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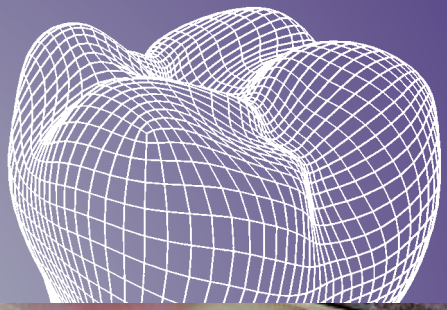
All-Ceramics at a Glance

Excerpt



3rd English Edition

Updated and enlarged Edition

An introduction to the indications, material selection, preparation and insertion techniques for all-ceramic restorations

agkeramik

Ceramics in Dentistry – the Success Story

Preface to the 3rd English Edition

Dear Reader,

In front of you, you have one of the most popular manuals in recent years on all-ceramic restorations. Initially in 2006 as a German edition, and appearing in English in 2007, this book has become an internationally established standard with editions in French, Japanese, Korean and excerpts in Chinese. Editions are used as study material at many universities. This competent and practical presentation of the importants aspects of all-ceramic restorations is well-regarded by experts and makes the book well worth a read.

This 3rd English Edition has been updated and expanded to encompass the rapidly advancing use of all-ceramic restorations, the development of new and improved ceramic materials and the optimisation of CAD/CAM technology. These advances have influenced treatment procedures worldwide. This is why leading scientific experts, together with practicing dentists, supported by ceramic manufacturers and developers, have reviewed findings from hospitals and practices as well as new publications and have included them in this manual.

The long-term clinical experience of the authors is fundamental to this book and forms an important basis for the predictability of treatment success. This compendium should be considered as a guideline which, in addition to knowledge of the robust fundamentals, should help clinicians optimise the outcomes of ceramic restorations.

Dr. Bernd Reiss
Chairman of the Board
Society for Dental Ceramics
Arbeitsgemeinschaft für Keramik in der Zahnheilkunde e.V.

Ceramics in Dentistry – the Success Story

Our gratitude goes to Professors Beuer, Edelhoff, Frankenberger, Kern, Kohal, Kunzelmann, Lohbauer, Mehl, Pospiech, Proebster, Reich, Rosentritt, Tinschert, Walther, Wolfart, to Dr. Hajtó, Dr. Wiedhahn and Mr Kern, Secretary of Society for Dental Ceramics, for their collaboration in producing this manual. Thanks to their contributions, the materials information and clinical content have been updated and expanded. For preparation of the 3rd English Edition of this book for English speaking professionals, the services of members of King's College London Dental Institute were secured. Our thanks also go to the many providers of illustrations for making the figures available.

Our goal for this edition remains: We want to set practical standards.

Dr. Bernd Reiss
D-Malsch

Prof. Van P. Thompson
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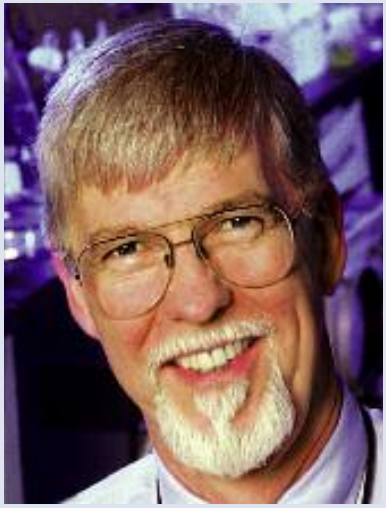
January 2017



Prof. Van P. Thompson
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PS: Due to popular demand, the publisher reprinted this edition in July 2018.
Corrections were made based on changes in the range of commercially available restorative materials and clinical cases were updated.

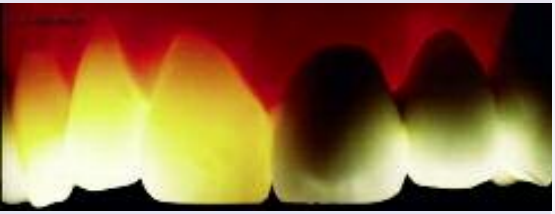
All-ceramics – customised, aesthetic and metal-free

All-ceramics is the term used for restorations consisting originally solely of porcelain and now may include different ceramics, without any metal support. Ceramics are abrasion resistant, have light-transmitting and light-diffracting properties, are absolutely colour stable, and enable an invisible transition of the restoration margin into the dental tissues. The materials are relatively insoluble and chemically inert in comparison with other restorative materials and this contributes to their higher level of biological compatibility. The ability to achieve a glazed or highly-polished surface finish also improves the biocompatibility of ceramic restorations. The durability of some ceramics exceeds even that of precious metal casting alloys. During the industrial manufacturing process, the mineral building-blocks of ceramics can be selected and adjusted to yield ideal optical properties, in order to reproduce in a restoration the full range of natural tooth shades.

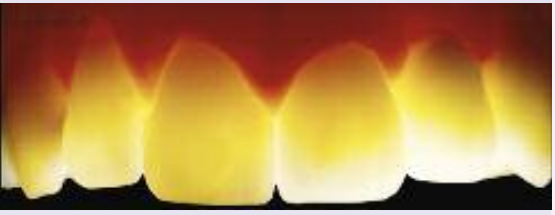
Characteristic properties of ceramics include brittleness and, when compared to metal, low flexural strength and fracture toughness. Ceramics are resistant to compressive stresses, but vulnerable to tensile forces. In dental treatment, ceramic restorations may require more attention to clinical detail in terms of both preparation design and insertion procedures. For a given indication, ceramics must be chosen carefully and anatomical requirements must be met. In the dental laboratory, careful attention to detail during fabrication is necessary, particularly when grinding the ceramic framework. Today, these challenges can be met with appropriate techniques. Systems proven by research are now available for fabrication and insertion. The low fracture-resistance of individual ceramic systems can be compensated for clinically by adhesive bonding to tooth structure.

All-ceramic inlays and onlays, laminate veneers, crowns, and FDPs (fixed dental prostheses) are gaining increasing popularity due to their excellent aesthetics and biocompatibility. To meet the high demands of mechanical loads in the oral environment, high-quality industrially prefabricated ceramics, which can be processed in CAD/CAM systems, are the first choice.

Restorations made industrially using prefabricated ceramics can be superficially customised and characterised. The advantages of ceramic blanks produced under standardised conditions are the higher material quality and increased fracture toughness compared to manually layered restorations.



This porcelain-fused-to-metal restoration created a shadow-effect which impaired light transmission and, thus the aesthetics.



Ceramic materials are translucent like the natural tooth. Crystals reflect incident light, direct the coloration into the deeper layers, and together with the veneering porcelain, provide the foundation for outstanding aesthetics.
Figs.: Edelhoff

Dental ceramics – structure and possibilities

Dental ceramics and their derivatives can be classified into the following groups:

- Ceramics with a glass phase: silicate glass-ceramics, glass infiltrated ceramics
- Ceramics without a glass phase: oxide ceramics (polycrystalline)
- Hybrid and composite ceramics with the addition of polymers.

As a rule, conventional dental ceramics consist of an amorphous, transparent glass phase in which the crystalline particles are distributed randomly. The following properties are attributable to the crystalline particles:

- Properties of light scattering and translucency in the transparent glass phase
- Consequent adaptation of the shade to the tooth
- Stability whilst firing (sintering)
- Control of the coefficient of thermal expansion
- Final strength under functional load in the mouth.

