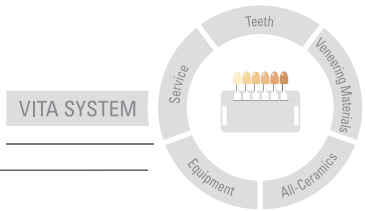
Clinical Aspects of All-Ceramics

Ceramic Design

VITA shade taking | VITA shade communication | VITA shade reproduction | VITA shade control

Edition 11.10



VITA SYSTEM 3D-MASTER

VITA

Preparation / Cementation

Univ.-Prof. Dr. Gerwin Arnetzl
Dr. Gerwin V. Arnetzl

Dr. Gerwin V. Arnetzl

Gerwin V. Arnetzl, born in 1980, graduated from the Brophy College Prep., Phoenix, Arizona (USA), received his Dr. med. dent. in 2008; his thesis dealt with the subject of "Study of the load bearing capacity of all-ceramic inlays depending on the preparation type". He is a research assistant at the Clinical Department for Prosthetics, Restorative Dentistry and Periodontology of the University Dental Clinic in Graz. In 2009 he had a study visit at the Department of Oral Medicine at the Aeskulap Clinic Brunnen, Switzerland. Gerwin V. Arnetzl is the author of numerous articles on the strength behavior and material design of dental ceramics. Moreover he won the Austrian Dental Award in 2007 and 2008, he was also honored with the Scientific Award of the Austrian Dental Association/Branch Styria in 2008.

Certified investigator for clinical studies in dentistry,
Certified Cerec trainer of the International Society of Computerized Dentistry.

Univ.-Prof. Dr. Gerwin Arnetzl

Gerwin Arnetzl, born in 1954, graduated with a Dr. med. univ. in 1983 to complete his training as a specialist for oral and maxillofacial surgery in 1988. From 1988 to 1994 he was an assistant at the clinical department for Prosthetics, Restorative Dentistry and Periodontolgy of the University Dental Clinic in Graz and received his habilitation (German qualification for professorship) in 1994. From 1995 until today Prof. Arnetzl has been the head of the Work Group for Restorative Dentistry and Adhesive Prosthetics. From 1995: University professor at the clinical Department for Prosthodontics. He was the scientific head of ÖGZMK and responsible for the professional training of his dental colleagues from 1996 to 2006 and elected General Secretary of ÖGZMK (association for oral and maxillofacial medicine) in 2003. Prof. Arnetzl has been the President of the Association for Computerized Dentistry in Austria since 2002 and Vice President of ISCD (International Society of Computerized Dentistry) since 2007.

His fields of activities include adhesive techniques and the fabrication of all-ceramic restorations. Since 1989 he has been intensively studying CAD/CAM technologies, which finally resulted in numerous relevant publications and the Habilitationsschrift (professorial dissertation) on the subject "Laborkeramik und CAD/CAM Inlay-Technologie im klinischen und experimentellen Vergleich". This was also the basis for his studies and activities concerning the causes of failure patterns and the preparation of all-ceramic restorations.

Preface

All-ceramic restorations are not the future but established and scientifically documented reality of our daily activities as dentists. Failures in the use of this technology result in financial losses for dentists working in practices. To ensure patient satisfaction through long-term durability of his restorations and to guarantee the success of your own practice, it is helpful to understand the function when using the all-ceramic material to be able to fabricate successful restorations for all indications and to ensure patient satisfaction. VITA Zahnfabrik has decades of experience in all-ceramic materials and this know-how makes the company one of the leading manufacturers worldwide. This brochure may contribute to a better understanding of the handling and processing of these materials.

Graz, April 2010

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Dr. Gerwin V. Arnetzl
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Manufacturing technique around 1900

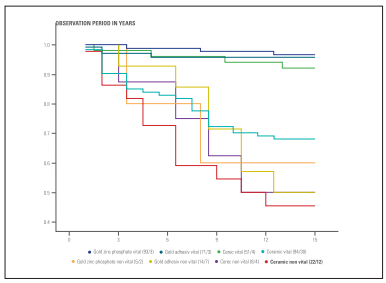
"There is probably no other restorative material which has caused more enthusiasm among dental users than the porcelain inlay since it signaled an entirely new era for preservative dentistry. Not only the younger practitioners but also older and more experienced ones were very confident that soon gold, amalgam and cement would no longer be included in the range of materials used by dentists to make room for the porcelain inlay."

Quote: Julius Scheff, Handbuch der Zahnheilkunde,1909, Wien-Leipzig

115 years after the fabrication of the first ceramic inlay by Fouchard.

In the meantime the use of a large number of ceramic restoration types has been abandoned. One only need think of the "jacket crown" of the sixties. In addition to material properties, the main reasons for failure are the cementation method and the ceramic design. Consequently, this brochure aims to support the understanding of "Thinking in ceramic dimensions" - for the benefit of the patient, the satisfaction of the dentist and finally for acknowledging the dental schoolbook of the past century in a respectful manner.

Univ.-Prof. Dr. Gerwin Arnetzl



KAPLAN-MEIER ANALYSE

General clinical experience with all-ceramic restorations

"Highly densified, industrially manufactured ceramics have significantly higher survival rates than individual, laboratory-made ceramic inlays."
G. Arnetzl; „Different Ceramic Technologies in a clinical Long-term Comparison"
State of the Art of CAD/CAM Restorations, 2006, Quintessence Publishing
ISBN 10: 1-85097-164-1

"Laboratory-made ceramic inlays produce the highest costs and have a lower cost-effectiveness than CAD/CAM ceramics and gold inlays."
T. Kerschbaum; „A Comparison of the Longevity and Cost-effectiveness of Three Inlay-types"
State of the Art of CAD/CAM Restorations, 2006, Quintessence Publishing
ISBN 10: 1-85097-164-1

"Sufficient clinical data are available for all-ceramic restorations, such as inlays, onlays, veneers and crowns, to recommend their use as an alternative to conventional, metal-supported restorations."
M. Kern; „Clinical Performance of All-ceramic Restorations"
State of the Art of CAD/CAM Restorations, 2006, Quintesse nce Publishing
ISBN 10: 1-85097-164-1

"The consequent use of adhesive techniques allows to increase the use of partial all-ceramic restorations instead of crowns. Adhesive cementation leads to significantly better long-term results."
B. Reiss; „Eighteen-Year Clinical Study in a Dental Practice" ,
State of the Art of CAD/CAM Restorations, 2006, Quintessence Publishing
ISBN 10: 1-85097-164-1

"After an observation period of 9 years, Cerec veneers have a survival rate of 94% and in 90% of all cases the shades of the veneers have been perfectly matched with those of adjacent teeth."
K. Wiedhahn; „Cerec Veneers: Esthetics and Longevity"
State of the Art of CAD/CAM Restorations, 2006, Quintessence Publishing
ISBN 10: 1-85097-164-1

"The biogeneric model of tooth reconstruction allows fully-anatomical reconstruction of the tooth surfaces, for the indication of inlays/onlays as well as after crown preparations."
A. Mehl; „Biogeneric Tooth Reconstruction- a new fundamental method to describe and reconstruct the occlusal morphology of teeth"
State of the Art of CAD/CAM Restorations, 2006, Quintessence Publishing
ISBN 10: 1-85097-164-1

General clinical experience with all-ceramic restorations
Güß (Güß 2003) describes that it is recommended to keep a distance to the pulp by means of a **residual dentine thickness of at least 0.7 mm** to avoid a preparation trauma (Walther et al., 1984).

Convergence angles of 6° to 10° allow try-in of the ceramic restoration without the risk of fracture (Brodbeck & Schärer, 1992; Broderson, 1994; Fradeani & Barducci, 1996; Esquivel-Upshaw et al., 2000).

For occlusal reduction, values from 1.5 mm for premolars and up to 2 mm for molars are considered to be sufficient in literature. It is recommended to "recontour" the occlusal relief to obtain a restoration with uniform dimensions on all sides (Banks, 1990; Fradeani et al., 1997).

Bevels, slice-cuts and feather edges are contraindicated because of increased risk of fracture (Fradeani & Barducci, 1996). Restoration margins limited to enamel and proceeding coronally to the enamel cement border enable stable adhesive bonding of tooth, cement and ceramic and ensure lasting and improved quality of margins (Broderson, 1994).

Supragingival preparation borders are considered to be a precondition for adhesive cementation and are recommended for periodontal-prophylactic reasons. Moreover, preparation, impression and visual control of the marginal seal and hence the removal of excess adhesive can be completed more easily (Ottl & Lauer, 1996; Yatani et al., 1998).

The restorative material should have a layer thickness of 1.5 mm on occlusal and balance contacts on ceramic restorations (Dietschi & Spreaficio, 1997). The use of adhesive techniques also requires a minimum layer thickness of 2 to 2.5 mm of the walls of residual tooth substance (Güß 2003).

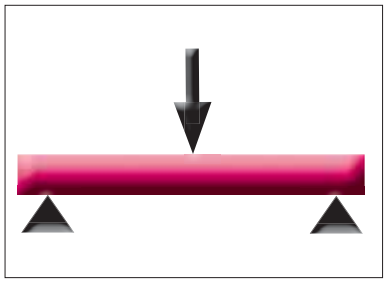
As far as the preparation of onlays is concerned, generally anatomically correct reduction is performed additionally. The occlusal margins of the inlay and only restorations should not be in the area of occlusal contact points (Broderson, 1994; Dietschi & Spreaficio, 1997; Yatani et al., 1998).

