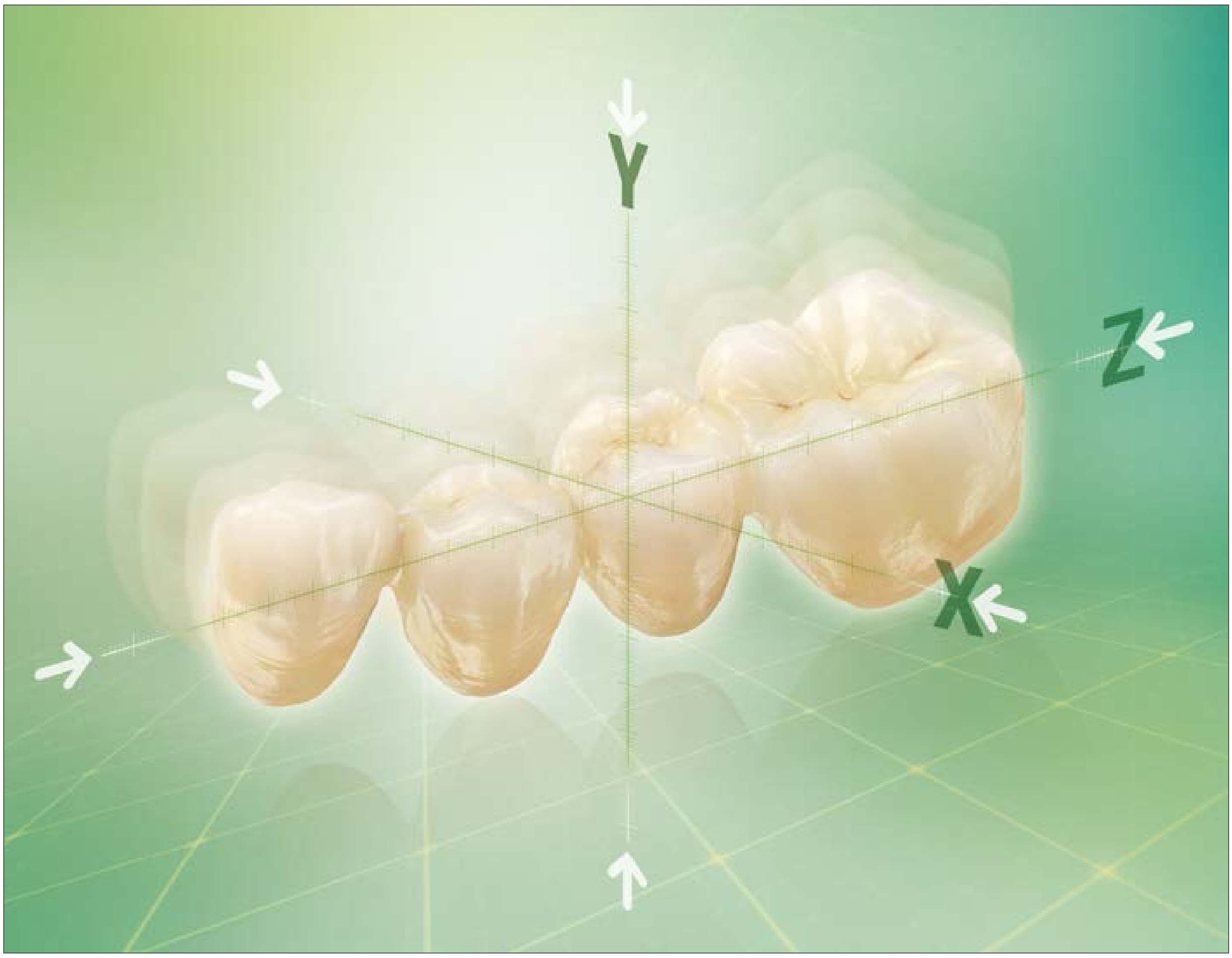
VITA YZ

Technical and scientific documentation



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Date of issue: 02.16

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1. Introduction

More and more materials are being developed for dental CAD/CAM techniques. An important milestone was the use of zirconia (ZrO_2) in the dental sector at the beginning of this millenium. It enabled the fabrication of multi-unit, all-ceramic bridges for the first time, which was based on three-dimensional visualization and the calculation of sinter shrinkage or its compensation.
VITA Zahnfabrik is one of the pioneers in this field and has been offering zirconia blanks for CAD/CAM fabrication of all-ceramic dental restorations since 2002 (introduced under the designation of VITA In-Ceram YZ).

3-point flexural strength of VITA YZ within the scope of internal batch testing

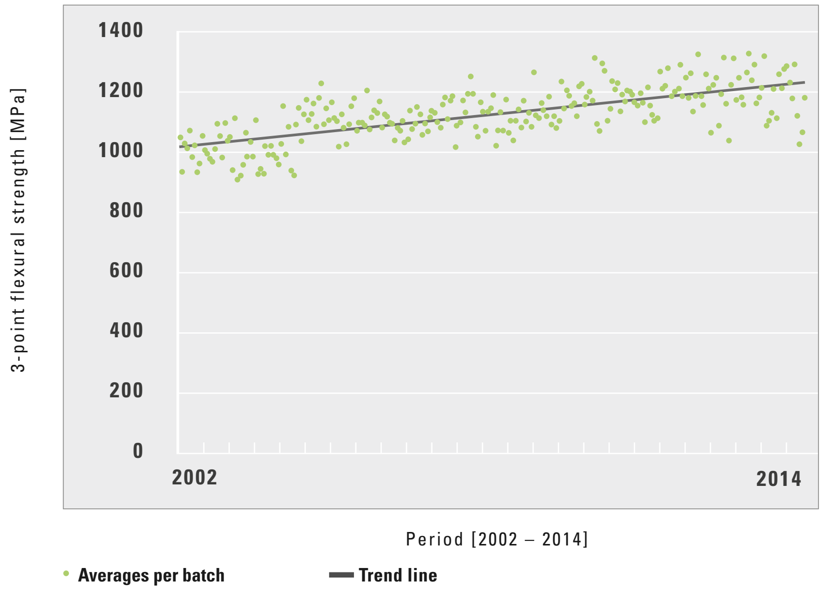


Figure 1: Flexural strength values from 2002 to 2014; determined within the scope of internal quality tests
Source: Internal study, VITA R&D ([1], cf.p. 30)

VITA Zahnfabrik is committed to high quality standards as far as CAD/CAM blanks made of zirconia and other materials are concerned. This includes the target of continuous improvement of materials and procedures. One example is the improvement of mechanical properties of VITA YZ, such as the 3-point flexural strength (cf. fig. 1).

VITA Zahnfabrik continues to invest in the development of new and advanced materials for substructures and bridges. In addition to the proven VITA YZ T (= Translucent) zirconia blanks for substructures, the current range of materials also includes a highly translucent VITA YZ HT (= High Translucent) material for fully anatomical reconstructions . This documentation provides an overview of the major technical and scientific information about VITA YZ.

1.1 Chemical composition

Components	VITA YZ T [wt. %]	VITA YZ HT [wt. %]
ZrO_2	90.9 – 94.5	90.4 – 94.5
Y_2O_3	4 – 6	4 – 6
HfO_2	1.5 – 2.5	1.5 – 2.5
Al_2O_3	0 – 0.3	0 – 0.3
Er_2O_3	0	0 – 0.5
Fe_2O_3	0 – 0.3	0 – 0.3

1.2 Physical/mechanical properties

Test	VITA YZ T VITA YZ HT	Standard ISO 6872
3-point flexural strength	approx. 1,200 MPa	> 800 MPa
Modulus of elasticity	approx. 210 GPa	None specified
Weibull modulus	approx. 14	None specified
Fracture toughness (SEVNB)	approx. 7.0 MPa $m^{-0.5}$	None specified
Hardness	approx. 12 GPa HV10	None specified
CTE	approx. $10.5 \cdot 10^{-6} \cdot K^{-1}$	None specified
Chemical solubility	< 20 µg/cm^2	< 100 µg/cm^2
Melting temperature	approx. 2,700 °C	None specified
Sintering density	approx. 6.05 g/cm^3	None specified
Particle size after sintering	approx. 500 nm	None specified

1.3 Manufacturing and quality standards

Today there is a vast number of companies that offer zirconia blanks. So many practices and laboratories ask the question:
"is all zirconia the same?" And although numerous blanks do not reveal any significant differences at first sight, substantial differences become obvious when taking a closer look at the material quality and properties.

Within a decade VITA Zahnfabrik has continuously optimized the manufacturing processes for VITA quality zirconia and implemented high process standards and strict test criteria. Only top-quality materials are used for the production of VITA YZ. To ensure the high quality, each new batch is not only subjected to standard measurements of particle size distribution, flowability and sintering behavior but detailed quality controls are carried out to ensure constant biocompatibility.