The crystals influence the aesthetic appearance and the stability of the ceramic. Its stability is determined by a high crystal content, the dense and homogeneous particle distribution and the bond between the crystals and the glass matrix. Increasing the strength causes a loss of translucency and as a result, a loss of aesthetic qualities.

The difference with polycrystalline ceramics is that a distinct improvement in strength and fracture toughness has been achieved by increasing the crystal proportion and elimination of the glass phase. Because of the opacity that results, they can be used only as framework material and must be veneered as in the case of metallic frameworks. Newer, translucent oxide ceramic (zirconia) can be coloured and used for veneer-free crowns and FDPs.

Silicate ceramics

- A naturally or synthetically-produced feldspathic glass matrix with included crystals (leucite, lithium disilicate).
- Indications:
  Inlays, onlays, veneers, partial crowns, single crowns in the anterior region. Additionally, lithium disilicate and zirconia-reinforced lithium silicate can be used for single crowns in the posterior region, small 3-unit FDPs in the anterior or pre-molar region, implant-supported crowns, hybrid abutments or hybrid abutment crowns and occlusal veneers (table tops).
- Properties:
  Light-transmitting, they adapt to the surrounding shade (chameleon effect)
  Plaque repellent
  Additionally with lithium disilicate and zirconia-reinforced lithium silicate – higher strength (360 – 420 MPa)

This all-ceramic restoration has been integrated inconspicuously into the patient's mouth.
Fig.: Reichel

- Processing:
  Shaping in the plastic condition (pressable ceramics)
  Strengthening by firing in the furnace
  As an alternative, computer-controlled milling from industrially-prefabricated ceramic blocks
  Shading by staining or veneering (cut-back method)
  Dimensionally stable on firing.

Oxide ceramics

- Purely crystalline matrix of aluminium oxide (Al_2O_3) or zirconium oxide (ZrO_2)
- Crystalline structure consisting of semi-highly transparent zirconia for veneer-free, monolithic crowns
- Indications:
  ZrO_2: Frameworks for single crowns in the anterior and posterior region, frameworks for fixed dental prostheses in the anterior and posterior region, implant abutments (anterior), primary crowns for telescopic crown technique, fully anatomical crowns and fixed dental prostheses
- Properties:
  White to opaque, negligible light-transmission, plaque-resistant
- Processing:
  Al_2O_3: Computer-controlled milling of industrially produced, densely sintered blocks
  ZrO_2: Computer-controlled milling of industrially produced blocks in the pre-sintered (green) or in the densely sintered condition, final sintering of the pre-sintered frameworks in the sintering furnace, shrinkage of the framework (approx. 20 percent) after final sintering
  Optional framework staining with dentin shade for thin veneer layers
  Customising by veneering
  In the case of fully anatomical crowns and FDPs, surface polishing in conclusion.

Hybrid and resin ceramics

- Framework of silicate ceramic, with polymer infiltrated (Hybrid) or polymer matrix consisting of silicate or zirconia nanoparticles (composite). Composite not etchable with HF.
- Indications:
  Inlays, onlays, partial crowns, monolithic single crowns, endo crowns, occlusal veneers for increasing vertical dimension, implant supported crowns

- Properties:
  Lower modulus of elasticity, damping of chewing forces under load.
- Processing:
  Shaping through computer controlled, subtractive milling
  Hybrid ceramics: can be etched with hydrofluoric (HF) acid like silicate ceramics
  Composite ceramics: cannot be etched with HF
  Sandblasting of the adhesive surface with alumina particles.

Optical properties

The optical properties of glass-ceramics (translucency, light reflection) are similar to those of the tooth structure. It is therefore the material of choice for reconstructions in aesthetically sensitive regions such as the anterior teeth.

The translucency of the ceramic influences its aesthetic appearance decisively. It depends upon the thickness of the material. If a non-vital, discoloured dentin core is to reconstructed with all-ceramics, a larger amount of space must be created for the glass-ceramic. High strength ceramics (oxide ceramics) are more opaque because of their crystalline structure. The different optical properties must be considered according to localisation, dentin core colour and the space available. To be able to restore conservatively and yet with all-ceramics, a more opaque oxide ceramic (e.g. ZrO_2) can be selected.

An alternative restorative material available for masking discoloured cores is opaque lithium disilicate ceramic.

Overview of dental ceramic systems

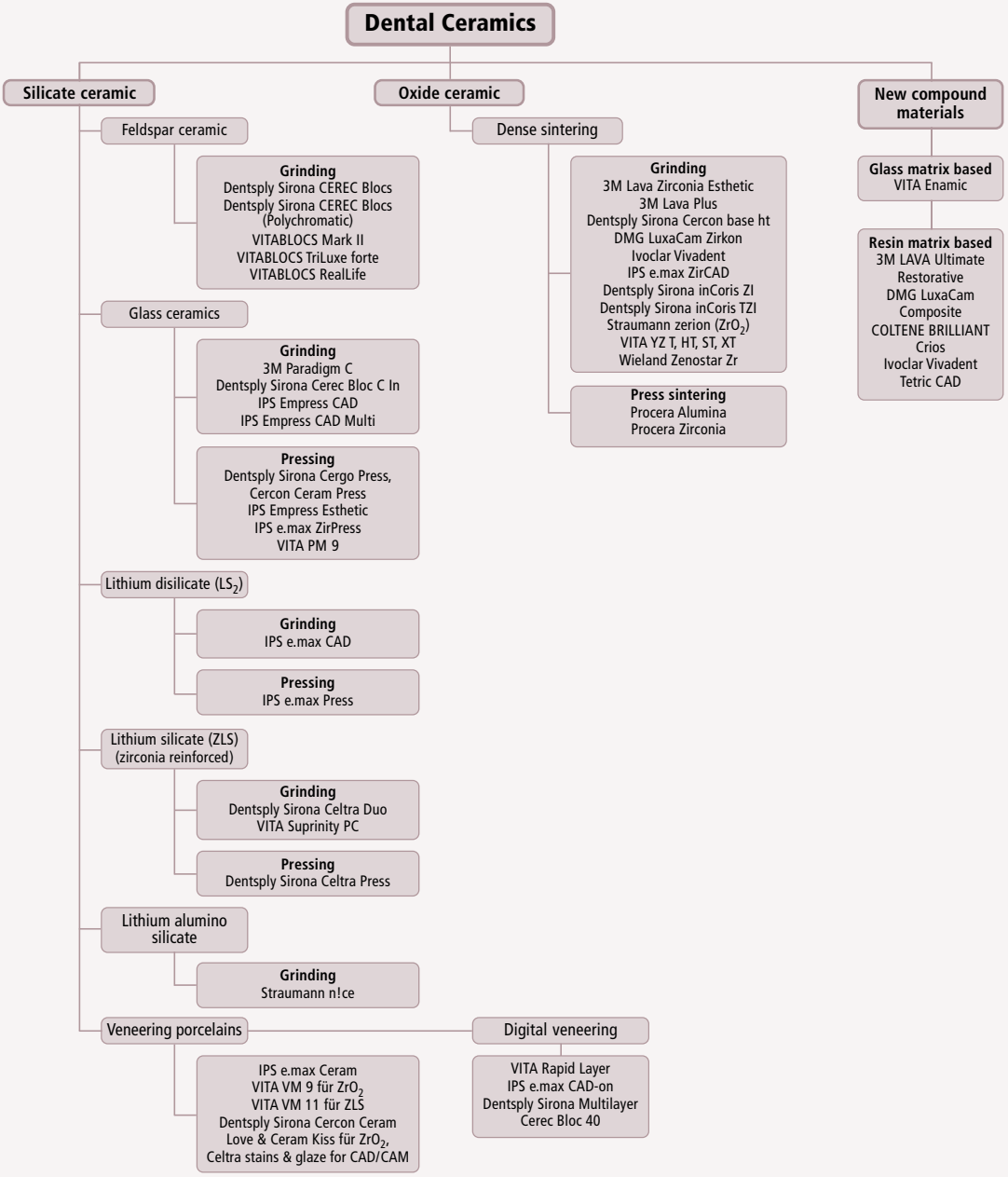


Fig.: AG Keramik

The Clinical Use

Initial condition for semi-invasive veneers: Exposed tooth cervices, insufficient composite fillings, severely aged teeth with a minimal overbite can be treated with veneers.