To avoid thermal irritation of the pulp, a sufficient amount of cooling water of 50 ml/min and a cooling water temperature of no more than 30°C are required during the preparation (Hellwig et al: 1999a; Strub et al., 1999).

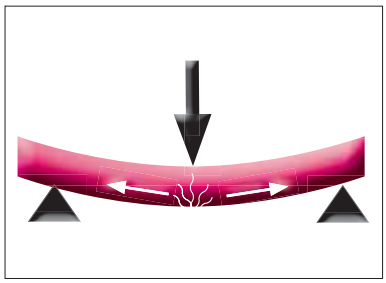
To ensure sufficient strength of the ceramic material and to minimize the risk of fracture caused by the masticatory function, **an adequate layer thickness of the restoration both in the occlusal and the axial dimension is recommended.** (Wamser 1999).

Physical behavior of ceramics
Materials technology: non-metal inorganic materials

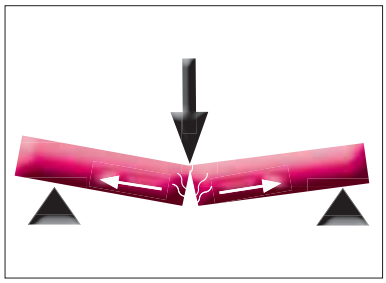
Group of materials	Glass, ceramic	Metals	Polymers
Type of binding	Ion binding	Metallic bond	Covalent binding
Modulus of elasticity	High	Medium	Low
Thermal expansion	Low	Medium	High
Density	Medium	High	Low
Mechanical behavior (room temperature)	Brittle	Plastic	Viscous-brittle



Transmission of force to the ceramic body



results in tensile stress in the ceramic (on the opposite side)



and hence in microcrack and crack formation which will finally lead to total fracture

Evaluation criteria for the strength of ceramic

- Flexural strength MPa (N/mm^2)

  Flexural strength is determined using standardized specimen
  Standardized test methods include
  3-point flexural test
  4-point flexural test
  biaxial flexural test

- Surface quality

  Stress corrosion cracking caused by surface defects, such as porosities, cavities and microracks in combination with moisture result in subcritical crack propagation.

- Fracture strength Newton (N)

  Fracture strength is determined at real geometries
  such as crowns and bridges.
  (no international standard)

- Weibull modulus m

  Weibull modulus provides a value for the variation in strength of a ceramic (the lower the variation, the higher the Weibull modulus m).

- Fracture toughness K_{IC} Wert

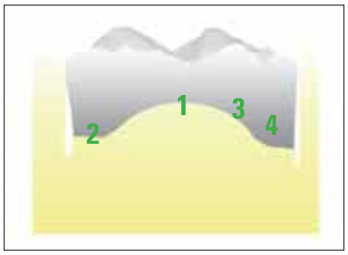
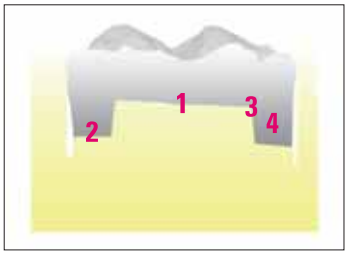
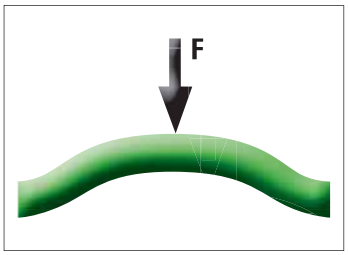
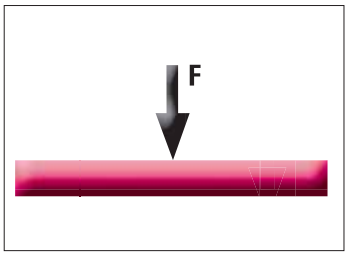
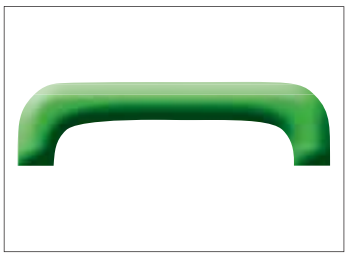
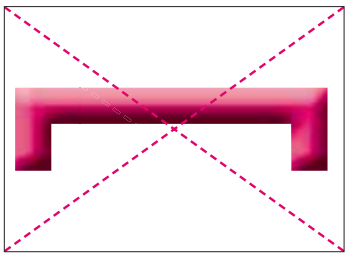
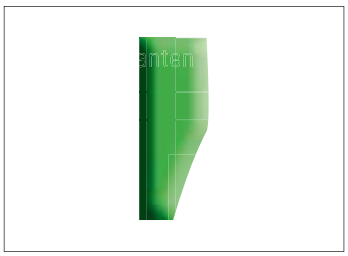
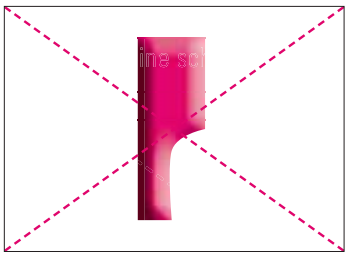
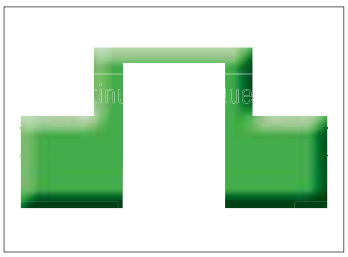
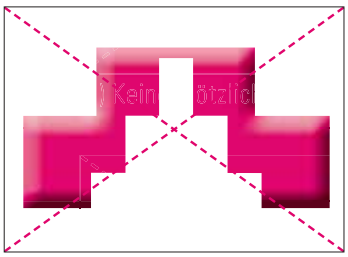
  Fracture toughnesss is the resistance of the ceramic to the propagation of a crack.

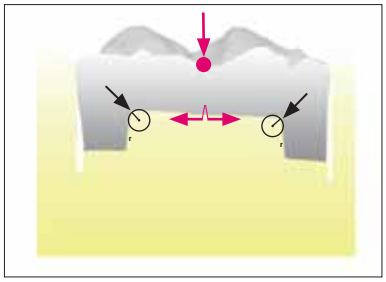
  The **stress intensity factor K_{IC}** is a value for the intensity of the area of stress in the vicinity of the crack tip, which depends on the geometry of the crack, the external stress and the geometry of the component.
  The critical stress intensity factor K_{IC} represents the value for the occurrence of unstable crack propagation.

- Fatigue strength SPT Diagramm

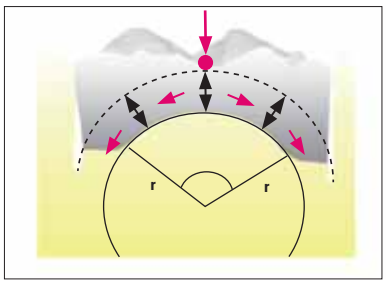
  What are the changes of a material under the influence of stress and time?

  SPT diagram (strength, probability, time)
  serves to estimate the fatigue strength potential

Favorable designs	Unfavorable designs
	
 1.) Transforming tensile into compressive stress	 1.) Avoiding tensile stress
 2.) Round transitions	 2.) No sharp edges
 3.) Continuous changes in the cross-section	 3.) No sudden change in the cross-section
 4.) Simple designs	 4.) No complicated designs

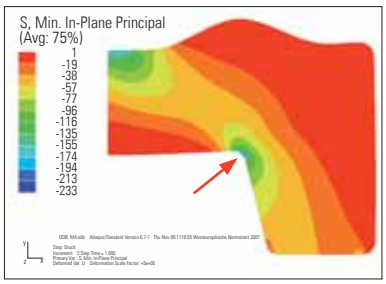


Box-shaped preparation results in tensile stress at the side opposite the one where the force is generated