Dilator measurements of various zirconia granules in the range of the presintering temperature

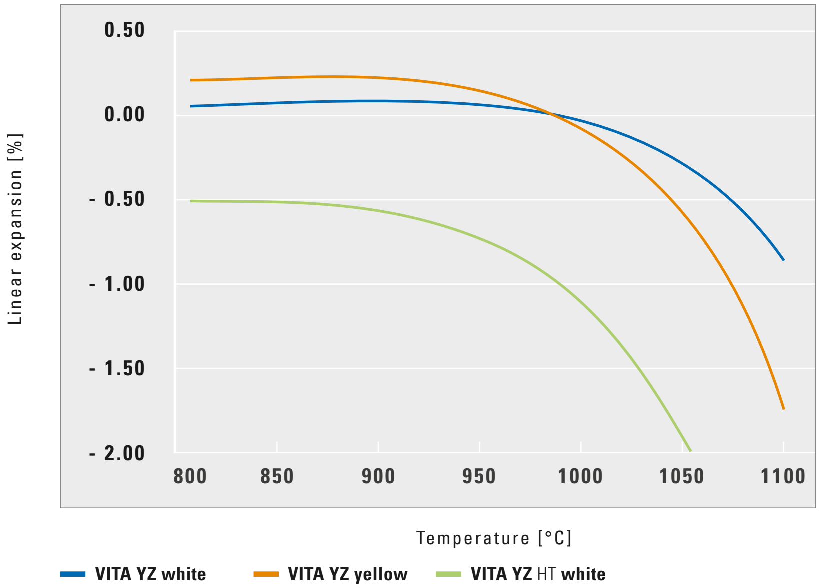


Figure 2: Study of the sintering behavior of various VITA YZ granules
Source: Internal study, VITA R&D ([1], cf.p. 30)

The target of VITA Zahnfabrik's high quality standards is to enable users in laboratories and practices to achieve reproducible results independent of the material type in use. Granules made of non-colored (e. g. VITA YZ HT^{White} material type) and precolored zirconia (e.g. VITA YZ HT^{Color} material type) exhibit different sintering properties since the sintering behavior of the granules is influenced by adding color pigments.

VITA focuses on modern procedures and measuring techniques (cf. fig. 2) to be able to determine the differences in a precise manner and to optimize the granules in a previous industrial process (e.g. by material-specific presintering) so that the various types of blanks do not differ with regard to the sintering behavior and machinability when they are used in practices and laboratories.

1.4 Control of the sintering behavior

To control or adjust the sintering behavior of zirconia in a way that enables practices and laboratories to achieve accurate and reproducible sintering results is a core challenge for each manufacturer. For example, essential parameters are the quality of the raw material and the control of the molding and presintering process.

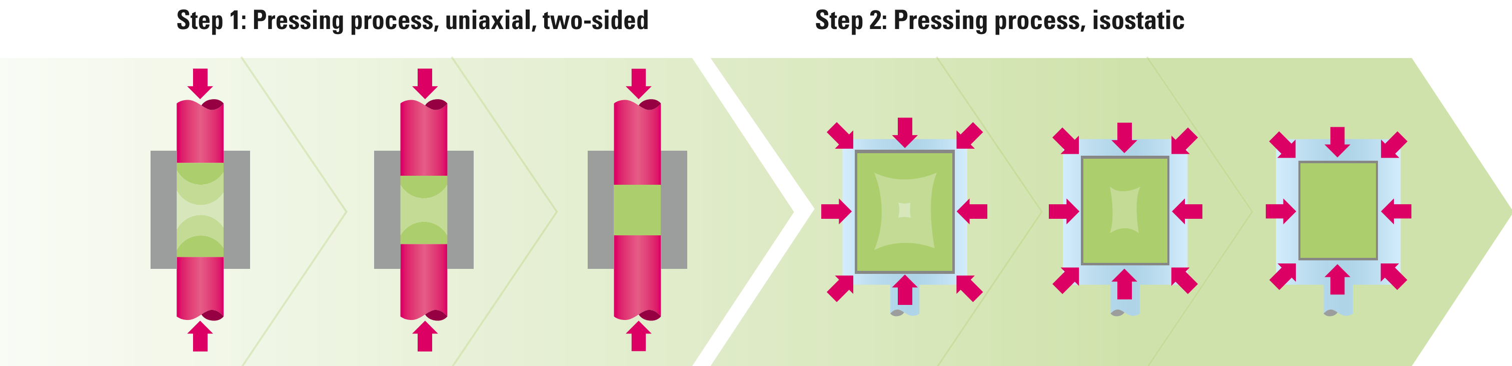


Figure 3: Schematic view of the pressing process for VITA YZ

At VITA Zahnfabrik, the basic shape of the zirconia blanks is achieved in a uniaxial pressing process and then the blanks are repressed isostatically in a high pressure container. The homogeneous density that is achieved is an essential precondition for homogeneous sintering behavior. Moreover the presintering process, that is the industrial firing process, is precisely adjusted to the respective batch and blank geometry.

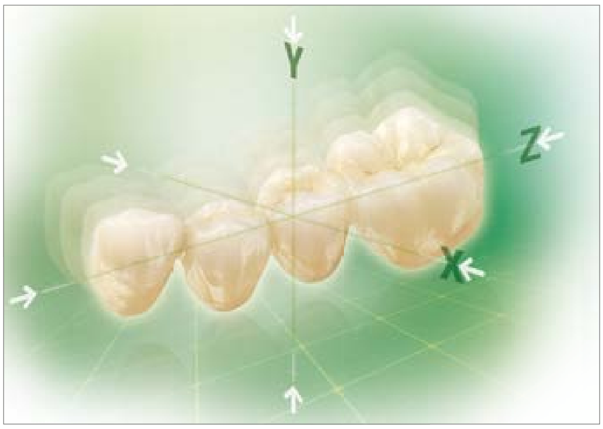


Figure 4: Example of sintering shrinkage (X-,Y-,Z-dimension)

Figure 5: Example of enlargement factors indicated on blanks

Another essential step on the way towards accurate sintering results is the precise determination of the enlargement factor. VITA Zahnfabrik determines this factor in all three spatial dimensions (X-, Y-, Z-dimension) for each production batch and integrates the information in the print on the blank (as a bar code or plain text). Some manufacturers, however, only determine the average values and indicate them. Exact determination of sintering shrinkage and hence the precision of fit of the densely sintered dental object is particularly essential for multi-unit bridge constructions.

Figure 6: Example of sinter shrinkage of ZrO_2 by approx. 20 %

Abbildung 7: Example of check of fit with model made of metal

The final quality inspection at VITA is carried out using a check of the fit on a standardized steel model (fig. 7). For this purpose, the maximum size of the bridge structure is milled from the blank geometry (based on the enlargement factor determined for each batch) and then the fit of the densely sintered object is checked (cf. 2.7).

1.5 Material and structural quality

The structural quality is an important factor for a high level of strength or load capacity. Both the raw material quality and a manufacturing process matched with the raw material are of central importance. If process steps, such as molding, debinding and presintering are matched with one another, a homogeneous and pore-free structure is achieved. As a result, users in practices and laboratories will receive a high-quality blank. If this is not ensured, defects may occur in the structure, which may affect the long-term stability of the object in clinical use.

1.6 Study of the microstructure

a) Materials and methods
SEM image analysis of the structure of densely sintered samples made of VITA YZ and a competitor's zirconia after polishing and thermal etching.

b) Source
Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

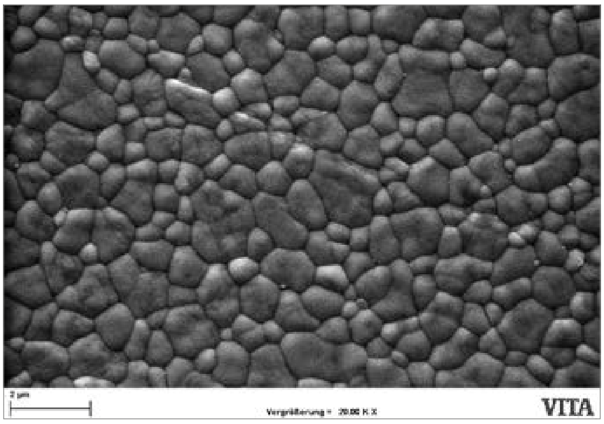


Figure 8: VITA YZ at 20,000x magnification

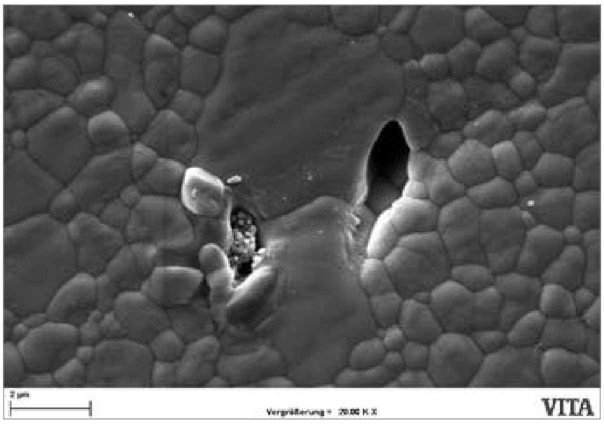
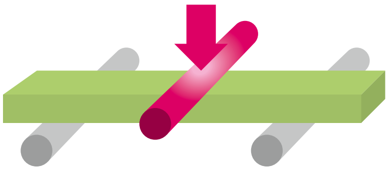