Teeth 13 – 23 and 33 – 43 have been restored with lithium disilicate veneers.
Figs.: Hajto

General considerations

The following pages offer a practical guide for all clinical and technical considerations which affect material selection for all-ceramic restorations.

The following points must be considered when selecting the type of ceramic that is appropriate for the treatment planned for different clinical indications:

- Which restorations are intended?
- How extensive is the loss of tooth structure or that compromised by the carious lesion?
- Where will the preparation finish-line be placed?
- Are single-tooth restorations or fixed dental prostheses required?
- Are the restorations in the anterior or posterior segments?
- Are there signs of parafunctional occlusal habits and bruxism?
- How are static and dynamic occlusal loads distributed?
- Is the restoration to be adhesively bonded or conventionally cemented?
- Is the occlusal scheme to be changed?
- Are there any discolourations of the dental tissues that have to be masked or concealed?
- What degree of transparency and translucency do the natural teeth possess?
- How much of the tooth and gingival margins is visible?

The broad range of possibilities offered by the currently available all-ceramic systems make it necessary to perform meticulous examination, diagnosis and treatment planning before beginning treatment, because the preparation, fabrication, function and longevity of the restoration depend on these. Physical and anatomical conditions have to be taken into consideration, as well as the desires and goals of the patient.

All-ceramic inlays, onlays, and posterior partial-coverage crowns

Indications

All-ceramics are suitable for treating all acquired defects and replacing missing tooth structure of single teeth.

The use of rubber-dam to control moisture is highly recommended for placing inlays and partial crowns with adhesive bonding systems.

In contrast to conventional direct restorations and metallic partial coverage crowns, the advantage of adhesive bonding to enamel is that even thin, structurally-compromised cusps do not necessarily have to be covered.

For the following clinical scenarios, all-ceramic restorations should not be considered:

- Extremely shallow and narrow cavities where the physical properties of the porcelain are inadequate. As an alternative, consider extended fissure sealing and the use of a direct composite-resin restoration.
- If moisture control cannot be maintained.
- Given bruxism or suspected parafunctional habits and a suboptimal occlusal relationship, an occlusal heat-processed acrylic resin night guard appliance to protect the teeth should be considered.

Silicate ceramics (glass/feldspathic ceramics) are the material of choice for ceramic inlays, onlays and partial-coverage crowns, because they can best mimic dental enamel. Such restorations must be adhesively luted.

Shade selection

- Shade determination must be performed prior to preparation of the tooth. If there are amalgam fillings present, the shade should be determined after removal of the amalgam (see page 109).

Preparation design

The following features should not be included in the preparation design for adhesively-bonded all-ceramic restorations:

- Bevels
- The necessity of dentin to support overlying enamel
- Extensive retention forms.

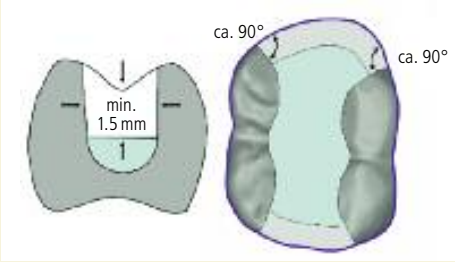
Enamel margins are not absolutely necessary. Nevertheless, it must be possible to keep the cavity margins at or below the gingival margin dry during the adhesive placement of the inlays. Subgingival margins can cause problems in achieving a durable dentin-composite bond and can be problematic in removing excess composite-resin cement after seating and polymerisation.

Inadequate amalgam fillings, tooth 25 and 26.

The situation following appropriate tooth preparation to create extensive cavities yet preserve the residual cuspal walls. Resin-bonded ceramic inlays are envisaged for stabilising the cusps.

CAD / CAM fabricated zirconia-reinforced lithium silicate inlays (Celtra Duo, Dentsply) following adhesive luting and polishing.
Figs.: Zimmermann / Mehl

All-ceramic inlays, onlays, and posterior partial-coverage crowns



Preparation design for ceramic inlays.
The isthmus width and thickness should be not less at least 1.5 mm occlusally. At the preparation finish-line, care should be taken to create a nearly perpendicular transition to the tooth surface (ca. 70 – 110°).
Fig.: Mehl

Residual tooth structure with extensive cavities. Cuspal coverage is planned with adhesively bonded ceramic inlays.

Inlays made of pressed ceramic on the master cast.
Figs.: Mehl

The use of the adhesive techniques makes it possible to create largely defect-oriented, tooth structure-conserving preparations. Occlusal contacts near inlay finish-lines should be avoided.

With more durable ceramics, e.g. lithium disilicate, the minimum values in the figure (see left) can be further reduced (always follow manufacturer's instructions). In vitro fatigue simulations suggest that even inlays with a thickness of 0.8 mm will survive extensive fatigue loads (100 N, 1 million cycles).

The cavity design for an indirect restoration should fulfill the following requirements:

- Opening angle of the cavity wall not more than 6°, diverging towards the occlusal surface (facilitates easier technical and clinical processing)
- The isthmus of an inlay preparation should be at least 1.5 mm in width and depth for adequate strength. The following three recommendations are very traditional, yet still accepted safety measures which even work with weakly sintered silicate ceramic inlays. The measures will be revisited for more recent, stronger ceramic materials like lithium disilicate or zirconia-reinforced lithium silicate in order to preserve more tooth tissue
- It is not necessary to extend the preparation proximally far enough to break the interproximal contacts in order to ease the removal of excess luting composite if the marginal adaption of the ceramic inlays is good. However, the indication of ceramic inlays suggests that the cavities are already wide enough to have eliminated the proximal contacts before preparation
- Rounded internal line angles between the preparation axial walls and pulpal floor
- The minimum occlusal thickness should be 1.5 mm at the deepest point of the central fossa. Exception: 1.0 mm of thickness occlusally is sufficient for lithium disilicate ceramic
- Extensions of the approximal anatomy of the restoration to achieve interproximal contact should not exceed 1.5 – 2.0 mm
- The cavosurface margin should be a butt joint (90°) at the transition between the restoration and the tooth structure (this maximises the resistance form of marginal areas)
- Complete cuspal coverage may not be necessary
- Finishing of the cavity walls with rotary diamond instruments of 25 – 40 µm grit
- If necessary, use reciprocating, safe-side oscillating diamond files interproximally (mechanically or ultrasonically driven)
- Do not leave any enamel extensions.

The preparation design requirements for onlays and posterior ceramic partial-coverage crowns are:

- Material thickness of at least 1.5 mm, an exception being lithium disilicate where 1 mm minimum thickness suffices
- An isthmus for improving retention is not necessary
- Internal edges and line angles must be rounded
- No long, branching cavity margins
- Axial remaining wall thicknesses should be at least 1.5 mm
- Strive for a box preparation with an internal 90° rounded shoulder
- Chamfer preparations with slightly sloped shoulders are acceptable in some situations.