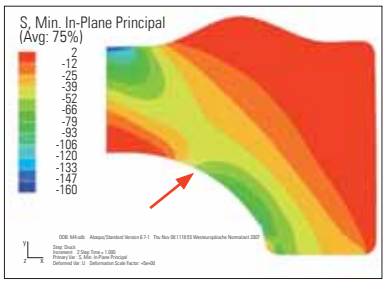


Convex cavity bottom design leads to the formation of compressive stress

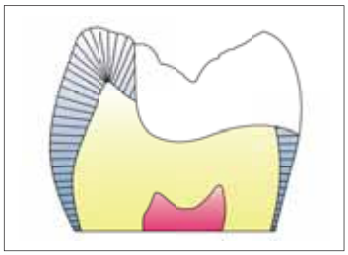
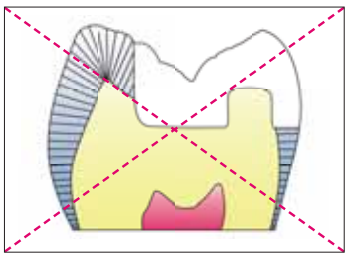
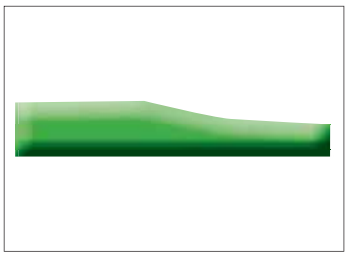
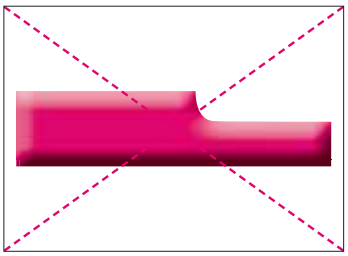
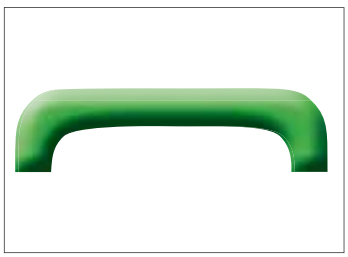
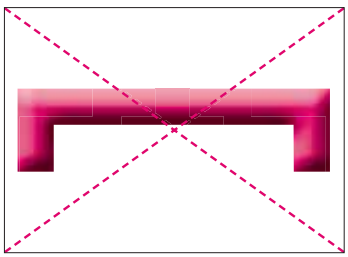
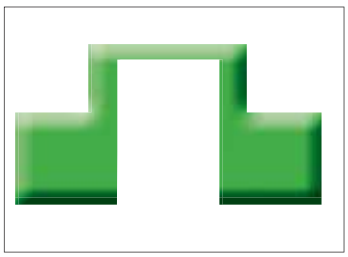
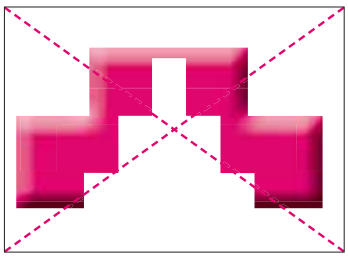
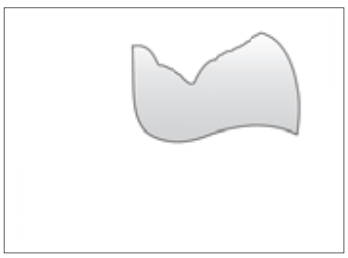
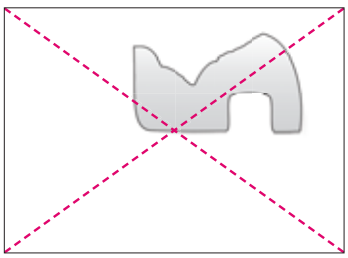
Example of an ancient, proven basic principle.
Formation of compressive stress - avoidance of tensile stress



Occurrence of major notch stress in the area of rounded edges



No notch stress thanks to convex preparation types and avoidance of box-shaped preparation

Ceramic-specific preparation design	Example of an unfavorable preparation type
 Transforming tensile into compressive stress (by convex cavity bottom)	
 Continuous changes in the cross-section (no box-shaped preparation)	 Unfavorable
 Round transitions (avoiding notch stress)	 Avoid complicated wall design
 Simple designs (no deep fissures)	 Avoid notch stress at edges
 Ceramic-specific form design	 Unfavorable ceramic design (in several respects)

Basics of preparation

In addition to the biological vitality principles, the preparation for all-ceramic restorations is exclusively based on the requirements profile of the ceramic material.

In contrast to traditional restoration methods, different, new and material-specific requirements must be defined for all-ceramics.

The basic requirements that generally apply to the clinical procedure, however, remain unchanged:

- Sufficient cooling during the preparation
- Avoiding exposure to heat caused by high pressure
- Use of instruments with good cutting performance
- Coarse preparation before fine preparation
- Protecting the pulp against damage caused by milling/grinding
- No subgingival preparation margin

The preparation should comply with the following requirements

- Defect-oriented
  - Minimally invasive preparation resulting in extremely thin restorations is not compatible with ceramics
  - As much as necessary, as little as possible
  - Providing a stable basis for the restoration
  - Ensuring freedom of rotation and accurate positioning

- Tooth-specific
  - Anterior, posterior tooth, alignment with the tooth axes (upper and lower)
  - Securing the required residual dentine thickness of 0.7 - 1.0 mm in all areas

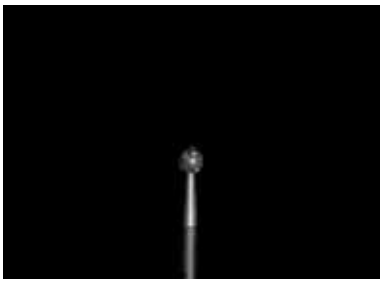
- Material-specific
  - Sufficient space for structural retention depending on the eligible ceramic material and the indication
  - Sufficient space for esthetic rehabilitation

- Technology-specific

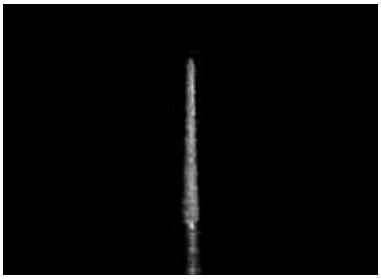
  In accordance with the
  - requirements profile of the CAD/CAM system in use
  - software specification
  - geometry of axles of the milling system
  - size of the smallest milling tool

Preparation instruments for the preparation of all-ceramics
Within the scope of his professional activities, each dentist develops a preference for a certain number and shapes of instruments.

The following pictures show a selection of instruments which have proved to be suitable for the preparation of all-ceramic restorations:

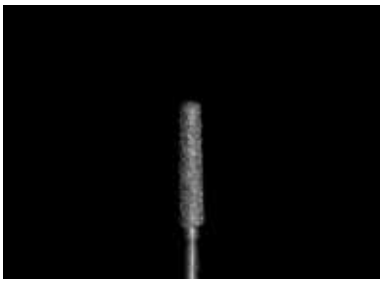


Diamond-coated round instrument is suitable to prepare vertical and horizontal depth orientation grooves

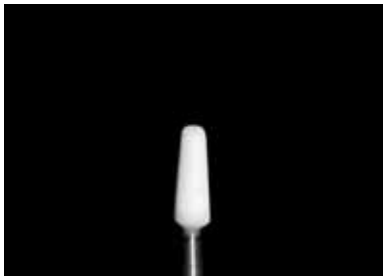


Separating diamond

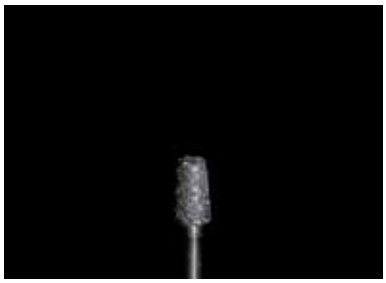
Chamfer diamond
approx. 70-80 µm for coarse preparation
approx. 30 µm for fine preparation



Cylindrical diamond for shoulder preparation with rounded inner edge
approx. 70-80 µm for coarse preparation,
approx. 30 µm for fine preparation

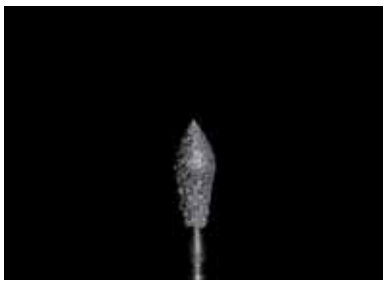


Arkansas stone allows for individualizing the shape for fine preparation and hence for milling all geometries from the chamfer to the shoulder with rounded inner edge.



Conical inlay diamond ensures that minimum thicknesses of the ceramic are adhered to thanks to its diameter of 1.5 mm.

Bud for palatal reduction

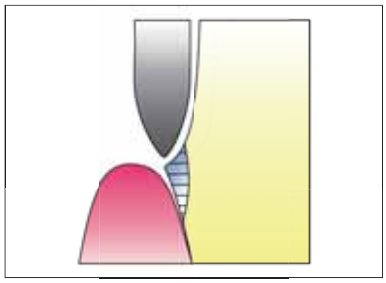


Double cone bur for occlusal reduction

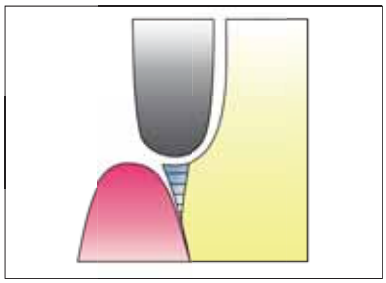
Diamond-coated oscillating files for fine preparation

Preparation type

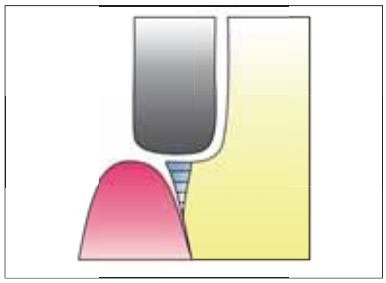
A chamfer or shoulder with rounded inner angle should be prepared in the case of all-ceramic crowns. The aim should be a circumferential cutting depth of one millimeter. The vertical preparation angle should be at least 3°. All transitions from the axial to the occlusal or incisal surfaces should be rounded. Uniform and smooth surfaces are recommended. A wax-up and the preparation of silicone keys to control the preparation are recommended for the diagnosis and the clinical application (defect-oriented preparation).