Figure 9: Competitor's ZrO_2 at 20,000x magnification

d) Conclusion
Based on particularly high quality standards, VITA YZ features a homogeneous structure without pores or defects (cf. fig. 8). The sintered structure has an average particle size of approx. 500 nm.
Contamination, different particle sizes and structural defects can frequently be found (cf. fig. 9) in low-quality zirconia blanks (often low price products).
Depending on the size and position in the structure, the defects may deteriorate the mechanical properties. Some defects, however, can only be detected at high magnification.



2. Physical/mechanical properties (in vitro)

2.1 3-point flexural strength of VITA YZ

a) Materials and methods

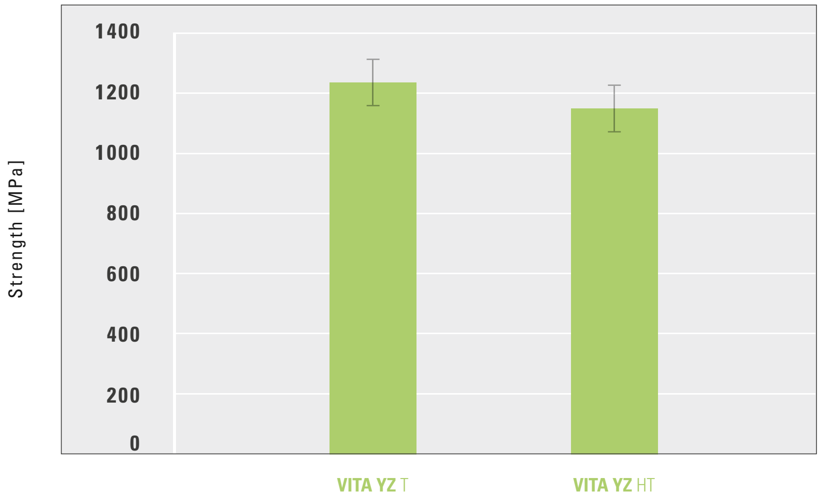
The test was carried out in accordance with ISO 6872. A diamond saw was used to prepare bending rods from the VITA zirconia blanks. Then, using SiC paper (grain size 1,200), the specimens were milled manually to final dimensions of 20.0 x 4.0 x 1.2 mm^3, a 45° chamfer was added to the side exposed to tensile stress and sintering was carried out according to the manufacturer's instructions. 30 specimens of each material were loaded until fracturing occurred (Zwick universal testing machine) and the 3-point flexural strength was determined.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

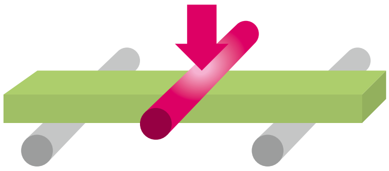
c) Result

3-point flexural strength



d) Conclusion

With average strength values of approx. 1,150 MPa to 1,230 MPa (standard deviation < 10 %), VITA YZ HT and VITA YZ T produce comparable high values in this series of tests, which exceed the standard value of > 800 MPa for this class of materials.



2.2 Comparison of 3-point flexural strength

a) Materials and methods

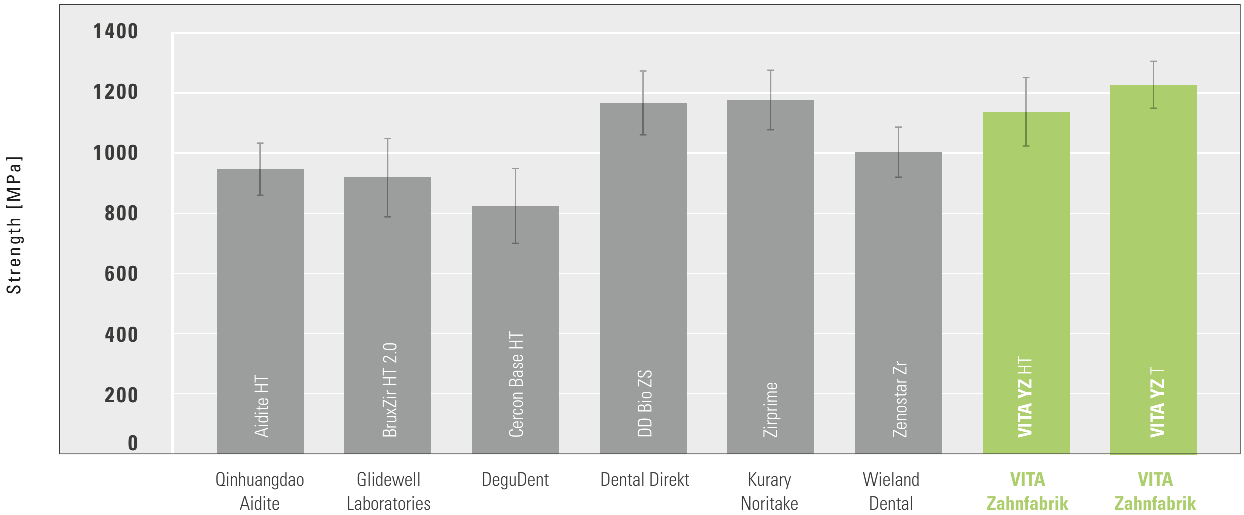
The test was carried out in accordance with ISO 6872. A diamond saw was used to prepare bending rods from the blocks and the materials mentioned below. Then, using SiC paper (grain size 1,200), the specimens were milled manually to final dimensions of 20.0 x 4.0 x 1.2 mm³, a 45° chamfer was added to the side exposed to tensile stress and sintering was carried out according to the manufacturer's instructions. 10 specimens of each material were loaded until fracturing occurred (Zwick universal testing machine) and the 3-point flexural strength was determined.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Comparison of 3-point flexural strength

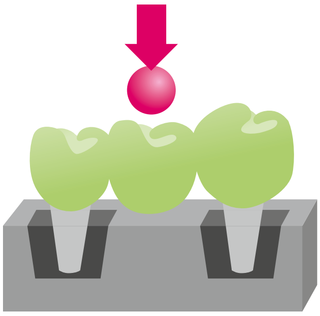


d) Conclusion

In the comparison with competitors, the strength values determined for VITA YZ are at a very high level. All zirconias examined in this test produced values above the standard requirement (> 800 MPa).

Differences in strength that were determined may result from the fact that the various materials were not equally presintered, which renders sample preparation quite difficult in some cases.

Additionally, dry green strength (= strength of the specimens in the presintered stage) of the materials tested ranged from 40 to 90 MPa, which results in differences in the processing characteristics.



2.3 Static fracture load

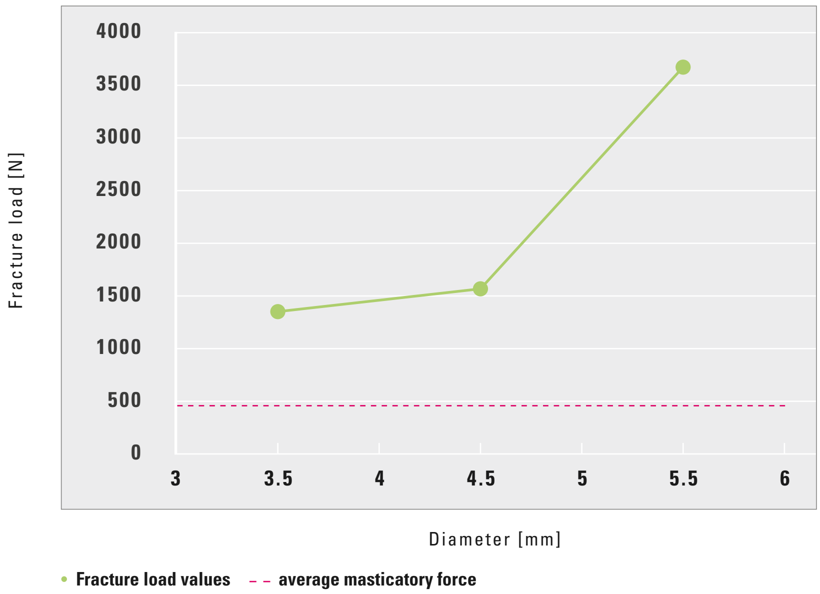
Static fracture load of different connector cross-sections

a) Materials and methods
Stylized posterior bridges made of VITA YZ were fabricated using an industrial milling machine. A total of three different series were prepared - with connector cross-sections of 3.5 mm (~ 9.6 mm²), 4.5 mm (~ 15.9 mm²) and 5.5 mm (~ 23.8 mm²). All bridges were bonded to steel stumps using zinc-phosphate cement. Ten bridges of each series were loaded until fracturing occurred (Zwick universal testing machine).