Preparation design of non-vital teeth:

- The same preparation design as for inlays and partial-coverage crowns. In order to obtain additional adhesive areas, the pulp chamber can be included into the preparation (= endo-inlay design).

The provisional restoration – an additional procedure

Depending upon the construction method chosen, a provisional restoration of the cavity may be necessary. If the restoration is made chairside, i. e. using a CAD / CAM system (for instance, Cerec), in one appointment, a provisional restoration is not needed.

Provisional restorations should not be made of semi-plastic materials, but of mechanically stable Bis-GMA or PMMA resin.

Impression taking

- The 'impression' is taken directly in the patient's mouth using a 3D intra-oral camera when using a chairside CAD / CAM system
- Labside fabrication requires a conventional impression for making the dies and for the indirect procedures necessary for fabricating the restoration by the dental laboratory.

Laboratory procedures

The following steps are performed for inlays and partial-coverage crowns:

- Shade selection, determination of customised colouration (shade mapping)
- Fabrication of master cast: type IV dental stone, dentin-coloured composite resin or ceramic stump are used (only for feldspathic ceramics)

Ceramic inlays after 9 years in situ.
Fig.: Mehl

Cuspal coverage with a conservative partial coverage crown.
Fig.: Kunzelmann

All-ceramic inlays, onlays, and posterior partial-coverage crowns

Preparation of a partial-coverage crown for an endodontically treated tooth.

Master cast with defined crown finish-line.

Adhesively bonded partial-coverage crown on an endodontically treated tooth.
Source: Krekel/Kunzelmann

- Use of die spacer for cement spacer (in CAD/CAM milling, the software performs this step)
- Strict observance of manufacturer recommendations for wall thickness to prevent internal stresses and cracking, and avoidance of air entrapment and surface defects during fabrication are essential for the longevity of the restoration
- Coordinating of occlusal concepts with the dentist to minimise the time required for occlusal adjustments on the restoration by grinding, including adjustment of the opposing dentition
- Fitting the interproximal contacts on an unsectioned, duplicated cast.

Chairside procedures

For inlays and partial-coverage crowns made chairside, CAD / CAM technology performs the following steps:

- The restoration is designed on the screen with strict observance of the manufacturer's recommendations on layer thickness to prevent stresses and cracking; the occlusal concept is followed to ensure minimal grinding for adjustments
- Automatic milling of the full-contour restoration
- Removal of the milling peg and polishing or glaze firing.

Insertion procedure

- Try-in of the ceramic restoration without pressure and without occlusal check
- Check the interproximal contacts and marginal fit with silicone (low viscosity) fit checker or powder disclosing agent
- Check the shade with glycerol gel or try-in pastes
- Ensure complete removal of residual try-in agents and completely clean the tooth and restoration after try-in
- Provisional evaluation with the use of provisional cement is not required
- Moisture control (rubber-dam) is highly recommended when using composite-resin cements for adhesive bonding as it facilitates moisture control even during a lengthy luting session of several inlays / crowns
- Etch and condition the restoration with hydrofluoric acid (HF) and silane only shortly prior to insertion (chairside)
- Apply silane (follow manufacturer's instructions), blow dry
- Etch and condition the cavity

- Apply dentin adhesive which ensures polymerisation of the resin cement
- Insert the restoration with composite-resin cement
- Apply glycerol gel before curing
- Remove excess composite-resin cement prior to removing the rubber-dam
- Check occlusion and adjust as required on the luted restoration
- Polish the adjusted areas.

The adhesive bonding process is described in detail in Chapter "Luting Techniques", page 111 – 127.

Trimming and polishing

- Check, adjust and re-check occlusion
- Remove excess composite-resin cement, use rotary diamond finishing instrument and finishing strips (40 µm, 25 µm, 10 µm)
- Polish the adjusted areas
- Apply fluoride varnish to etched enamel surfaces.

Final steps

- Check for excess cement
- Check the occlusion
- Final polish of the restoration
- Fluoridation of the surface enamel
- Schedule a recall appointment with the patient (dental prophylaxis).

The CAD / CAM technique enables automatic milling of the full-contour restoration in 10 – 15 minutes.
Fig.: Dentsply Sirona

Adhesive luting of the restoration requires conditioning of the enamel and / or the dentin and the ceramic surface, the latter with HF acid.
Fig.: Frankenberger

Literature:

Frankenberger R, Mörig G, Blunck U, Hajto J, Pröbster L, Ahlers MO: Präparationsregeln für Keramikinlays und -Teilkronen. Teamwork J Continuing Dent Education 10, Heft 6 (2007)

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Pröbster L, Groten M: Keramikinlays, der konservative Ansatz. Quintessenz 61, 597-605 (2010)

Partial-coverage crowns made without a cast semi-chairside by Cerec Omnicam and MCXL milling unit

Fig. 1: **These amalgam fillings are to be replaced as part of raising the bite.**

Fig. 2: **Preparations for all-ceramic partial-coverage crowns.**

Fig. 3: **Anterior cross-bite: buccal view with the bite registration placed on the left of the mouth to raise the bite. Shows the situation for registering the bite buccally.**

Fig. 4: **The bite registration fabricated on an articulator for raising the bite.**

Fig. 5: **Virtual 3D model of the preparations based on the intraoral scan taken with an Omnicam (Sirona).**

Fig. 6: **CAD fabricated partial-coverage crowns created with biogeneric software (Cerec SW 4.2).**

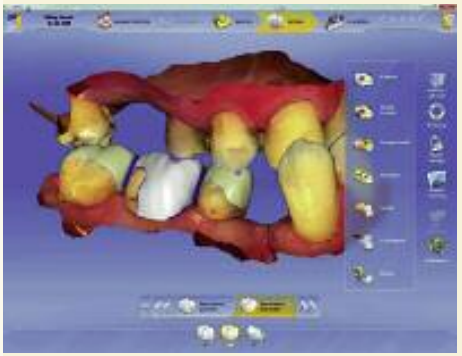


Fig. 7: **CAD fabricated partial-coverage crowns taking the new bite into account.**

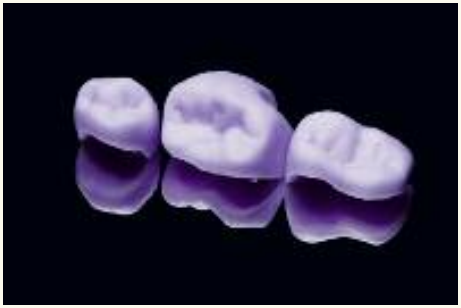
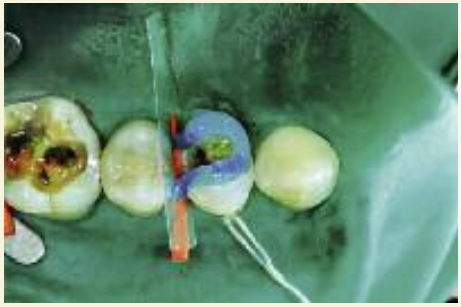


Fig. 8: **Ground partial-coverage lithium disilicate crowns (e.max CAD LT, Ivoclar Vivadent) in their blue state prior to crystallisation firing.**

Fig. 9: **Resin-bonded partial-coverage crowns.**
Figs.: Bindl

Amalgam fillings to be replaced with ceramic inlays.