Chamfer preparation



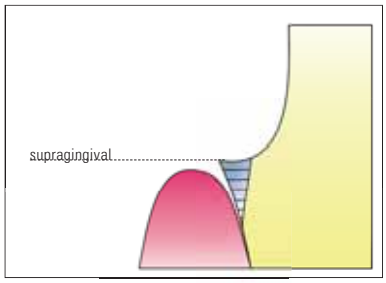
Accentuated chamfer preparation



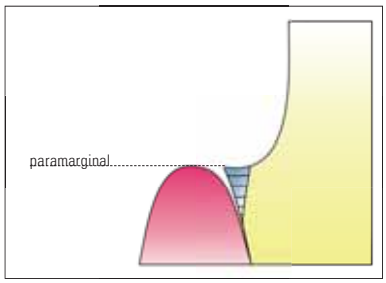
Shoulder preparation or shoulder with rounded inner edge

Location of the preparation border

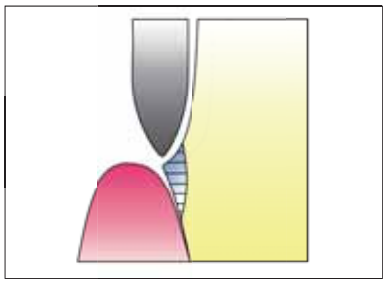
The location of the preparation border is of special relevance as far as esthetic aspects are concerned but above all with regard to biological ones.
In light of periodontal-physiological considerations a subgingival preparation border should be prepared if possible.
If esthetic aspects are more important, a preparation border located in the paramarginal area may be required. A subgingival preparation border should generally be avoided.



Supragingival preparation border

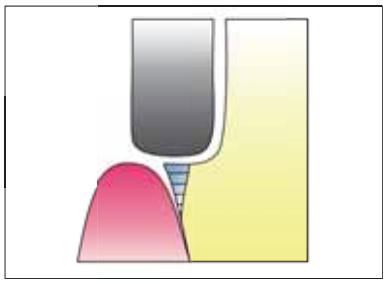


Paramarginal preparation border

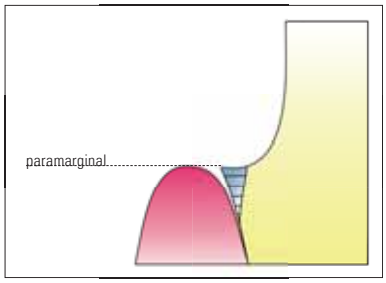


General information
on the preparation of anterior crowns

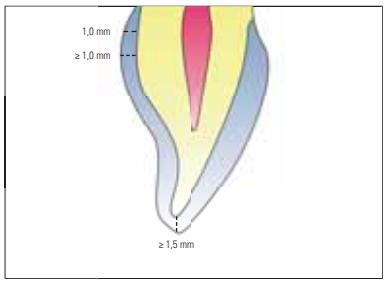
Chamfer



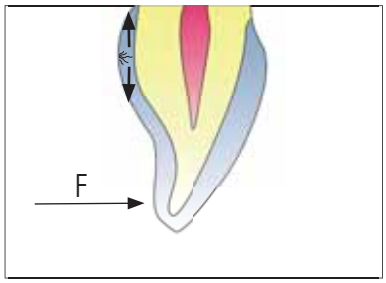
Shoulder preparation



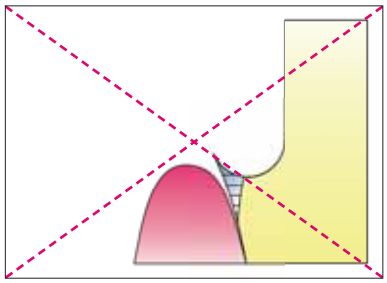
Paramarginal preparation border



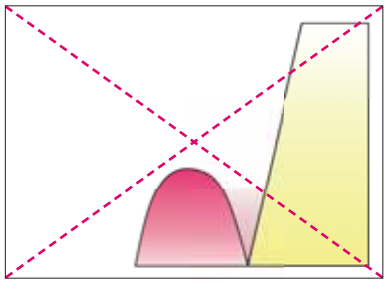
Anterior teeth
- Incisal wall thickness: at least 1.5 mm
- Circumferential wall thickness: at least 1.0 mm
- Tapering crown margin: at least 1.0 mm



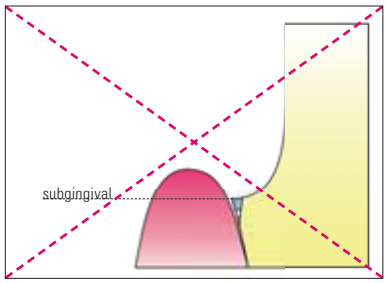
Provide adequate space in the areas exposed to maximum tensile stress



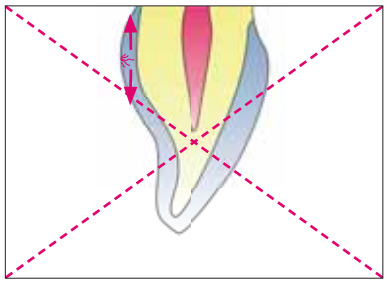
"Gutter-shaped" preparation margin - excessive preparation depth



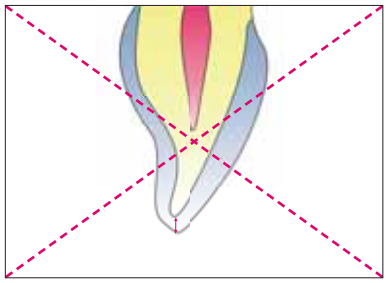
Tangential preparation types must be avoided



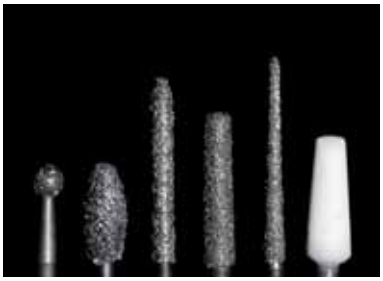
Subgingival preparation border



Minimum layer thickness in areas of maximum tensile stress is not adhered to



Minimum incisal layer thickness is not adhered to



Preparation of anterior crowns
The instruments - available with coarse (approx. 80 µm) and fine diamond coating (approx. 30 µm) - are recommended for the preparation of anterior teeth.

Initial situation

Preparing depth orientation grooves parallel to the anatomical tooth shape. Use either chamfer diamond instruments (1 mm Ø) ...

or diamond-coated round instruments
(defined penetration depth from the outer curvature to the shaft: approx. 1 mm).

Preparing incisal depth orientation grooves.
Once the preparation has been completed, the incisal reduction should be at least 1.5 mm or even 2 mm.

Palatal depth orientation grooves are also prepared

Carefully separate from the adjacent tooth
without damaging it during the preparation!

Coarse preparation:
- labial and palatal reduction: approx. 1 mm
- incisal reduction: 1.5 - 2 mm
- removal of undercuts

Rounding off the incisal edge and preparation of esthetic bevel

to obtain sufficient space in the incisal third of the tooth
for the ceramic and the perfect appearance.

Palatal reduction

Palatal chamfer preparation

This classic preparation method produces the thinnest ceramic layer exactly at the point of maximum tensile stress (see arrow).

Consequently, ceramic-specific preparation at this point is mandatory!

Placement of a retraction cord to protect the gingiva. Fine preparation and exact definition of the preparation border (paramarginal)

Ceramic-specific preparation of anterior teeth from the labial side

From the proximal side

From the palatal side

Thinking in ceramic dimensions
requires 3D-visualization of the
ceramic design achieved by the preparation.

General guidelines for the preparation of posterior crowns

- The same general preparation guidelines apply for posterior crowns with regard to the type of preparation and the position of the preparation margin.

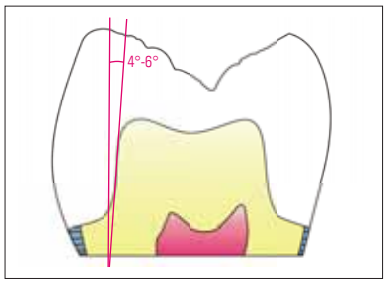
- The circumferential chamfer preparation has proven to be simple to implement and kind to ceramic in the all-ceramic technique.

- In esthetically challenging areas a pronounced circumferential chamfer is recommended in order to achieve a natural shade effect of the ceramic.

- Shoulder preparations of over 1 mm are to be avoided, particularly in the approximal area of the upper and lower premolars and in the lingual area of the lower molars in order to avoid the risk of falling short of the required minimum wall thickness of the dentine.

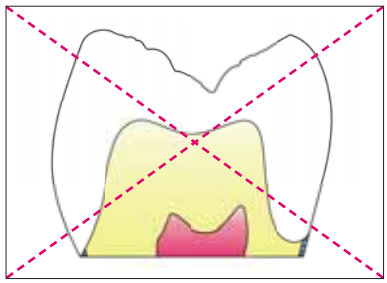
- Sharp-edged transitions and intricate bevelling are likewise to be avoided for this indication.

- The preparation must guarantee sufficient occlusal wall thicknesses of the ceramic (1.5 - 2 mm), since this guarantees a positive effect on the material strength properties of the crown geometries.

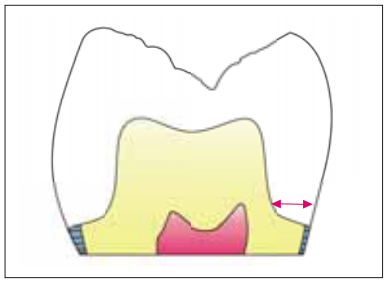


General guidelines
for the preparation of posterior crowns

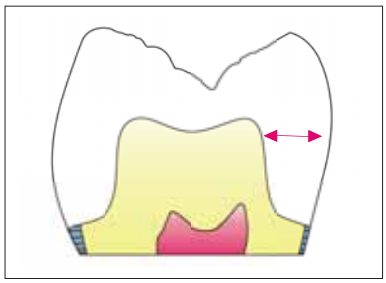
Prepare the tooth with a cone preparation of 4 - 6° and block out undercuts



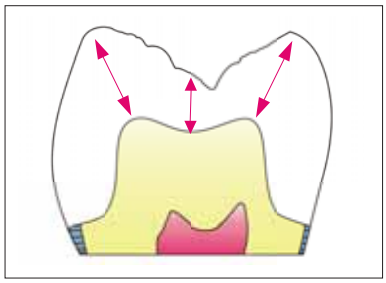
Tangential and "gutter-shaped" preparations should be avoided



The width of the circumferential chamfer or shoulder with a rounded inner angle should be 0.8 mm in the approximal area of premolars and the lingual area of the lower molars, and 1.0 mm in all other areas.