b) Source
Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

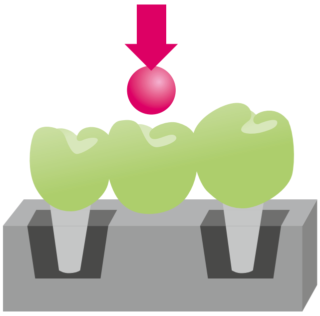
Fracture load - VITA YZ bridges with different connector cross-sections



d) Conclusion
This series of tests shows that a slight increase in the connector cross-section of the structure leads to a significant increase in the fracture load.
The results indicate, among others, that this effect has a positive influence on the load capacity of monolithic bridge structures since it allows to use of larger cross-sections than those used for substructures. All values determined in this test, however, clearly exceed the average maximum masticatory force which is approx. 490 N and the maximum masticatory force of 725 N [5].

2.4 Fracture load after dynamic loading/aging

Dynamess method



a) Materials and methods

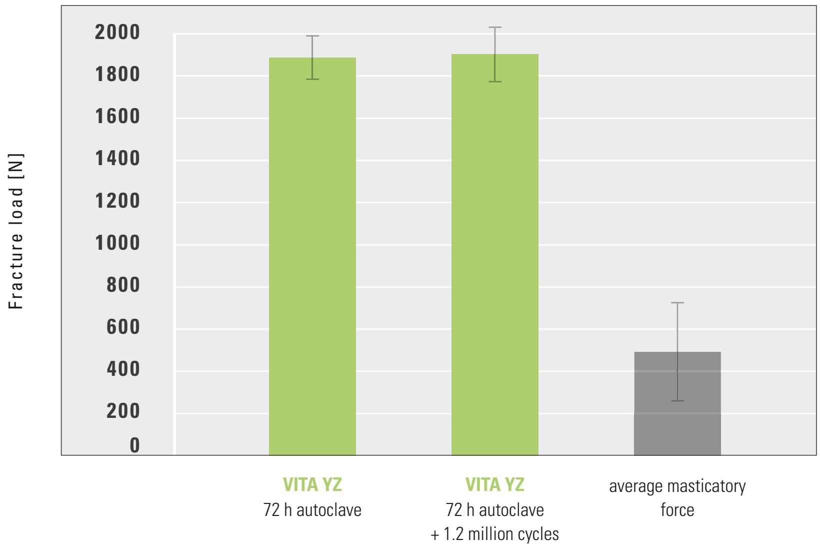
For this test, five stylized posterior bridges with minimum wall thicknesses and a connector cross-section of 3.5 mm were fabricated from VITA YZ HT and aged in an autoclave at 134 °C for a period of 72 hours.
Following accelerated aging, the bridges were bonded to steel stumps using zinc-phosphate cement and subjected to a cyclic load : 200 N for 1.2 million cycles, 2.0 Hz, 5 mm steel beads as the antagonist, temperature: 37 °C. Then static loading was carried out until material failure occurred (Zwick universal testing machine).

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Fracture load - VITA YZ bridges after aging/dynamic loading



d) Conclusion

In this test setup, the clinical use of the material is simulated and its stability is tested using material aging and/or dynamic loading. The fracture load determined for bridge structures made of VITA YZ HT produces a value of more than 1,800 N in this test , exceeding the average masticatory force [5].
Compared to structures exposed to static load (see 2.3/3.5 mm cross-section), the aged and dynamically loaded structures reached a comparable high level of load capacity.

2.5 Reliability/Weibull modulus

a) Materials and methods

The Weibull modulus was determined based on the flexural strength of 30 bending bars made of VITA YZ T and HT.

"Using a theory developed by Weibull, based on the concept of failure of the weakest link, the strength distribution of ceramic materials can be described effectively in mathematical terms. [. . .] Accordingly, if the distribution parameters are known, there is a clear correlation between the load and the probability of fracture." [2]

In simple terms, this means that a high Weibull modulus indicates uniform material quality. Together with the high load capacity values, it is an indicator of the reliability of a material.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Weibull modulus

d) Conclusion

In this test, excellent values - with regard to the level of strength - were determined with a Weibull modulus (m) of just under 12 or 16. Together with high load capacity values, a high Weibull modulus is an indicator of the reliability of a material.

2.6 Light transmission

a) Materials and methods

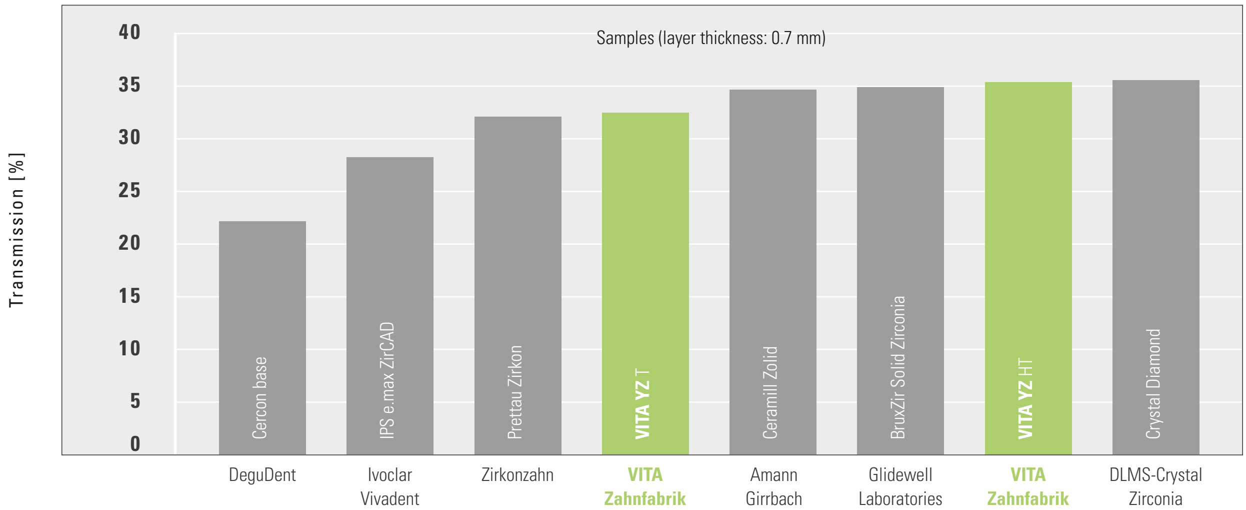
A photospectrometer was used to measure the transmission. The samples made of the materials of the manufacturers listed below had a wall thickness of 0.7 mm and were polished to high gloss on both sides. The measured values across the entire visible wavelength range (380 – 780 nm) were averaged.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Light transmission of zirconias



d) Conclusion

The light transmission of VITA YZ HT (= High Translucent) determined in this test is at a very high level in comparison with competitors. Comparatively high transmission is achieved even with the VITA YZ T material type.

The values determined in this test can only be compared within the scope of this test setup since measured values depend on the sample thickness, the measuring device and the apertures used.

2.7 Fit after the sintering process

a) Materials and methods

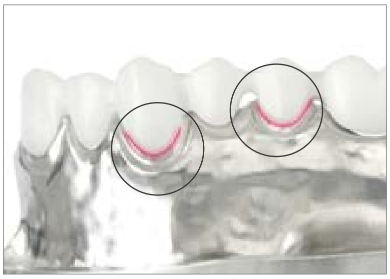
Various restorations are fabricated based on a digital model.
This documentation shows the example of a 14-unit VITA YZ bridge restoration. The corresponding aluminium model is milled using a CNC machine. The individual restorations with corresponding enlargements are also fabricated using this machine. As a result, potential measurement inaccuracies can be eliminated by the scan process. Finally, the sintered structure is subjected to visual/haptic testing using a model and to virtual testing using wrap software by overlapping the digital with the "real" structure to check for accurate fit.

b) Source

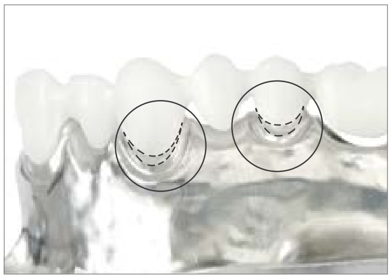
Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Figure 10a/b/c: a) model; b) milled, multi-unit VITA YZ structure; c) wrap software with overlapping structures (from left to right)



VITA YZ T



Competitor's ZrO_2

Figure 11/12: Visual fit check after sintering process using a control model for VITA YZ T/competitors

d) Conclusion

Using measurement equipment, the enlargement factor of each VITA YZ production batch is exactly determined in all three spatial dimensions so that excellent fit is also achieved for multi-unit VITA YZ bridge structures. All tolerances measured in this study are within the size of the cement gap (50 µm). The competitor's zirconia examined in this test, however, exhibited poor accuracy of fit already in the visual check (cf. fig. 12).