Etching the cavity margins with phosphoric acid.
Figs.: Kunzelmann

Procedure for restoring a cavity with a ceramic inlay – step by step

Treatment step	Helpful hints	Instruments / materials
Caries diagnostics	Repeat after removal of existing fillings	Mirror, diaphanoscopy (FOTI), optical procedure (e.g. Diagnocam), bite-wing radiographs
Shade selection	Moist tooth, natural light, no bright colours like lipstick	Proprietary shade guide of the composite system (or Vita Color Ring)
Impression taking for provisional restorations	For indirect manufacture, correct provisionals if needed	Tray, impression material
Marking occlusion points	Avoid placing preparation margins in occlusal contact areas	Occlusal papers (12 µm), e.g. Hanel paper
Placement of wedges	Warning: do not injure gingival papillae or damage adjacent teeth during preparation	Wooden wedges
Preparation, caries excavation	Minimum cavity depth according to the intended inlay material (details see text)	Carbide round bur, preparation diamonds (80 µm), finishing diamonds (40 µm), Sonicsys ceramic inlay abutment
Cavity cleaning	Disinfection	CHX (0.2%)
Treating the dentin lesion (cp), when needed	If dentin is exposed close to the pulp (<1 mm residual dentin thickness)	Apply calcium hydroxide compound – aqueous Ca (OH_2) suspension (e.g., Calicur, Calxyl)
Base	Shallow cavities: no base; deep cavities: cover with base or partially block	Adhesive base, dentin adhesive and flowable composite
Finishing the cavity	"Rounded" inner edges; no bevelled edges as the ceramic will break there; no thinly attenuating marginal areas, Soflex disks occlusally if needed	Finishing diamonds (25 µm), perhaps intra-Eva head (61 LA) and Eva files (cavisshape, bevelshape: 25 µm) or Sonicsys (mini: torpedo attachment)
Elastic impression: first fill tray, then inject, block out FDPs in same jaw	Try in mouth tray, block off distally, occlusal stops, if needed block large undercuts (FDP units), observe manufacturer's curing time!	Already prepare tray (stops); select based on situation model; elastic impression tray or hydrocolloid stick to individualise retraction cords, cord inserting instrument or Heidemann spatula, elastic impression material
Facebow, occlusal record	Where occlusal situation is ambiguous or extensive restorations exist, e.g., serial inlays	Facebow set, recording impression silicone
Elastic impression of opposing jaw	Already possible previously	Elastic impression tray, alginate
Construction and insertion of provisional restoration	Isolate cavity, block cervical undercuts, air-bubble-free injection of provisional material into total impression using a syringe, observe manufacturer's curing time! Check occlusion, determine temporary's layer thickness to check preparation depth, insert with eugenol-free cement	Especially where periodontally diseased dentition exists, total impression, preferrably vacuum-drawn heat-treated polyvinyl, paraffin oil, Protemp II, Provicol, milling cutter + laboratory handpiece, occlusal papers, paper holder

Procedure for restoring a cavity with a ceramic inlay – step by step

Treatment step	Helpful hints	Instruments / materials
Removal of provisional restoration	Do not damage cavity margins	Claw forceps, scaler
Tooth cleaning		Polishing paste (e.g. Zircate), polishing cup or brush
Inlay try-in	No occlusion check, just check fitting accuracy and approximal contacts (perhaps with wedging)	Dental floss, loupes; if needed "softprobe" and fine diamond abrasive tips, provoke no bleeding
Rubber-dam placement	When using clamps, do not injure tooth or gingiva	Rubber-dam sheet – medium; frame, if needed clamps and forceps, wedjets (expensive), alternatively: rubber tabs
Adhesively pretreat inlay (etch, silanize, bond)	Etch ceramic inlays with HF according to the intended inlay material, i.e. 60 s for silicate ceramic, 20 s or lithium disilicate ceramic, 30 s for zirconia-reinforced lithium silicate; dilute or neutralize HF before disposal; let silane solvent evaporate (5 min); do not cure dentin bonding agent (DBA)	HF (e.g., Vita Ceramics Etch), silane solution (e.g., Monobond Plus), bonding agent (see DBA), brush, receptacle for solutions, diamond-coated tweezers, application instrument, e.g. OptraSticks
Pretreat tooth (etch enamel and / or enamel and dentin, dentin adhesive and bonding agent)	Strictly follow manufacturer's instructions; touch primer and monomers only with a brush, recommended etching times with phophoric acid in case of selective or total etch: enamel 30 s, dentin 15 s	Phosphoric acid and application syringe, dentin adhesive and bonding agent, several brushes or applicators
Mix and apply luting composite	In deeper defects use only dual-curing composites; adapt luting composite to all cavity walls with a spatula	Luting composite, spatula, block
Insert inlay	Carefully press in inlay into definitive position	Diamond-coated tweezers, OptraStick
Remove excesses	Very carefully check for excesses approximally	Dental floss, scaler, loupes
Apply glycerine gel	Necessary if excesses are completely removed before curing	Glycerol gel, e.g. LiquidStrip, Airbloc gel, application syringe
Light curing	At least 40 s from each side	Polymerization lamp, perhaps protective eyewear
Remove rubber-dam	Check to ensure no bits of rubber-dam remain	Rubber-dam clamp forceps, if needed scissors or dental floss, scaler
Probe gingival sulcus	Cured excesses of DBA often remain otherwise overlooked in the sulcus, despite rubber-dam	Scaler / curette
Occlusion check	Also check latero- and mediotrusion	If needed fine-grain diamond instrument
Polishing	Do not treat adhesive joint with abrasive polishing paste, otherwise groove-like abrasions form	Polish adhesive joint areas with alumina disks (Soflex), ceramic surfaces if needed with diamond polishing paste or ceramic polisher
Fluoridation	Because of its color, Duraphat is a psychological disadvantage	Elmex fluid or Fluorprotector
Follow-up	Check restoration again a few days later; excesses are then easier to see	Mirror, probe, loupes

Insertion of a ceramic inlay with removal of excess luting cement.

Ceramic reconstruction of teeth 44 – 46.
Figs.: Kunzelmann

Treatment of general tooth defects with occlusal veneers by raising the vertical dimension of occlusion

Fig. 1: **Initial condition: General abrasions with biocorrosive components (exogenic causes) on all maxillary teeth.**

Fig. 2: **The corresponding initial condition in the mandibular dental arch.**

Fig. 3: **Areas of palatal destruction and insufficient composite fillings.**

Fig. 4: **Measuring the increase in occlusal vertical dimension on a diagnostic wax-up. The diagnostic wax-up had been previously successfully tried into the patient's mouth for the so-called aesthetic evaluation.**

Fig. 5: **Following this, the occlusal vertical dimension data from the wax-up are transferred to the initial model, articulated in centric relation, for fabricating a repositioning splint.**

Fig. 6 **Shows the repositioning splint with anterior / canine guidance fabricated according to the increase in occlusal vertical dimension set with the wax-up and intended for remaining in situ for approx. 3 months ("functional evaluation").**

Fig. 7: **Following evaluation of the occlusal vertical dimension, it can be transferred during the tooth preparation session using the repositioning splint. First the 1st and 4th quadrants are prepared, the splint sectioned and one half of it placed on the as yet unprepared teeth in the 2nd and 3rd quadrants. The sectioned splint can be used as a reference for determining the jaw relation in the tested occlusal vertical dimension. At a later stage, the teeth in the 2nd and 3rd quadrants are also prepared and the jaw relation determination prolonged.**

Fig. 8: **The maxillary master model for the bite raising, functionally-corrective restorations.**