Reduce circumferentially by 1.5 mm for optimum esthetic results.



For static reasons it is necessary to reduce by 1.5 - 2 mm in the cusp and fissure area.

Separate interdentally, protecting the adjacent tooth with a metal collar

Carry out a circumferential preparation, determining the preparation limit, if possible, supragingivally

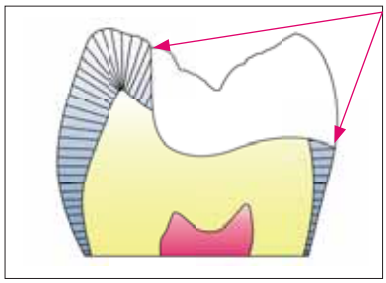
Reduce occlusally, reproducing the basic anatomical tooth shape

For esthetic reasons, reduce in the area of the buccal cusp

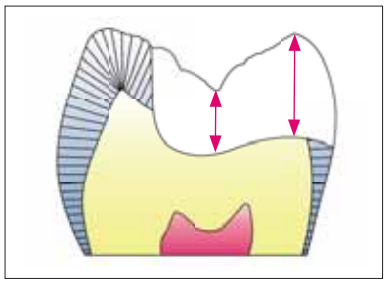
The completed posterior crown preparation
Now carry out a final check of the occlusal reduction and the interocclusal distance

General information on the preparation of inlays and onlays

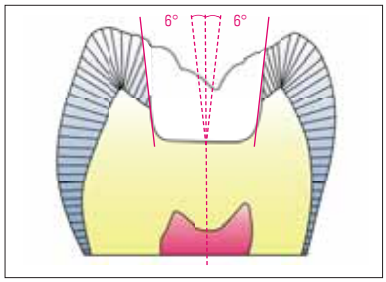
- When preparing inlays, onlays and all-ceramic partial restorations it is mandatory to adhere to the requirements profile of the ceramic material.
- Thinking in ceramic dimensions leads to a perfect design of the restoration and hence to enhanced clinical long-term success.
- Thanks to the use of the adhesive technique box preparations to achieve mechanical retention are not required and will also lead to unfavorable ceramic designs.
- Observing the defined minimum layer thicknesses is an essential precondition. These minimum requirements will be adhered to if instruments with suitable diameters are selected.
- To ensure increased resistance of the material, shaping of deep fissures can be omitted.
- If the requirements on the minimum thickness of dentine-supported residual tooth substance are not adhered to, the probability of failure will increase considerably.
- Early detection of non-compliance with the indication range and cusp-specific preparations produce better results.
- If preparation margins can be easily accessed, simple removal of excess adhesive and treatment of the adhesive joint are ensured.



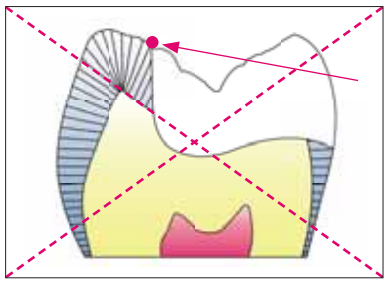
Preparation of inlays and onlays
Clearly cut preparation margins



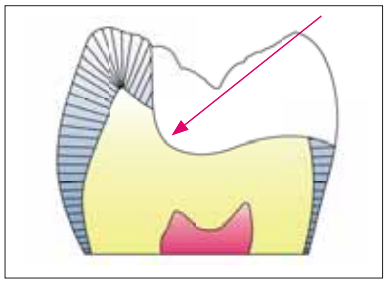
Minimum layer thickness in the area of fissures: 1.5 mm
Recommended layer thickness in the area of cusps: 2.0 mm



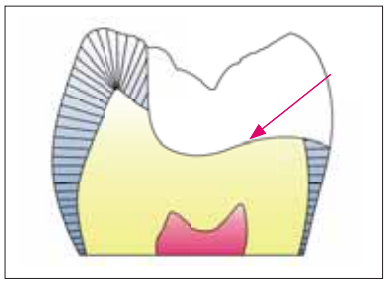
Opening angle > 10°



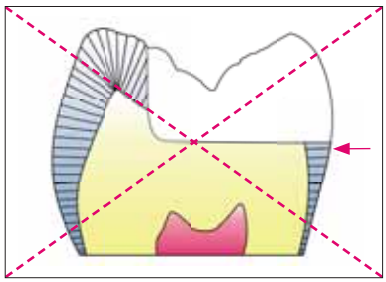
No preparation margin in the area of central stops



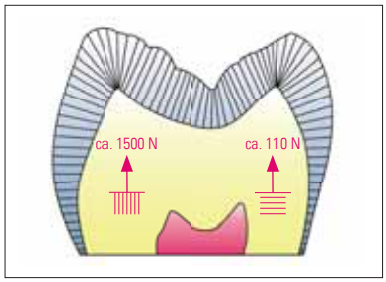
Round transitions with large radii



Convex cavity bottoms

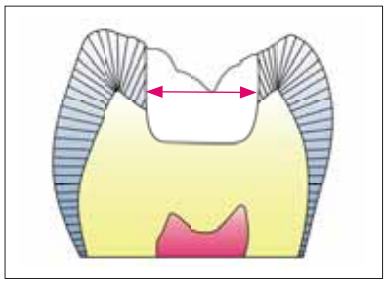


No parallel cut enamel prisms

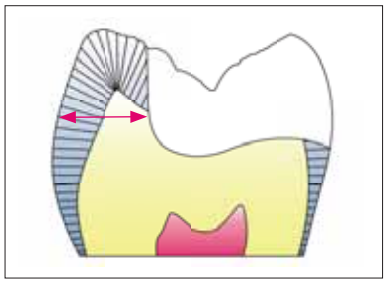


Loss of cohesion owing to parallel-cut enamel prisms

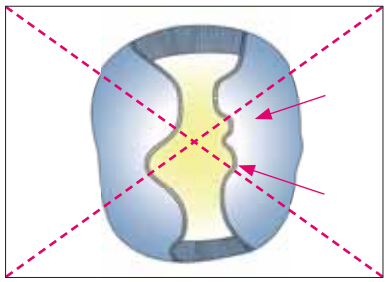
(Enamel prisms need to be cut obliquely and not parallelly for adhesive preparations (Lutz et al., 1991))



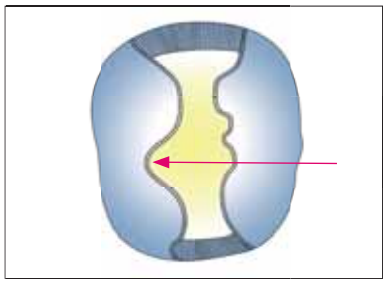
Minimum width in the area of the isthmus: 2.0 mm



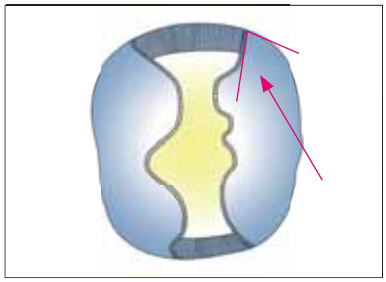
Minimum residual tooth substance: 2.0 - 2.5 mm



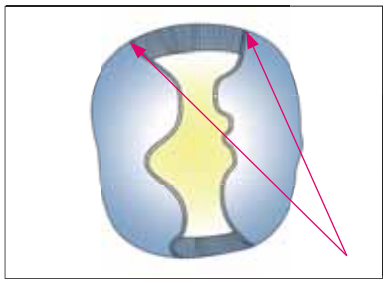
No macroretentions
No grooves



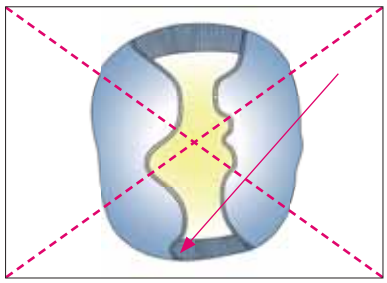
Round, curved transitions



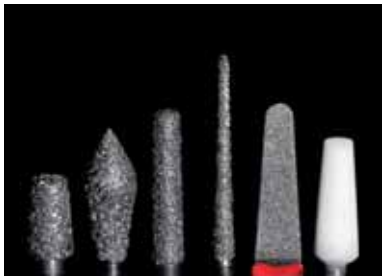
Obtuse preparation angles



Preparation border extending to the oral and vestibular directions



No acute preparation angles



Preparation of inlays and onlays
These drill shapes with coarse (approx. 80 µm) and fine diamond coating (30 µm) are recommended for the preparation of inlays and onlays.