2.8. CAM machinability/edge stability

a) Materials and methods

To check CAM processibility and edge stability after the CAM process, restorations made of VITA YZ and a competitor's zirconia were fabricated using Ceramill Motion 2 (Amann Girrbach, Koblach, Austria). Then the restorations were examined under the light microscope with regard to the edge stability.
Since color pigments may influence the sintering behavior and the green strength of the respective material, especially the machinability of precolored blanks was analyzed.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

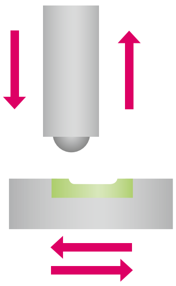
c) Result

Figure 13: VITA YZ T^Color precolored

Figure 14: Competitor's ZrO_2 precolored

d) Conclusion

This test shows that the use of VITA YZ enables the fabrication of extremely exact, precision-fit restorations thanks to the high edge stability (cf. p. 13). The competitor's material, however, exhibits marginal fractures in some areas after the CAM process (cf. p. 14).
VITA Zahnfabrik ensures that the green strength of non- and precolored VITA YZ material types is at a similar level to enable users in practices and laboratories to achieve reproducible results independent of the material type in use.



2.9 Abrasion

Two-body abrasive wear

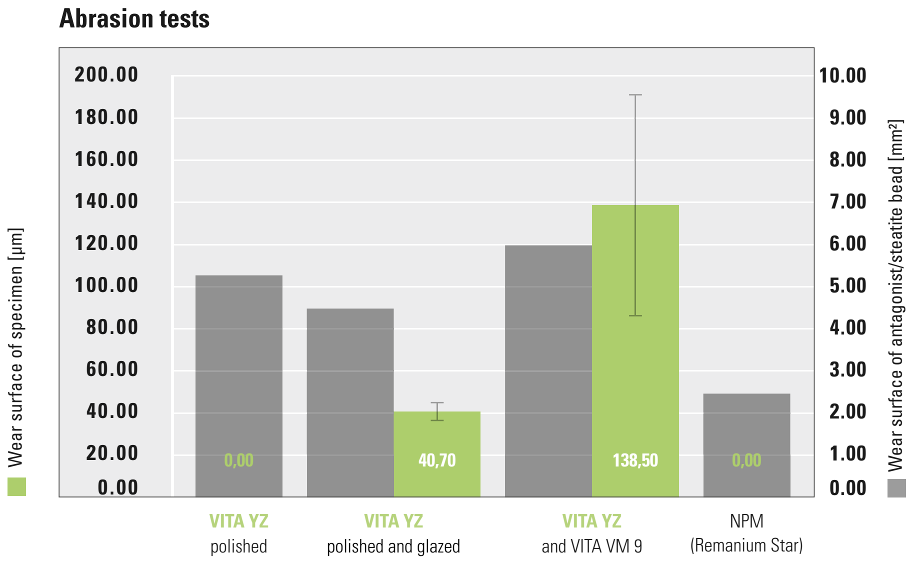
a) Materials and methods

To determine the abrasion level of zirconia and non-precious metal, a pin-on-block wear test in the chewing simulator was carried out at the University of Regensburg using the following parameters: steatite beads as the antagonist, 50 N load force, 1.2×10^5 cycles, 1.6 Hz and 600 thermal cycles at 5 - 55 °C. Removal of substance was measured after completion of a simulated chewing process.

b) Source

University of Regensburg, PD Dr. Rosentritt ([3], cf. p. 30)

c) Result



d) Conclusion

Material removal could not be measured for zirconia samples polished to high gloss (cf. test results for VITA YZ mentioned above) or for non-precious metal. If a glaze layer is applied to the VITA YZ samples, material removal can be measured again. The target of applying glaze material is to adjust the enamel-like abrasion behavior of dental zirconia restorations (cf. glazed VITA YZ samples). Results of clinical stability of the glaze layer are not yet available.

2.10 Fracture toughness

a) Materials and methods

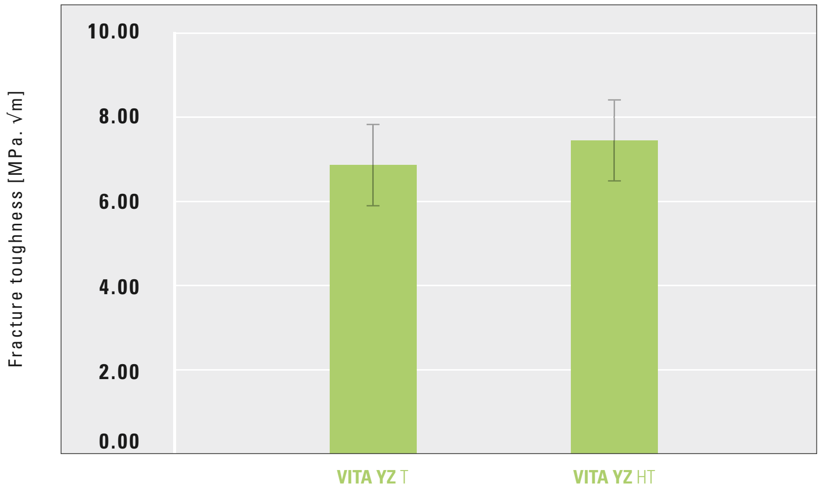
The fracture toughness of VITA YZ is measured using V-notched specimens (on one side) (SEVNB). Preparation is carried out in accordance with the recommendations of appendix A of DIN EN ISO 6872. 10 specimens were prepared for each series.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Fracture toughness measurement according to SEVNB method



d) Conclusion

According to the standard mentioned above, the recommended minimum value for substructure ceramics for four- or multi-unit restorations is 5.0 MPa √m. For the VITA YZ material types, average values of 6.9 or. 7.4 MPa . √m were determined (SD ±0.9). The values determined exceed the recommended minimum requirements.

2.11 Sintering behavior

2.11.1 Influence of the sintering temperature

a) Materials and methods

The influence of the sintering temperature on the particle size was studied by Piconi [4]. If the temperature is too low, the structure cannot be completely densely sintered. If the temperatures are too high, the material reveals a tendency to grain growth. In both cases there will be optical and mechanical effects on the final result. Samples made of VITA YZ were fired at 1,350 °C or 1,600 °C for the purpose of direct comparison. The temperature was kept for 2 hours. Then SEM analysis of the surfaces was carried out.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

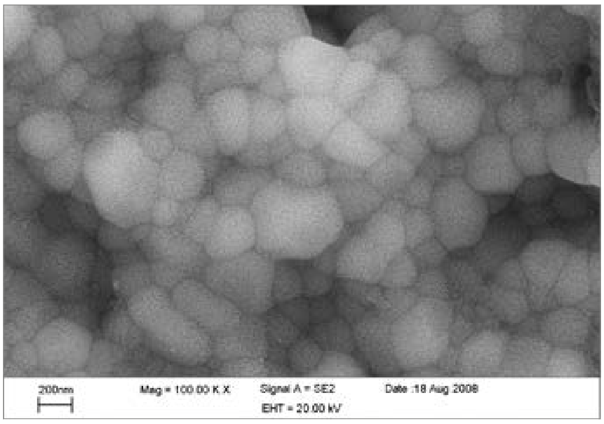


Figure 15a: VITA YZ structure at 1,350 °C, magnification 100,000x

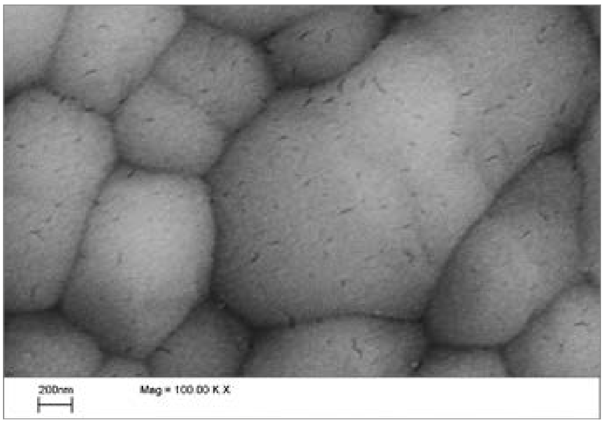


Figure 15b: VITA YZ structure at 1,600 °C, magnification 100,000x

d) Conclusion

Pores can still be recognized in the structure at a sintering temperature of 1,350 °C (see fig. 15a). The theoretical density cannot be achieved. At a sintering temperature of 1,600 °C (see fig. 15b), the sample is densely sintered; some grains, however, reveal critical growth behavior. Due to the increased sintering temperature, so-called huge grain growth can influence the light-optical properties so that the material appears to be more translucent. The excessive grain growth, however, can deteriorate the mechanical properties.