Fig. 9: **The posterior wax-ups (staining technique = monolithic) and anterior crown frameworks (layering technique = built up by hand).**

Fig. 10: **Labial view of the frameworks for the maxillary anterior crowns.**

Fig. 11: **Pressed lithium disilicate (IPS e.max Press) crown frameworks.**

Fig. 12: **Monolithic onlay veneers (bicuspids) and onlays (molars) after pressing on the lower model. The veneers on the canines were sintered onto refractory dies. Once the glass-ceramic restorations have been placed, anterior teeth 32 – 42 are built up with composite.**

Figs.: Edelhoff, Brix

Continued on page 48

Ceramic occlusal surfaces

Continued from page 47

Fig. 13: **The finish-lines were placed in enamel for occlusal veneers (canines) and onlays (molars).**

Fig. 14: **Monolithic lithium disilicate ceramic occlusal surfaces (IPS e.max Press, high translucency, minimum thickness 1 mm).**

Fig. 15: **Occlusal veneers adhesively bonded using the total etch technique.**

Fig. 16: **The maxillary situation after adhesive bonding.**

Fig. 17: **The mandibular situation after adhesive bonding.**

Fig. 18: **Occlusal veneers in perfect clinical condition 6 years post placement.**

Fig. 19: **Anterior view prior to treatment.**

Fig. 20: **Anterior situation post treatment – the vertical dimension has been adjusted.**

Figs.: Edelhoff, Brix

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Navigation of luting all-ceramic restaurations

Ceramic	Silicate		Lithium disilicate (LS_2)			Polycristalline oxide ceramic		
Brand name (selection)	Vitablocs Empress Cerec Blocs		e.max Press / e.max CAD			Procera, e.maxZirCAD, Lava, Dentsply Sirona inCoris, Dentsply Sirona inCoris ZI, Vita YZ		
Indication	Inlay, onlay, veneers, crowns		Crowns, inlay, veneers small fixed partial dentures (1)			Crowns, FDPs		
Luting material	Adhesive composite, light / dual-curing	Self-adhesive composite light / dualcuring (without veneer)	Glass ionomer	Adhesive composite	Self-adhesive composite	Glass ionomer	Adhesive composite self-curing	Self-adhesive composite
Brand name (selection)	Variolink 2, Bonder RelyX Ultimate	Rely X Unicem	Ketac-Cem	Multilink Automix Panavia F 2.0 RelyX Ultimate	RelyX Unicem	Ketac-Cem	Multilink Automix Panavia F 2.0 RelyX Ultimate	RelyX Unicem
Ceramic pretreatment	Hydrofluoric acid 60 s, silane, bonding agent	Hydrofluoric acid 60 s, silane	Hydrofluoric 20 s	Hydrofluoric 20 s, silane, Bond	Hydrofluoric 20 s, silane	Sand-blasting	Sandblasting (2) Zirkonia Primer	Sandblasting (2) Zirkonia Primer
Tooth pretreatment	Enamel-etching, dentin adhesive (light curing)	Cleaning Self-adhesive, selective etching on unprepared enamel recommended	Polyacryl acid	Dentin adhesive	Cleaning Self-adhesive, selective etching on unprepared enamel recommended	Polyacryl acid	Dentin-adhesive bond dry!	Cleaning Self-adhesive, selective etching on unprepared enamel recommended
Helpful hints	Rubber-dam Dry			Dry	Scotchbond Universal contains primer and silane	No phosphoric acid for cleaning ZrO_2 with zirconia primer if luting adhesively is intended.		

Inlays and veneers made of silicate and lithium disilicate must be luted adhesively.

Observe the manufacturer's instructions absolutely.

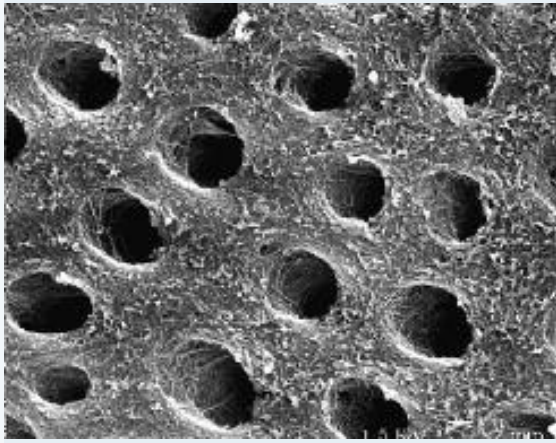
(1) Anterior teeth up to the 2nd premolar. FDPs up to 3 units.
(2) Sandblast after try-in. Corundum (Al_2O_3) single-use sandblasting, grit size 50 µm, pressure 1.0 – 2.5 bar. Monobond Plus or Rocatec system.
Self-adhesive luting composites require no enamel etching with phosphoric acid on the tooth and no additional adhesive. The bond to enamel and dentin is achieved by special monomers that are part of these composite-resins.
Adhesive luting composites require the enamel and dentin to be etched, then application of an adhesive to occlude the dentinal tubules.

Adhesive luting step-by-step

The following techniques – with various numbers of steps – for the adhesive luting of ceramic restorations are currently used in practice:

1. Three-step selective etching technique (without exposed dentin, e.g. veneers)
(e.g. with Syntac, A.R.T. Bond, Gluma Solid Bond, OptiBond FL, Adper Scotchbond Multi-Purpose Plus)

Procedure	Duration (min : sec)
Remove temporary and clean cavity	02:00
Rubber-dam	05:00 – 10:00
Check fit of the restoration	01:00 – 10:00
Pretreatment of inlay with HF, silane and bonding agent (air thin)	03:00 – 08:00
Etch enamel (30 s) from periphery to centre	00:30
Rinse 30 s	00:30
Dry to visualise etching pattern	00:10
Apply primer, allow to work or scrub	00:20 – 00:30
Active drying to evaporate water in primer	00:10
For Syntac: apply and dry adhesive	00:10
Apply bonding agent, scrub (short period) remove operator light, air thin	00:15
Dual-curing bonding agents are advantageous	
Do not use light-curing bonding agent	
Apply luting composite	00:15
Insert inlay and place in final position, remove excess and cover margins with glycerol gel	03:00
Photopolymerisation	02:00
Remove excess with scaler	00:30
Finishing with super-fine grit diamond instrument and finishing strips	05:00
High lustre polish to remove microcracks and prevent fractures	05:00
Apply fluoride	00:30

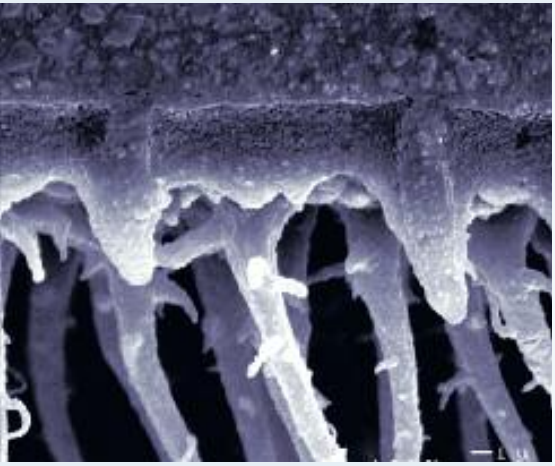


Dentinal tubules with collagen network exposed after acid etching and left moist.
Fig.: Frankenberger

Working steps
for strong bonds

2. Three-step selective etching technique (with exposed dentin)
(e.g. with Syntac, A.R.T. Bond, Gluma Solid Bond, OptiBond FL, Adper Scotchbond Multi-Purpose Plus)

