermocycle	approx. 1450 N
Fracture strength 3-unit **Anterior** bridge a) initial	approx. 1430 N
b) long-term strength at 250 N (above masticatory force)	no fracture



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