2.11.2 Influence of the high speed sintering method

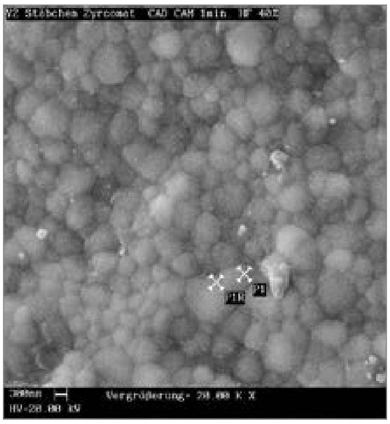
a) Materials and methods

Restorations made of VITA YZ can be densely sintered with the VITA ZYRCOMAT 6000 MS within 80 minutes. Appropriate heating and cooling parameters are used to enable this. A high speed sintering method, however, should not affect the structural quality, mechanical properties and the fit. In the following series of tests, material samples made of VITA YZ were sintered using a conventional and a speed technique. Then the structure was examined in the SEM and analyzed in various other tests.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result



Fgure 16a: Structure of VITA YZ, conventionally sintered, magnification 20,000x

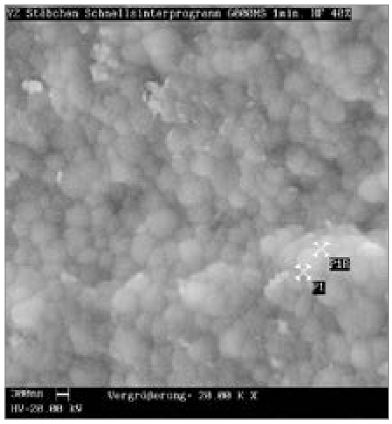


Figure 16b: Structure of VITA YZ, high speed sintered, magnification 20,000x

Characteristic values/ data of VITA YZ	Conventional sintering process	High speed sintering process
Sintered density [g/cm³]	6.06	6.07
3-point flexural strength [MPa]	1,200	1,278
Crystal structure	tetragonal	tetragonal
Particle size [nm]	500	500
Fit of bridges	Excellent	Excellent

d) Conclusion

Equally good results can be achieved for VITA YZ both with high speed sintering and conventional sintering. All test series within the aspects mentioned produce comparable results with regard to structure, mechanical properties and fit of conventionally and high speed sintered VITA YZ samples.

2.12 Manual adjustments/surface treatment

2.12.1 Influence of systems of grinding tools for ceramics

a) Materials and methods

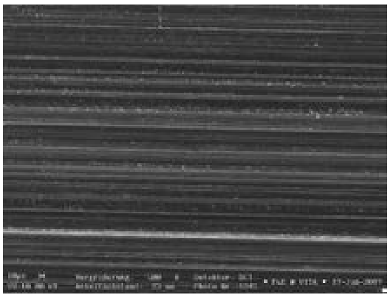
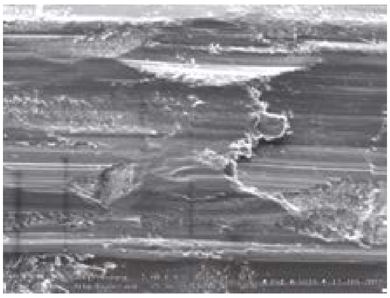
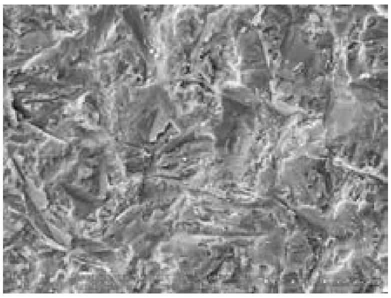
Within the scope of the study, the influence of milling tools and sandblasting on the VITA YZ T substructure material were examined. A total of 158 milling tools from 12 different manufacturers were used. A special test system was developed for these tests to ensure a standardized milling process. The material samples were examined under the SEM following surface treatment (milling tools or sand-blasting).

b) Source

Einfluss Keramikschleifersysteme, Quintessenz Zahntechnik 2009 ([6], cf. p. 30)

c) Result

Machined surfaces after the use of polishers, diamond grinding tools and after sandblasting (see SEM pictures, from left to right).

Figures 17 – 19: VITA YZ surfaces polished, adjusted with grinding/milling tools and sandblasted (from left to right), magnification 5,000x in each case

d) Conclusion

Different tools and methods cause different degrees of damage to zirconia surfaces (see fig. 17 to 19).

It is recommended to finish the dental object in the presintered stage (always from coarse to fine). Ideally, in the last step the surfaces should be polished to minimize defects on the surface.

The sandblasting process used for reasons of comparison produces a rugged surface. The resulting defects might deteriorate the mechanical properties and cause stress in the bonding area towards the veneering ceramic.

2.12.2 Influence of sandblasting

a) Materials and methods

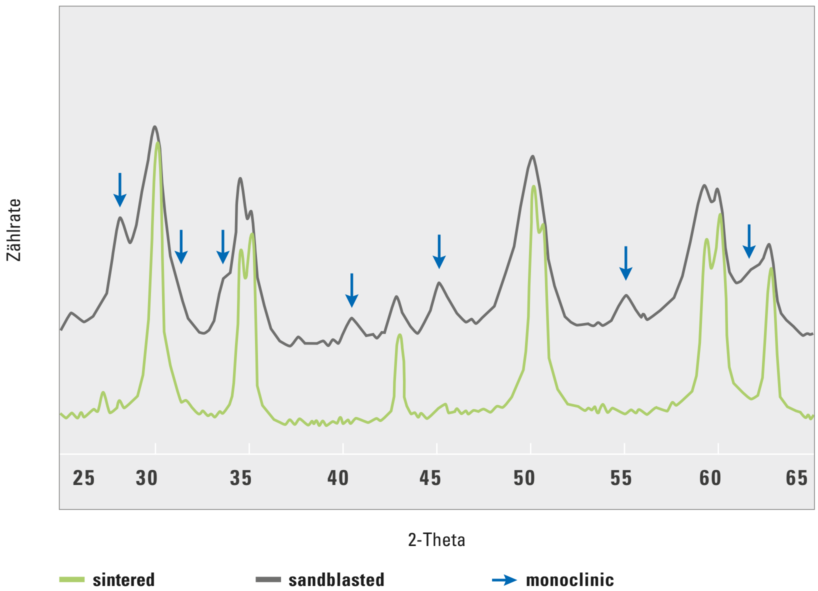
Identical specimens were prepared from VITA YZ T and sintered for this test. The specimens of the first series were not reworked. The surface of the specimens of the second series were treated in the sandblasting unit (50 µm corundum, 2 bar). Then the existing crystal structures were analyzed in the X-ray diffractometer. The peaks of the untreated specimens in the diagram below demonstrate that only tetragonal crystal structures can be detected on the surface. The additional peaks and widening of peaks after sandblasting are indicators of stress in the structure and monoclinic phase contents.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

Diffractometer measurement of VITA YZ before and after sandblasting



d) Conclusion

The zirconia lattice is transformed into a monoclinic crystal structure by sandblasting. Positive material properties, such as fracture toughness and resistance to aging that are attributed to the tetragonal modification cannot be ensured any longer in this case. In addition, the monoclinic phase features a different CTE which may result in unfavorable stress in the bonding area in combination with the veneering ceramic. Assumed positive effects of sandblasting, such as increasing the surface roughness, cannot be proven after the CAM process. Accordingly, it is unlikely that sandblasting will improve the wettability with veneering ceramic.

2.13 Biocompatibility

VITA YZ is tested and evaluated by independent institutes in accordance with the Standards Series ISO 10993 Biological Evaluation of Medical Devices. The material types T and HT of VITA YZ were both deemed biocompatible. Based on detailed quality controls for each new batch, such as radioactivity measurements, it is ensured that constant biocompatibility is guaranteed.