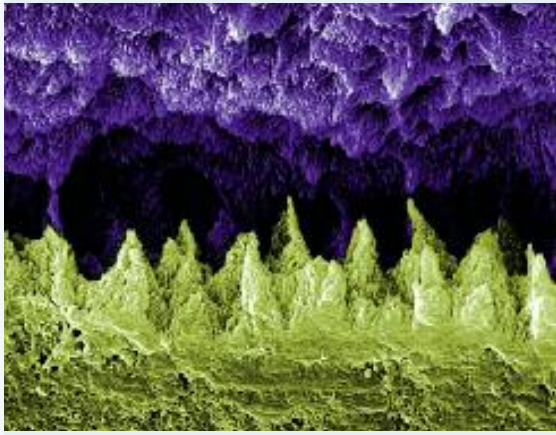
Procedure	Duration (min : sec)
Remove temporary and clean cavity	02:00
Rubber-dam	05:00 – 10:00
Check fit of the restoration	01:00 – 10:00
Pretreat inlay with HF, silane and bonding agent (air thin)	03:00 – 08:00
Apply phosphoric acid (enamel 30 s, dentin 15 s) from periphery to centre, dentin never > 15 s	00:30
Rinse 15 s	00:30
Dry to visualise etching pattern	00:10
Apply primer, scrub in	00:30
Dry primer	00:05
Apply bonding agent, scrub in (briefly) remove operator light, air thin	00:15
Dual curing bonding agents are advantageous	
Do not use light-curing bonding agent	
Apply luting composite	00:15
Insert inlay and place in final position, remove excess and cover margins with glycerol geln	03:00
Photopolymerisation	02:00
Remove excess with scaler	00:30
Finishing with super-fine grit diamond instrument and finishing strips	05:00
High luster polish to remove microcracks and prevent fractures	05:00
Apply fluoride	00:30



Resin tags formed by monomer penetration into dentinal tubules exposed by acid etching.
Fig.: Frankenberger

3. Two-step total-etch technique (with or without exposed dentin)
(e.g. with Gluma Comfort Bond, Prime&Bond NT, Excite, OptiBond Solo Plus, Scotchbond Universal)

Procedure	Duration (min : sec)
Remove temporary and clean cavity	02:00
Rubber-dam	05:00 – 10:00
Check fit of the restoration	01:00 – 10:00
Pretreatment of inlay with HF, silane and bonding agent (air thin)	03:00 – 08:00
Apply phosphoric acid (enamel 30 s, dentin 15 s) from periphery to centre	00:30
Rinse 30 s	00:30
Aqueous primer-adhesive:	
Dry to visualise etching pattern	00:10
Acetone / alcohol-based systems:	
Dry to visualise etching pattern, re-wet exposed dentin with micro brush and water	00:05
Re-apply primer-adhesive	00:30
Aqueous primer-adhesive	
Active drying to evaporate water in primer	00:15
Acetone / alcohol-based systems:	
Solvent is more volatile – therefore requires less air thinning	00:05
Dual curing bonding agents are advantageous!	
Do not use light-curing bonding agent	
Apply luting composite	00:15
Insert inlay and place in final position, remove excess and cover margins with glycerol gel	03:00
Photopolymerisation	02:00
Remove excess with scaler	00:30
Finishing with super-fine grit diamond instrument and finishing strips	05:00
High luster polish to removel microcracks and prevent fractures	05:00
Apply fluoride	00:30



Etched enamel relief.
Fig.: Frankenberger

Working steps
for strong bonds

4. Two-step self-conditioning
(e. g. AdheSE, Clearfil SE Bond), One Coat Self-Etch Bond)

Procedure	Duration (min : sec)
Remove temporary and clean cavity	02:00
Rubber-dam	05:00 – 10:00
Check fit of the restoration	01:00 – 10:00
Pretreat inlay with HF, silane and bonding agent (air thin)	03:00 – 08:00
If possible: Selective enamel etching, spray-rinse off and dry	01:10
If selectively etched enamel, apply primer	00:30
Without selective etching: re-apply primer and actively massage into enamel	00:30
Dry primer	00:10
Apply bonding agent, scrub in briefly, remove operator light, air thin	00:15
Dual-curing bonding agents (AdheSE) are advantageous	
Do not use light-curing bonding agent	
Apply luting composite	00:15
Insert inlay and place in final position, remove excess and cover margins with glycerol gel	03:00
Photopolymerisation	02:00
Remove excess with scaler	00:30
Finishing with super-fine grit diamond instrument and finishing strips	05:00
High luster polish to remove microcracks and prevent fractures	05:00
Apply fluoride	00:30

High-lustre polish removes microcracks and helps counteract fractures.
Fig.: Ivoclar Vivadent

5. Adhesive luting of composite ceramics
(Resin Ceramic, Lava Ultimate, 3M)

Procedure	Duration (min : sec)
Restoration: try-in of the restoration	01:00 – 10:00
Clean restoration using ultrasonic or steam cleaning, air dry	02:30
Sandblast with aluminium oxide 50 µm Do not etch with HF or phosphoric acid	01:00
Apply Scotchbond Universal Adhesive to bonding surfaces of the restoration, massage in for 20 s, air dry	01:00 – 10:00
Tooth: Rubber-dam	05:00 – 10:00
Clean tooth surfaces (rubber cup with fluoride-free prophylaxis paste or pumice)	02:00
Enamel etching 15 s **or** enamel and dentin etching 15 s with 35% phosphoric acid, rinse off, dry	01:00
Apply Scotchbond Universal Adhesive, massage in 20 s, air dry 5 s Remove any adhesive pooling with a microbrush Light-curing adhesive 10 s	01:00
Insertion:	
Apply RelyX Ultimate luting composite onto the tooth or restoration	00:30
Polymerise 1 s until luting composite has reached gel stage. Remove excess with sharp instrument	01:30
Light cure every surface for 20 s Total curing time should be at least 60 s, depending on the number of surfaces	01:30
Check for excess – if present, remove with scaler, dental floss	01:30
Apply fluoride	00:30

Working steps
for strong bonds

Indications:
Inlay, onlay, veneer.
Adhesive luting:
use of conventional etching of dentin,
bonding, conditioning

Source: Arnetzl

Working steps
for strong bonds

Indications:
Inlay, onlay, veneer, crown.
Adhesive luting:
use of conventional etching of enamel and dentin, bonding, conditioning

6. Adhesive luting of hybrid ceramic restorations made with Vita Enamic

Procedure (chairside fabrication)	Duration (min : sec)
Try-in of restoration	01:00 – 10:00
Conditioning of restoration: 1. HF etch (e.g. Vita Ceramics Etch) 60 s 2. Clean carefully (spray off and ultrasonically clean or 60 s in 98% ethanol), air dry	02:30
Silanate (e. g. Vitasil), exposure 60 s, dry	01:30
Place rubber-dam (optional)	05:00 – 10:00
Clean tooth surfaces, rubber cup with fluoride-free prophylaxis paste	02:00
Condition the preparation with 35% phosphoric acid (e. g. Vita Etchant Gel): enamel 30 s and dentin 15 s. Carefully rinse off and lightly dry	01:00
Primer (e. g. Vita A.R.T Primer A & B): massage into the preparation, dry 15 s, Bond (e.g. Vita A.R.T. Bond): apply to the preparation, let work 30 s, air thin	01:00 01:00
Light curing – optional	00:40
Apply luting composite (e.g. Vita Duo Cement)	00:30
Insert the restoration (it is possible to fix restoration in place by light curing for 3 – 5 s) and remove excess	01:30
Cover adhesive margins with glycerol gel (optional)	00:30
Light cure: minimum of 40 s from occlusal, buccal and lingual / palatal	01:30
In case of previously unsuccessful polymerisation, allow adhesive to harden	04:00
Check for excess – if present, remove with scaler, dental floss	01:30
Apply fluoride	00:30