Determining the minimum occlusal width

and the minimum depth of the preparation

Separating in the approximal area without damaging the adjacent tooth

This can also be carried out using ultrasonic instruments that are diamond-coated on one side

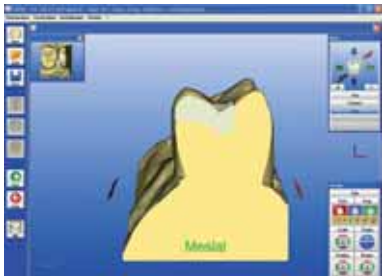
To avoid preparations with acute angles, diamond-coated oscillating files are recommended.

Favorable preparation of inlay with convex cavity bottom

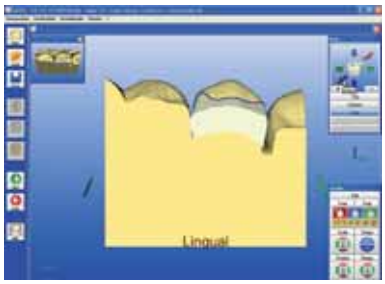
If layer thicknesses of the residual tooth substance are too low or continuous enamel cracks can be seen, the cusp should be integrated into the preparation.

Anatomically correct reduction of the palatal cusp

Ceramic-specific preparation design of an onlay



The sectional view in the CAD/CAM software shows the material-specific ceramic design.



Formation of compressive stress.
Avoiding tensile stress

When preparing all cusps, complex cusp coverage results in "occlusal veneer"

Preparation in the approximal area

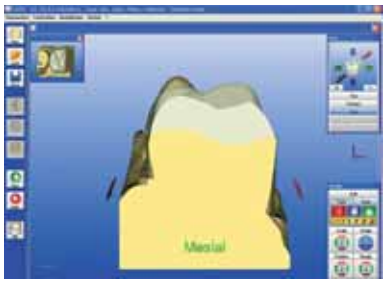
Anatomically and esthetically correct reduction of the cusps

Ceramic-specific convex contouring of the cusps

Ceramic-specific contouring of the bottom of the restoration

The esthetic result can be optimized by reproducing the contour of the cusps

Preparation design for occlusal veneer



Optimized ceramic design

The preparation of veneers offers a wide range of variations - from minimally invasive reduction of the surface enamel layers through classical, more extensive veneer preparation to 3/4 of the crown, thereby mostly conserving the natural palatal tooth substance. By means of the combination of the all-ceramic and adhesive technique, a crown preparation is no longer necessary in the vast majority of cases.

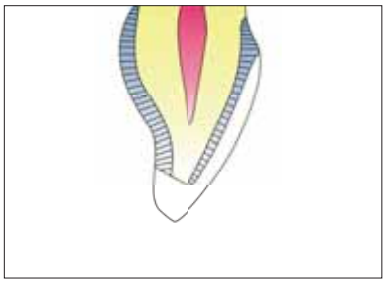
- Minimum reduction of the enamel (0.5 mm)

- Preparation limit supragingival to paramarginal

- Incisal reduction (2 - 2.5 mm)

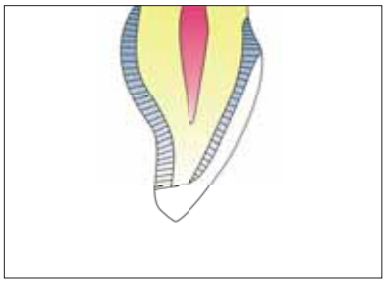
- Approximal reduction conserving the contact point

- Positioning of the restoration

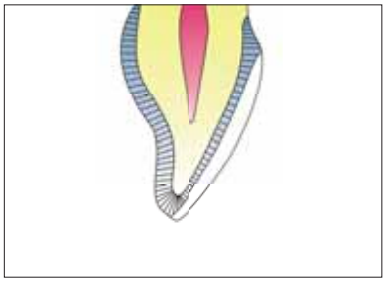


General guidelines
for the preparation of veneers

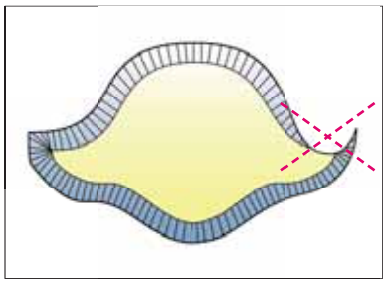
Incisal reduction with bevelling in the palatal direction
(incisal path of insertion)



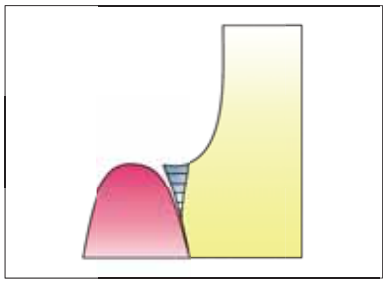
Incisally reduced, but labially inclined preparation margin
(buccal path of insertion)



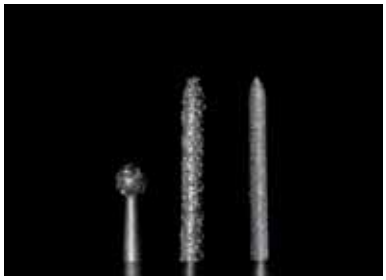
The preparation limit should taper towards the incisal edge if
at least 1.5 mm of tooth substance remain



"Gutter-shaped" preparations should be avoided



Paramarginal preparation limit



Veneer preparation
All that is required for veneer preparation are coarse-grained and fine-grained chamfer diamonds and a spherical diamond bur for preparing the depth orientation grooves.

Minimally invasive depth orientation grooves

Taking into account the convex, labial anatomy of the tooth

Homogeneous labial reduction

For checking purposes it is recommended to use a preparation template, which can also be manufactured from a mock-up.

Reduce cervically up to just before the exposed gingival margin

Preparation in the approximal area

Particular attention should be paid to the cervico-approximal area. If the preparation is too flat, a possibly discoloured tooth will be clearly recognisable.

Incisal securing of the tooth after adding depth orientation grooves enables precise positioning of the veneer during cementation.

Placing a retraction cord for the detailed preparation of the cervical preparation margin.

Detailed preparation of the cervical preparation margin

The determination of the cervical preparation limit can, for esthetic reasons, also take the form of a more pronounced chamfer.

"Gutter preparations" in the approximal area can be avoided by using oscillating files.

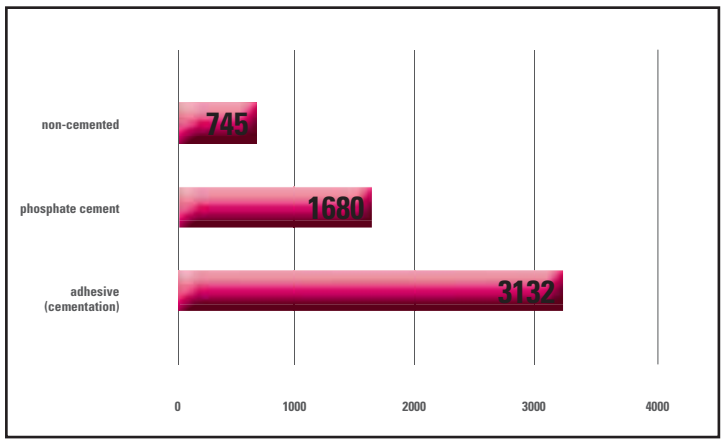
Also in the incisal area, diamond files are excellent for carrying out the fine preparation.

Veneer preparation

Evaluation criteria for the strength of ceramic

The fracture strength values of crowns made of silicate ceramic were increased significantly when fixing them with phosphate cement and the use of adhesive cementation produced even considerably higher fracture strength values.

Failure load (N)



W. Mörmann et al.
„Der Einfluß von Präparation und Befestigungsmethode auf die Bruchlast vollkeramischer Computerkronen."
Acta Med Dent Helv, Vol.3:2/1998

Requirements on the ideal cementation material McLean,J prost Dent, 1984

	Cementing	Luting
Simple handling	+	– / +
Low viscosity and layer thickness	+	+
Extended processing time and quick hardening in situ	+	+
Resistance to acids and water	–	+
High compressive and tensile strength	–	+
Resistance to plastic deformation	–	+
Adhesion to tooth structure and restorations	–	+
Cariostatic effect	–	+
Biological compatibility with the pulp	–	–
Translucency	–	+
Radiopacity	–	+

Standard protocol for the adhesive cementation of restorations made of silicate ceramics

by
Priv. Doz. Dr. M. Oliver Ahlers (Hamburg), Prof. Dr. Gerwin Arnetzl (Graz), Dr. Uwe Blunck (Berlin),
Prof. Dr. Roland Frankenberger (Marburg), Dr. Jan Hajtó (München), Dr. Gernot Mörig (Düsseldorf),
Prof. Dr. Mutlu Özcan (Zürich), Prof. Dr. Lothar Pröbster (Wiesbaden)

1. Preparation of the cavity

The most important precondition for adhesive cementation is the fact that the surfaces must be free from any contamination. If possible, exposed dentine should be sealed with a composite (dentine adhesive). Dentine that is not exposed needs to be cleaned before the adhesive system is applied. This can be perfectly achieved by sandblasting with glycine powder or aluminium oxide.
The use of bicarbonate powder, however, leads to a decrease of the bonding values in the dentine and must therefore be avoided. Alternatively, the cavity can also be cleaned with rotating brushes and the additional use of pumice powder or fluoride-free prophylaxis paste.