3 VITA VM 9 veneering material

3.1 Physical/mechanical properties

VITA VM 9	Unit of measure	Value
Coefficient of thermal expansion (25 - 500°C)	$10^{-6} \cdot K^{-1}$	8.8 – 9.2
Softening point	°C	approx. 670
Transformation temperature (TG)	°C	approx. 600
Chemical solubility (ISO 6872)	$\mu g/cm^2$	approx. 9.9
Average particle size	µm (d_{50})	approx. 18
3-point flexural strength (ISO 6872)	MPa	approx. 102
Vickers hardness (Transpa Dentine)	HV1	approx. 670

3.2 Chemical composition

Components	Wt%
SiO_2	60 – 64
Al_2O_3	13 – 15
Na_2O	4 – 6
K_2O	7 – 10
CaO	1 – 2
ZrO_2	0 – 1
B_2O_3	3 – 5

3.3 Dilatometer measurement

a) Materials and methods

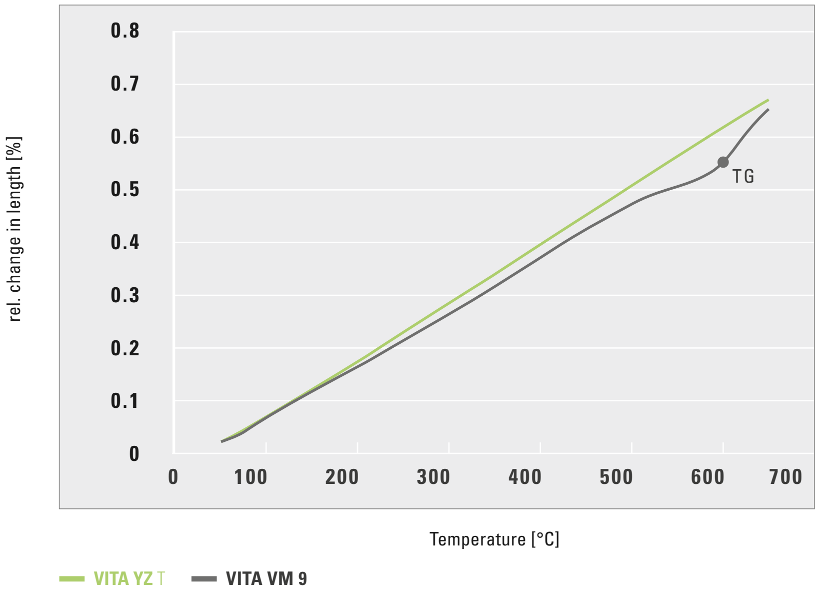
In a direct comparison, specimens made of VITA YZ T and VITA VM 9 were measured in the dilatometer (Netzsch). The specimens were heated up to the softening temperature with a heating rate of 5 °C/min. The coefficient of thermal expansion (CTE) for the respective material is obtained from the measured, relative change in length up to a defined temperature (500 °C).

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

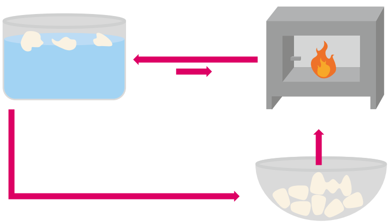
c) Result

Dilatometer measurement of VITA YZ T and VITA VM 9



d) Conclusion

VITA YZ T has a CTE of approx. $10.5 \cdot 10^{-6} \cdot K^{-1}$. To ensure optimal stress ratios, the CTE of VITA VM 9 veneering material is slightly lower at approx. $9.2 \cdot 10^{-6} \cdot K^{-1}$. This is to ensure that long-term reliable bonding between the veneer and the substructure can be achieved. When using this measurement method, the determined glass transition temperature (TG) of the veneering material is approx. 602 °C.



3.4 Thermal shock resistance

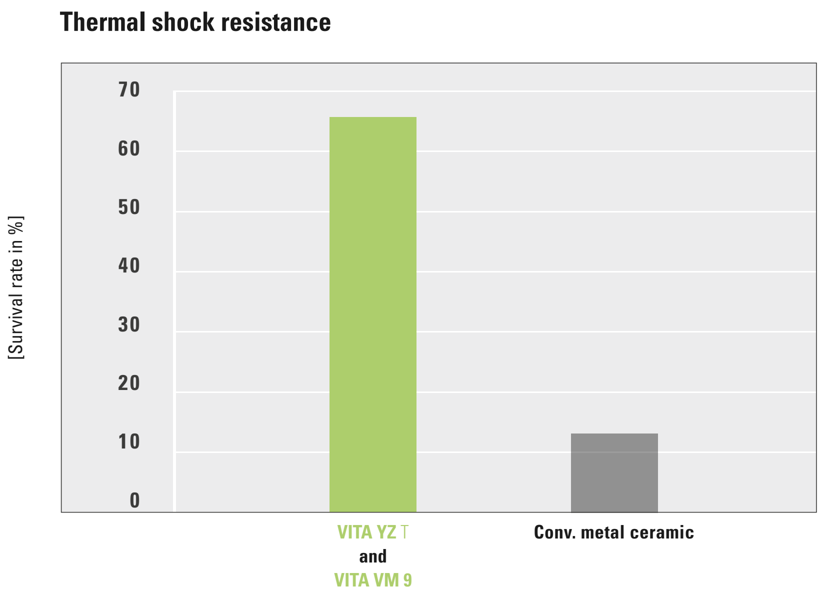
a) Materials and methods

The thermal shock resistance (TSR) test is a proven internal test procedure of VITA used to evaluate the interaction of substructure material and veneering material, or of the residual stress in the overall system.
For this test, six crowns and a three-unit substructure made of VITA YZ T were fabricated according to the manufacturer's working instructions and subsequently veneered with VITA VM 9.
In the next step, the crowns were heated to 105 °C in a furnace, the temperature was kept for 30 minutes and the restorations were quenched subsequently in ice water. Then the restorations were checked for crack formation and flaking of the ceramic. Undamaged restorations were subsequently heated to the next temperature level (120 °C), etc. This process is carried out in 15 °C steps up to a maximum temperature of 165 °C.

b) Source

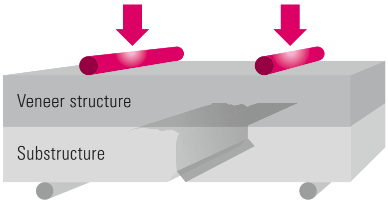
Internal study, VITA R&D, ([1] cf. p. 30)

c) Result



d) Conclusion

The higher the survival rate of the restorations used in this test, the lower the risk of crack formation or flaking of the veneering material based on long-term experience in daily use in practices/laboratories. In combination with VITA VM 9, VITA YZ T demonstrates a clearly higher survival rate than veneered metal ceramic in this test setup.
The values determined for VITA YZ in combination with VITA VM 9 were compared with the average results of metal ceramic studies (various VMK generations in combination with various metal alloys) of the past years.



3.5 Bond quality of VITA YZ T and VITA VM 9

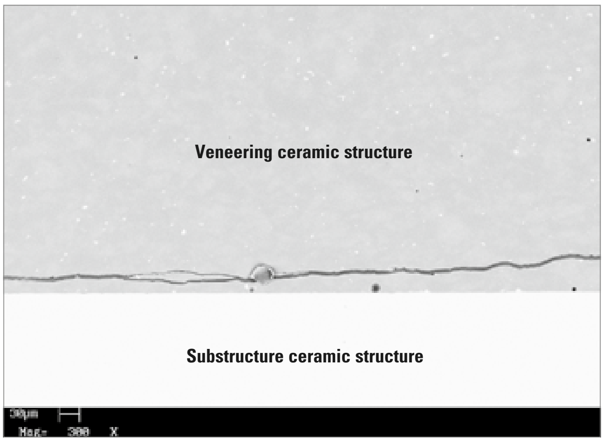
a) Materials and methods

Bond tests are test methods to evaluate the bond quality, i.e. the load capacity of the bond of the substructure material to the veneering material. The "Schwickerath test" (see ISO 9693), for example, is used as a 3-point bending test for metal ceramic. There is no ISO standard test for all-ceramic systems.
In the test setup used in this study, a 4-point bending test was carried out to direct a crack into the bonding area to determine the energy released during crack propagation (cf. energy release rate). This method (established by Charalambides et al.) is used, for example, by NASA (National Aeronautics and Space Administration) for paint coatings on the outer wall of rockets.

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

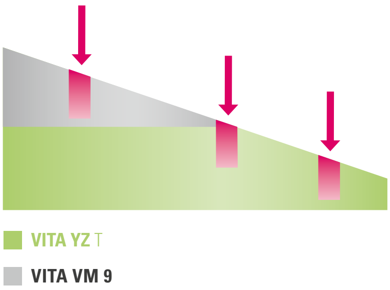
c) Result



Figures 20 : VITA YZ T veneered with VITA VM 9, crack path in the veneer, magnification 300x

d) Conclusion

The bond of VITA YZ T to VITA VM 9 can be deemed excellent since crack formation did not occur at all in the bonding area in the test series; the cracks progress through the layer of veneering material (cf. SEM picture; substructure - light grey and veneer structure - dark grey). Consequently, no measurable (energy) value of the actual bond can be determined.