Source: Vita Zahnfabrik

Indication:
Crown only.
Adhesive Luting:
use of self-adhesive composite

7. Self-adhesive cementation of hybrid ceramic restorations made with Vita Enamic

Procedure (chairside fabrication)	Duration (min : sec)
Try-in of restoration	01:00 – 10:00
Conditioning of restoration 1. HF etch (e. g. Vita Ceramics Etch) Vita Enamic 60 s 2. Clean carefully (spray off and ultrasonic or 60 s in 98% ethanol), air dry	02:30
Silanate (e.g. Vitasil), exposure 60 s, dry	01:30
Clean tooth surfaces (rubber cup with fluoride-free prophylaxis paste)	02:00
Apply luting composite (e. g. RelyX Unicem 2)	00:30
Insert the restoration (possible to fix in place by light curing for 3 – 5 s) remove excess	01:30
Cover adhesive margins with glycerol gel (optional)	00:30
Light cure: minimum of 40s from occlusal, buccal and lingual / palatal	01:30
Check for excess and remove with scaler, dental floss	01:30

Source: Vita Zahnfabrik

Working steps for strong bonds

Indications:
Inlay, onlay, veneer, crown.
Adhesive luting:
use of conventional etching of enamel and dentin, bonding, conditioning

8. Adhesive luting of zirconia reinforced lithium disilicate ceramics (ZLS)
(Celtra Duo, Dentsply Sirona, Vita Suprinity PC, Vita Zahnfabrik)

Procedure (chairside fabrication)	Duration (min : sec)
Try-in of restoration	01:00 – 10:00
Conditioning of restoration 1. HF etch (e.g. Vita Ceramics Etch) Celtro Duo 30 s; Vita Suprinity 20 s 2. Clean carefully (spray off and ultrasonic ca. 60 s in 98% ethanol), air dry	02:30
Silanate (e.g. Calibra Silan or Vitasil), exposure 60 s, dry	01:30
Place rubber-dam (optional)	05:00 – 10:00
Clean tooth surfaces (rubber cup with fluoride free prophylaxis paste)	02:00
Condition the preparation with 35% phosphoric acid (e.g. Dentsply Conditioner 36 or Vita Etchant Gel): enamel 30 s and dentin 15 s Carefully rinse off and gently air dry	01:00
Bond (e.g. Prime & Bond XP + SCA-Activator or Vita A.R.T. Bond): apply to the preparation, leave for 30s to work, air thin	01:00
Light cure (optional)	00:40
Apply luting composite (e.g. Dentsply Calibra or Vita Duo Cement)	00:30
Insert the restoration (it is possible to fix restoration in place by light-curing for 3 – 5 s) and remove excess	01:30
Cover adhesive margins with glycerol gel (optional)	00:30
Light cure: minimum of 40 s from occlusal, buccal and lingual / palatal	01:30
In case of previously unsuccessful polymerisation, allow adhesive to harden	04:00
Check for excess – if present, remove with scaler, dental floss	01:30
Apply fluoride	00:30

Source: Rinke

9. Self-adhesive luting of zirconia reinforced lithium silicate ceramic (ZLS)
(Celtra Duo, Dentsply Sirona, Vita Suprinity PC, Vita Zahnfabrik)

Procedure (chairside fabrication)	Duration (min : sec)
Try-in of restoration	01:00 – 10:00
Conditioning of restoration 1. HF etch (e. g. Vita Ceramics Etch) 60 s Celtra Duo 30 s; Vita Suprinity 20 s 2. Clean carefully (spray off and ultrasonic or 60 s in 98% ethanol), air dry	02:30 00:20 – 00:30 00:60
Silanate (e. g. Calibra Silan or Vitasil), exposure 60 s, dry	01:30
Clean tooth surfaces (rubber cup with fluoride free prophylaxis paste)	02:00
Apply luting composite to the restoration (e. g. RelyX Unicem 2, SmartCem 2, iCem)	00:30
Insert the restoration (possible to fix in place by light curing for 3 – 5 s), remove excess	01:30
Cover adhesive margins with glycerol gel (optional)	00:30
Light cure: minimum of 40 s from occlusal, buccal and lingual / palatal	01:30
Check for excess – if present, remove with scaler, dental floss	01:30

Prefered indication:
Crowns.
Adhesive luting:
use of self-adhesive composite

Source: Rinke

Working steps for strong bonds

Sandblasting the ZrO_2 framework for a adhesively bonded FDP. The red plastic is to protect the polished pontic.
Fig.: Kern

Adhesive and self-adhesive luting of oxide ceramic

Additional clinical longevity for high-strength oxide ceramics can be attained with adhesive and self-adhesive luting. Using self-adhesive composites with acidic monomers (RelyX Unicem) and without further pre-treatment of tooth substance, bond strengths can be reached which are comparable to those of multi-step adhesive systems. The phosphate monomer MDP (such as in Panavia 21) is self-adhesive to the oxide ceramic; however, the tooth surface must be pretreated with a primer.

The retention with short, clinical crowns of alumina or zirconia ceramic is improved if the ceramic surface is first sandblasted under low pressure with corundum (max. 50 µm, 1.0 – 2.5 bar).

Sandblasting dentin surfaces with Prophypearls and subsequent self-etching bonding with RelyX Unicem reduces the adhesion to the dentin. Sandblasting is not recommended in this procedure because the carbonate particles prevent adhesion between luting composite and tooth. Cleaning only with pumice powder.

10. Adhesive and self-adhesive luting of high-strength oxide ceramics
(e.g. RelyX Unicem, RelyX Ultimate, Multilink Automix, Panavia 21)

Procedure	Duration (min : sec)
Remove temporary and temporary cement	02:00
Try-in restoration	01:00 – 10:00
Clean the restoration: sandblasting with alumina > 50 µm 1.0 – 2.5 bar (chairside or laboratory)	02:00
Place rubber-dam (optional)	05:00 – 10:00
Clean tooth surfaces, • remove residual saliva and proteins with rubber cup and prophylaxis paste or pumice – when using RelyX Ultimate: apply Scotchbond Universal to tooth structure, massage in 20 s, air dry 5 s, polymerise 10 s	02:00
Only when using Panavia 21: • Mix primer and apply to tooth, allow 30 s to work • air dry – when using RelyX Ultimate: apply Scotchbond Universal to the restoration and allow 20 s to work. Do not light cure	01:40
Mix and apply luting composite	00:30
Insert restoration, remove excess	01:00
Cover adhesive margins: • Panavia 21: Oxyguard, • RelyX Unicem, RelyX Ultimate: glycerol gel	01:00
Self-curing	02:00
Check for excess – if present, remove with scaler, dental floss	00:30

In order to adhesively lute oxide ceramics, the tooth surface must be pre-treated with a dentin adhesive. The luting composite and ceramic restoration can only be incorporated after the dentin adhesive has been applied.

Adhesive and self-adhesive luting of oxide ceramics is justified particularly for use in the anterior region where, for instance, high restoration translucency is desired or where there is low mechanical retention, with a risk of retention loss. Adhesive fixed dental prostheses and inlay-fixed prostheses can only be cemented adhesively.