2. Adhesives

Multi-bottle systems in combination with the etch & rinse technique are mostly recommended.
They exhibit low sensitivity to overdrying or excessive moisture of the etched dentine. In particular, postoperative complaints, such as hypersensitivities, can be avoided. It must be ensured that a new brush is used for each component. It is not consequential to use a purely light-curing adhesive below a dual-hardening cementation composite if it is not hardened before. It the adhesive is hardened before, excessive accumulation of liquid adhesive (formation of puddles) must be avoided in order not to prevent correct insertion by the hardened adhesive.
When using dual-hardening cementation composites, adhesives containing chemical initiators may also be used. Since these products are one-bottle systems, rewetting of the etched and dried dentine areas of the cavity is particularly important and should be carried out using a microbrush which is wetted by spraying with a multi-function syringe.

The activator which is added to the adhesive induces the adhesive to react already when the cementation composite is applied. Depending on the concentration, the adhesive may harden too quickly, which may also prevent the correct insertion.

When using a purely light-curing cementation composite, these recommendations may be ignored since the adhesive is polymerized together with the cementation material.

3. Adhesive composites

Adhesive composites may be classified based on the method of hardening (light- or dual-curing) and based on their viscosities (high- or low-viscous).
Adequate supply of light must be ensured for purely light-curing materials and a polymerization protocol needs to be strictly adhered to. Exposure to light for at least 30 seconds (approximal) both from the oral and vestibular directions and at least 30 seconds from the occlusal direction for premolars and 60 seconds from the occlusal direction for molars are required. It must be ensured that the polymerization units in use provide high power (>800 mW/cm2). The power must be regularly checked using suitable measuring devices.

Moreover it must be ensured to avoid excessive layer thicknesses already during cavity preparation with dentine adhesive composites.

When using highly viscous adhesive composites, the viscosity should be reduced for the application into the cavity using ultrasonic (or sonic) activation (ultrasonic (or sonic) insertion technique).

Preparing the silicate ceramic

The fit of silicate ceramics should not be checked with silicone-containing try-in pastes since silicone oils remain on the surface, which are difficult to remove and affect adhesive cementation later on.
The ceramic surface must also be free from any contamination to enable successful adhesive cementation.

Phosphoric acid, which is more efficient than acetone, may be used to clean restorations which have been previously integrated in the patient's mouth.

Then the underside of the ceramic is etched with hydrofluoric acid for 60 seconds. It must be ensured that the hydrofluoric acid is carefully applied up to the preparation margin. Then the hydrofluoric acid is rinsed off with forceful water spray. Cleaning in the ultrasonic bath (1 to 3 minutes in 98 % alcohol) allows to remove precipitates and hydrofluoric acid residues more easily; the clinical relevance, however, has not been established.

Before the silane is applied, the ceramic surface should be dried with alcohol (98 %). A perfectly dried surface is a precondition for reliable silanization. The silane should be allowed to react for one minute and then dispersed to obtain a very thin silane coat. When using a one-component silane, the expiration date needs to be observed; a two-component silane allows the use of a freshly mixed solution for each individual application.

A light-curing adhesive may (but does not have to) be applied to the ceramic restoration when using light-curing composites. Light-curing adhesive should not be used for this processing step when using dual-curing composites.

General information

The standard protocol described above requires reliable contamination control over a period of several minutes. Therefore the use of rubber dam provides more safety but only if it is used properly. In such cases the use of rubber dam will reduce the stress on dentists and their patients.

The application of glycerol gel is recommended since the adhesive composite cures more easily in the joint areas on the surface. Therefore the use is particularly suitable for wide joints. The application of glycerol gel can be omitted for restorations with high accuracy of fit (narrow joint).

These explanations and recommendations refer exclusively to restorations made of silicate ceramics which are to be cemented adhesively and require special preparation methods matched with the ceramic material.

Since the quality and durability of restorations made of silicate ceramics mainly depend on the fixation (cementation), it was deliberately renounced to set an optimal or minimal standard. There should only be "one" standard for the integration of a restoration made of silicate ceramic - especially since this standard provides the desired basis for dental professionals.

The alternative - the use of self-adhesive cements - was generally rejected. The marginal behavior in the enamel and initial results of clinical studies show that this group of cementation materials can currently not be recommended for the integration of ceramic restorations with cavity margins predominantly situated in the enamel.

VITA LUTING SET

All-ceramic restorations made of silicate ceramic
Inlay, onlay, partial crown, crown, veneer

- e.g. made of VITABLOCS, VITA PM 9
- Conditioning of the ceramic:
  etching - silanizing
- Dentine conditioning:
  primer - adhesive
- Enamel conditioning:
  etching with phosphoric acid
- Classic adhesive cementation with
  light- or dual-curing adhesive systems (e.g. VITA LUTING SET).

PANAVIA F 2.0 TC

All-ceramic restorations made of oxide ceramic
Crown, bridge

- e.g. made of VITA In-Ceram SPINELL, ALUMINA, ZIRCONIA, AL und YZ
- Conditioning of the ceramic
  Sandblast the inner surfaces with a microblaster
  and aluminium oxide (max. 50 µm). Pressure ≤ 2.5 bar.
  - Sandblasted surface must not be touched.
  - Silanization is not required if a phosphate monomer-containing cementation material, such as PANAVIA, is used
- Dentine conditioning:
  primer and adhesive (multi-bottle system)
- Enamel conditioning:
  etching with phosphoric acid
- Adhesive cementation with a phosphate monomer-containing composite (e.g. PANAVIA).
- For crowns and bridges, self-conditioning cementation materials are also used.

Clinical procedure step-by-step
Initial situation with generalized enamel hypoplasia

Initial situation prior to luting of veneers

Careful placement of a retraction cord to prevent adhesive and composite from flowing into the gingival sulcus.

Individual try-in of the veneers to check primary fit and shade effect

Try-in with silicone-free try-in pastes to check the shade effect

Mechanical cleaning of the preparation and adhesion surfaces with fluoride-free paste

Decontamination of the adhesion surfaces as an essential step to achieve successful adhesive bonding

Additional sandblasting of the cavity with glycine powder produces a surface completely free from contaminations.

Pretreatment of the ceramic according to the manufacturer's instructions. Etching of the ceramic with hydrofluoric gel, 60 seconds (e.g. VITA CERAMICS ETCH).

> ⚠ **Note:** VITA CERAMICS ETCH is a hazardous material. Please observe the information on page 63.

Pretreatment of the ceramic
Rinsing with water, blowing dry, silanizing (e.g. VITASIL).

Pretreatment of the ceramic
Application of the bonding agent (e.g. VITA A.R.T. BOND, Bonder)
and non-exposure to light until the integration

Pretreatment of the cavity
Etching of enamel with phosphoric acid gel, 35% (e.g. VITA ETCHANT GEL).

⚠ **Note:** VITA CERAMICS ETCH is a hazardous material.
Please observe the information on page 63.

Pretreatment of the tooth
Etching of all enamel areas

Pretreatment of the tooth
Rinsing with water
(for at least 60 seconds)

Pretreatment of the tooth
Use of multi-bottle adhesive systems (e.g. VITA A.R.T. BOND)
for enhanced adhesive bonding
Application of the primer (e.g. A.R.T. BOND, Primer A+B).

Excess primer is carefully blown off

Application of the adhesive (e.g. VITA A.R.T. BOND, Bonder)

Excess adhesive is blown off and adhesive is hardened

Hardening of adhesive and bonding

Application of the composite to the restoration. (e.g. VITA DUO CEMENT)

Placement of the restoration onto the tooth

Light-curing for 1-2 seconds

Removal of excess in the gel phase using a sharp scaler

Removal of excess in the gel phase using a sharp scaler

Covering the cementation joint with glycerine gel (e.g. VITA OXY-PREVENT)

Final curing for 60 seconds from each side

Removal of the retraction cord, finishing and polishing

Try-in of the next restoration including any necessary correction at the contact point

Final fluoridation of the restored teeth

Same presentation in the lower jaw

Same procedure in the lower jaw as well

Initial situation

Final situation

Material	**Fine-structure feldspar ceramics**			**Oxide ceramics**
All-ceramic system	• VITABLOCS Mark II for CEREC/inLab • VITABLOCS TriLuxe for CEREC/inLab • VITABLOCS TriLuxe forte for CEREC/inLab • **VITABLOCS RealLife for CEREC/inLab** • VITABLOCS Mark II for KaVo Everest • VITABLOCS for CELAY • VITA VM 7 • VITA PM 9			• VITA In-Ceram SPINELL for inLab • VITA In-Ceram ALUMINA for inLab • VITA In-Ceram ZIRCONIA for inLab • VITA In-Ceram AL for inLab • VITA In-Ceram YZ for inLab • VITA In-Ceram SPINELL for CELAY • VITA In-Ceram ALUMINA for CELAY • VITA In-Ceram ZIRCONIA for CELAY • VITA In-Ceram SPINELL Schlickertechnik • VITA In-Ceram ALUMINA Schlickertechnik • VITA In-Ceram ZIRCONIA Schlickertechnik
Indication / Material	Inlay/Onlay/ Partial crown	Veneer	Crown	Primary crown, crown, bridge
Glass ionomer	–	–	–	●
Composite	●	●	●	● [1]
Self-adhesive composite [2]	–	–	●	●
Compomer/resin modified glass ionomer [3]	–	–	–	–
cementation	–	–	–	–

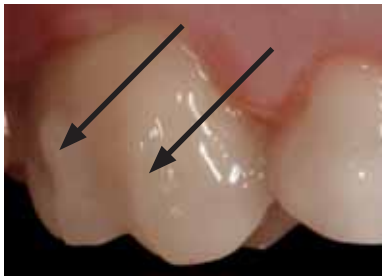
● = Indicated for adhesion

[1] We recommend to use PANAVIA 21 TC or PANAVIA F 2.0 (Kuraray) for In-Ceram crowns / bridges

[2] RelyX Unicem (3M Espe)

[3] Currently no significant scientific results on clinical long-term tests are available.