3.6 Bonding area between VITA YZ T and VITA VM 9

a) Materials and methods

To examine the bonding area between VITA YZ T and VITA VM 9 closely, the VITA YZ T specimens were veneered with VITA VM 9 and subsequently sawed into wedges. Then the specimens were treated with VITA CERAMICS ETCH (hydrofluoric acid gel, 5 %) for 20 seconds and the surfaces were examined under a scanning electron microscope (SEM).

b) Source

Internal study, VITA R&D, ([1] cf. p. 30)

c) Result

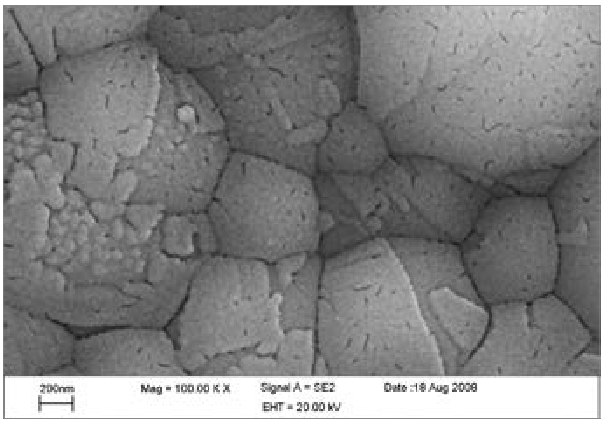


Figure 21: VITA YZ T structure after veneering, magnification 100,000x

d) Conclusion

The veneering process (application of ceramic and firing) changes the crystalline structure of the VITA YZ T substructure so that a new crystal structure is formed. The SEM picture shows this new surface (magnification 100,000x).
The results indicate that this new structure bonds perfectly to the VITA VM 9 veneering material structure and a high-strength bond between substructure and veneer is achieved.

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VITA YZ T

Recommended indications*

For framework constructions that offer high load capacity

Example

Zirconia, translucent

3-step material

VITA YZ T

Benefits:
- **precise results**
- **high reliability**
- **time-efficient fabrication**

VITA YZ HT

Recommended indications*

For monolithic bridge restorations

Example

Zirconia, highly translucent

3-step material

VITA YZ HT

Benefits:
- **precise results**
- **significant esthetic potential**
- **matched components**

VITA Rapid Layer Technology

Recommended indications*

For fully anatomical dual structure bridges

Example

Zirconia feldspar ceramics

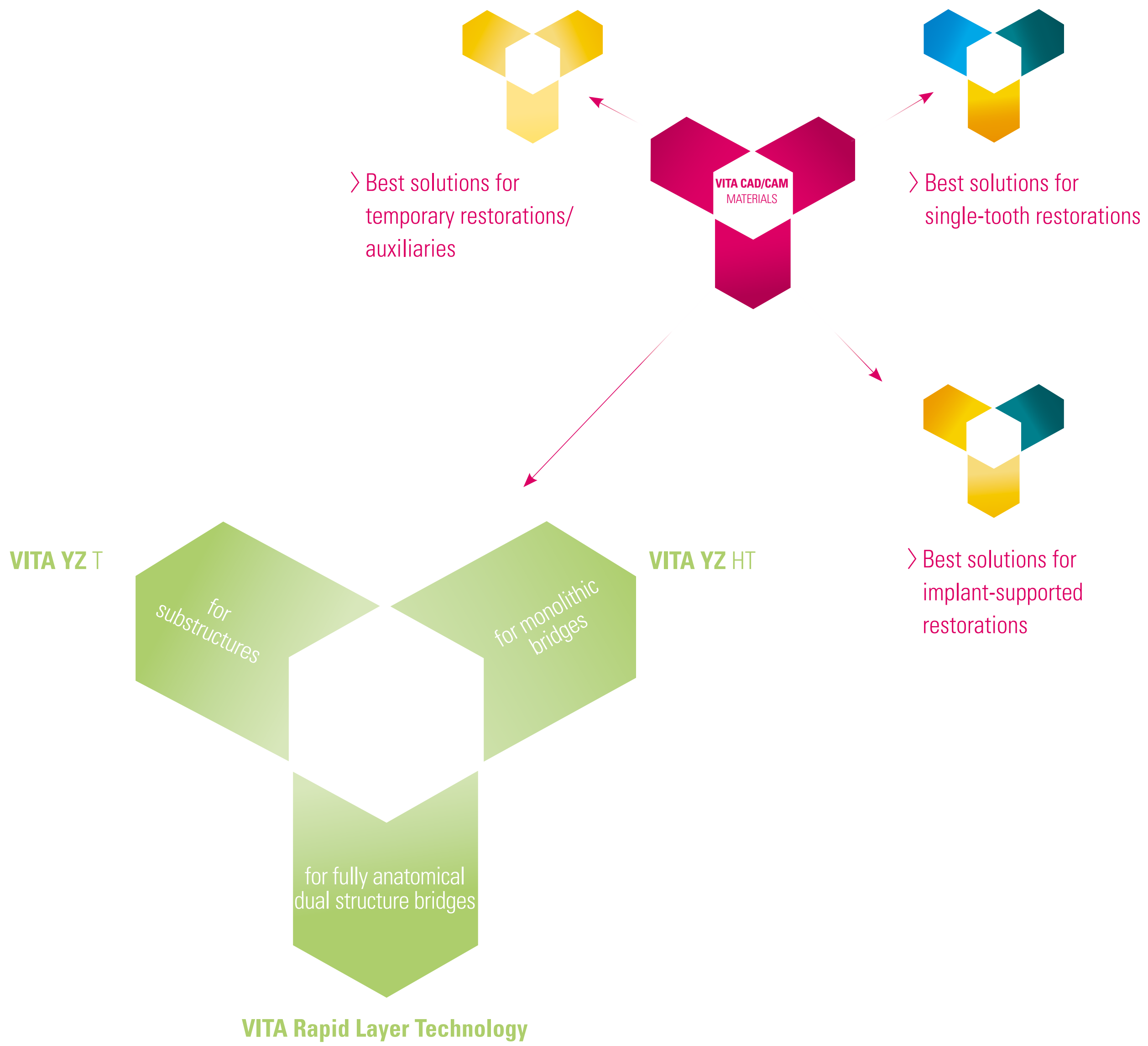
2-step process

VITA Rapid Layer Technology

Benefits:
- **time-efficient fabrication**
- **simple fabrication**
- **high reliability**

*) Note: While these are recommended indications; the entire range of single tooth restorations can normally be fabricated. For details, please refer to the respective working instructions of the products.

VITA CAD/CAM MATERIALS – for best solutions. Proven a million times over.



› Best solutions for framework constructions / fully anatomic bridges

Practices and laboratories have been relying on VITA CAD/CAM materials for substructure fabrication for more than 15 years.
In addition to the proven VITA YZ T zirconia for substructures, the range of materials also includes a highly translucent VITA YZ HT material for fully anatomical reconstructions and new manufacturing procedures such as the VITA Rapid Layer Technology.
Coloring liquids, stains and veneering ceramics are available for these material solutions - for maximum individuality, matched perfectly and from a single source.

VITA SYSTEM 3D-MASTER

Teeth · Veneering · Machinables · Equipment · Pressables

Please note: Our products must be used in accordance with the instructions for use. We accept no liability for any damage resulting from incorrect handling or usage. The user is furthermore obliged to check the product before use with regard to its suitability for the intended area of application. We cannot accept any liability if the product is used in conjunction with materials and equipment from other manufacturers that are not compatible or not authorized for use with our product. Furthermore, our liability for the accuracy of this information is independent of the legal basis and, in as far as legally permissible, shall always be limited to the value as invoiced of the goods supplied, excluding value-added tax. In particular, as far as legally permissible, we do not assume any liability for loss of earnings, indirect damages, ensuing damages or for third-party claims against the purchaser. Claims for damages based on fault liability (culpa in contrahendo, breach of contract, unlawful acts, etc.) can only be made in the case of intent or gross negligence. The VITA Modulbox is not necessarily a component of the product.
Date of issue of this information: 02.16

After the publication of these information for use any previous versions become obsolete. The current version can be found at www.vita-zahnfabrik.com

VITA Zahnfabrik has been certified in accordance to the Medical Device Directive and the following products bear the CE mark CE 0124 :
VITA YZ HT, **VITA YZ** T, VITA**VM**®**9**

VITA

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