⚠ **Note:** For the adhesive cementation of etchable ceramic restorations made of fine-structure feldspar ceramic (VITABLOCS Mark II, TriLuxe/TriLuxe forte for CEREC/ inLab, VITA PM 9) the VITA LUTING SET (Art. no. FLSET) with working instructions no. 799E is available.



Fabrication of temporary restorations for non-retentive preparation types

Cementing temporary restorations for non-retentive preparation types represents a particular challenge.

A one-stage restoration procedure should be carried out because of biological reasons (protection of the dentine wound) and material-technical requirements. Preparation - intraoral picture - designing and milling the restoration - integration of the restoration in one session = one-stage restoration procedure.

.

The fabrication of temporary restorations always requires two-stage restoration procedures (preparation and integration are carried out in separate sessions).

In the case of two- or three-surface inlays, the use of plastic, light-curing materials, such as Fermit, has proved to be suitable.

Despite reduced retention, conventional temporaries (resin temporaries temporarily fixed using a eugenol-free cement) can be used.

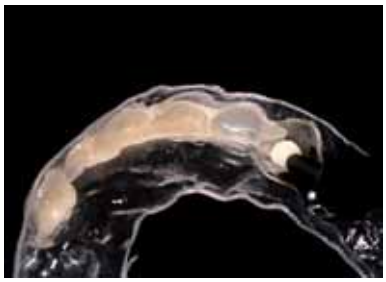
Entirely non-retentive preparation types cause problems in the field of onlays, partial crowns and veneers.

Onlay and partial crown

- Fabrication of the resin temporary
- Cleaning the surface of the tooth and placing the temporary on the unetched tooth using temporary cement or flowable composite
- Removing excess material
- Now the residual tooth substance is gradually etched in certain points and - starting from these small etched areas - strings of flowable composite are placed on the temporary (stripe-shaped pattern)
- 2 strings each are applied to the buccal and, if necessary, lingual area
- If required, undercuts can be fixed with flowable composite in the approximal area

Fabrication of temporary restorations for non-retentive preparation types
Due to minimally invasive preparation, a temporary restoration can be frequently omitted for veneers.

If a temporary restoration is required because of more complex preparation, it is recommended to fabricate the temporary using a previously produced vacuum formed template and light-curing composite materials.

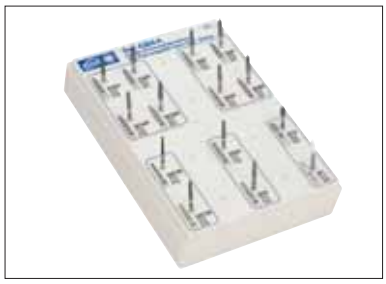


Cleaning teeth and preparations
- Do not etch or condition
- Composite in the vacuum formed template
- Remove excess composite carefully
- Light-curing

Removing the vacuum formed template
- Do not remove the temporaries from the teeth any more

The temporaries adhere perfectly for about 7-10 days and can be completely removed using a sharp scaler.

Preparation set for all-ceramics with guide pin instruments according to Dr. Julian Brandes. In addition to guide pin instruments for the shoulder preparation the set contains additional auxiliary instruments to cover the wide range of all-ceramic restorations (inlays, partial crowns, crowns and post build-ups).
(Komet/Gebr. Brasseler, Prod. No. 4410)*



Crown preparation set with guide pin instruments according to Prof. Günay. In addition to a range of standard instruments, the set contains various guide pin instruments and thus offers the suitable instruments for all processing steps of controlled chamfer preparation with defined cutting depth.
(Komet/Gebr. Brasseler, Prod. No. 4384 A)*

Preparation set according to Baltzer and Kaufmann with abrasives with axial guide pin for pre-defined preparation of chamfers and shoulders.
(Hager & Meisinger, Prod. No. 2531)**

Preparation set according to Küpper for crown and bridge restorations.
This preparation set allows to achieve the desired cutting depth in the area of the marginal preparation border almost automatically.
(Hager & Meisinger, Prod. No. 2560)**

Preparation set according to Arnetzl
Instruments require minimum widths and layer thicknesses of the ceramic and are supplied in the Intensiv Hygienic Tray
(Intensiv SA)***

Preparation set according to Arnetzl
(Hager & Meisinger)**

* Gebr. Brasseler GmbH & Co. KGH . Postfach 160H . 32631 Lemgo
Phone (+49 52 61) 701-0 . Fax (+49 52 61) 701-289 . www.kometdental.co.uk
** Hager & Meisinger GmbH . 41468 Neuss
Phone (+49 21 31) 20 120 . Fax (+49 21 31) 20 12 222 . www.meisinger.de
*** Tecdent HandelsgmbH Generalvertretung Österreich der Intensiv SA, Switzerland
A-2381 Laab im Walde . Phone (+43 22 39) 34 267 . Fax (+43 22 39) 34 268 . www.intensiv.ch

	Oxide ceramic					Fine-structure feldspar		
	Infiltration ceramic			Sinter ceramic				
	VITA In-Ceram SPINELL	VITA In-Ceram ALUMINA	VITA In-Ceram ZIRCONIA	VITA In-Ceram AL	VITA In-Ceram YZ	VITABLOCS Mark II	VITABLOCS TriLuxe/TriLuxe forte	VITABLOCS RealLife
	–	–	–	●	●	–	–	–
	○	–	–	–	–	●	○	–
	○	–	–	–	–	●	●	–
	–	–	–	–	–	●	●	●
	–	–	–	–	–	●	●	–
	●	● [1]	○	●	●	●	●	●
	–	●	●	●	●	–	–	–
 *	–	–	–	–	●	–	–	–
	○	● [1]	●	●	●	●	●	○
	–	–	●	–	●	–	–	–
 *	–	–	–	–	●	–	–	–
Veneering Material	VITA VM 7	VITA VM 7	VITA VM 7	VITA VM 7	VITA VM 9 VITA PM 9	VITA VM 9 **	VITA VM 9 **	VITA VM 9 **

● recommended ○ possible * maximum width: 2 pontics ** only for individualization

Material*		Glass infiltrated oxide ceramic			Polycrystalline oxide ceramic		Fine-structure feldspar
		VITA In-Ceram SPINELL	VITA In-Ceram ALUMINA	VITA In-Ceram ZIRCONIA	VITA In-Ceram AL	VITA In-Ceram YZ	VITABLOCS
CTE (25-500°C)	$10^{-6}\cdot K^{-1}$	7.7	7.4	7.8	7.3	10.5	9.4
Flexural strenght	MPa	400	500	600	550	> 900	150
Fracture toughness	$MPa\cdot m^{½}$	2.7	3.9	4.4	3.5	5.9	–
Modulus of elasticity	GPa	185	280	258	380	210	45
Average particle size	µm	approx. 4.0	approx. 3.0	approx. 3.0	approx. 2.0**	approx. 0.5**	–
Composition	wt.%	**Powder:** 100% $MgAl_2O_4$ **Structure:** 78% $MgAl_2O_4$ 22% infiltration glass	**Powder:** 100% Al_2O_3 **Structure:** 75% Al_2O_3 25% infiltration glass	**Powder:** 67% Al_2O_3 33% Ce-ZrO_2 **Structure:** 56% Al_2O_3 24% ZrO_2 20% infiltration glass	100% Al_2O_3	ZrO_2 5% Y_2O_3 < 3% Al_2O_3 < 1% SiO_2	56-64% SiO_2 20-23% Al_2O_3 6-9% Na_2O 6-8% K_2O 0.3-0.6% CaO 0.0-0.1% TiO_2

* The technical/physical values indicated are typical measuring results and refer to internal samples and measurements carried out with measurement equipment available on site. If samples are prepared using different methods and measurement equipment, other measuring results may be obtained.

** after sintering

The following products require hazard labelling:		
VITA CERAMICS ETCH **(hydrofluoric acid etching gel, 5%)**	**Caustic/Toxic** Toxic on inhalation, in contact with skin and if swallowed. Causes severe burns. Keep container tightly sealed at a well ventilated place. In case of contact with eyes, rinse thoroughly with water and consult a doctor. Wear suitable safety gloves and safety clothing. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). Keep away from living quarters. This material and its container must be disposed of as hazardous waste.	 
VITA ETCHANT GEL **(phosphoric acid etching gel, 35%)**	**Caustic** When using do not eat and drink. Do not inhale gas/fume/vapor/aerosol. In case of contact with eyes, rinse thoroughly with water and consult a doctor. When working with the product, wear suitable protective clothing, gloves and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). This material and its container must be disposed of as hazardous waste.	
Personal protective equipment	When working with the product, wear suitable safety goggles/face protection, safety gloves and safety clothing.	   

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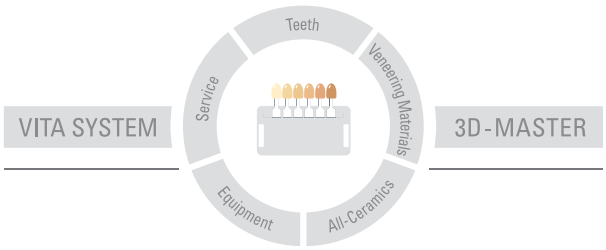

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