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Demystifying cementation:

Master the vital principles every dentist should know.

Prof. Jan-Frederik Güth — DMD, PhD | Munich

The last decades have seen an enormous change in dental treatments – especially in the field of indirect restorations – catalyzed by numerous new tooth-colored materials, adhesive protocols, an ongoing trend towards monolithic restorations and the general acceleration of development cycles. On the other hand, increasing economic pressure and hygiene requirements – particularly against the background of a pandemic – can be observed in the daily clinical routine. All this has led to rising complexity in our profession and our daily decision making. In this context, "simple" failure prevention is anything but. There is an urgent need for simplification, with the ultimate goal of elevating the quality of our work to the end benefit of our patients.

To help navigate the complex field of indirect restoration cementation, this article will explain the basic principles, summarize the most important facts and describe possible clinical pitfalls and their prevention – in pursuit of simplifying our daily routine.

The procedure of cementation has a critical and decisive role in the indirect workflow, and its many variables can make decision making complex. On the one hand, there is only "one try" to precisely place the restoration; on the other hand, the cementation mode might affect the longevity of indirect dental restorations, in addition to other factors. In recent decades, the development process has accelerated, especially regarding adhesive resin cements and adhesives, but also for conventional cements. Besides the quality enhancements of the materials themselves, they were also adapted to newly available restorative materials, and developed towards easier clinical handling and reduced technique sensitivity. On the other hand, this fast development led to some confusion in the market regarding the "do's and don'ts" of clinical handling, especially when it comes to adhesive bonding of indirect restorations.

And of course, the more complex the available options and materials get, the more difficult it is to make the "accurate decision" regarding the pretreatment, the cementation procedure and applied materials.

Generally, the purpose of a cement is to establish a reliable retention, to fill out and seal the space between abutment tooth and restoration, and to provide adequate optical properties when translucent tooth-colored materials are applied. Furthermore, the indication is the deciding factor for selecting the mode of cementation.

This means multiple factors influence our decision making. These can be divided into restoration material-associated, cement-related and clinical variables (Figure 1).

Please note: *The rules and recommendation in this article refer to generic material classes. While being in line with the instructions for use of many of the available products on the market, the guidelines may differ for specific brands and products available today or in the future. Always refer to the instructions for use of the manufacturer.*

Restoration

- restoration material
- fit of restoration
- design of restoration
- possible pretreatment

Cement

- viscosity
- biocompatibility
- adhesive potential
- solubility/dissolubility
- water intake
- color stability
- handling-properties
- curing properties
- aesthetic properties
- radiopacity

Clinical variables

- occlusion
- preparation design
- moisture control
- buildup material
- tooth/abutment
- tooth mobility
- surface roughness
- position of margin
  - subgingival
  - visibility
  - cleaning
  - enamel/dentin
- location of tooth
- degree of destruction

Fig. 1. Parameters influencing the selection of the cementation procedure.

For the choice of the cementation mode, multiple parameters need to be considered in a structured way, especially when an adhesive procedure is planned. But to be honest – can we really go through all these parameters during our decision process? Or might it be more realistic to figure out the most relevant key parameters to avoid severe mistakes that might compromise the quality and longevity of indirect restorations?

Adhesive or conventional?

Conventional and adhesive procedures both have specific advantages and limitations that need to be considered and balanced against the clinical prerequisites. In between the two, self-adhesive composite resin cements offer a smart alternative with several favorable properties: good bond strength is combined with a significant handling advantage compared to resin cements that require a separate bonding agent. This leads to a reduction in technique sensitivity, and significantly facilitates the clinical application of adhesive procedures for a broad range of indications.[1] Figure 2 shows three different cementation techniques and compares the most important properties.

Overall, the most relevant parameters for the decision for an adhesive procedure versus conventional cementation are: the restorative material, the preparation geometry and the possibility of moisture control. From a material standpoint, weaker materials with a flexural strength below 350 MPa, like silicate ceramics, generally need to be placed adhesively.

Cement properties	Conventional cement (e.g. zinc phosphate, glass ionomer and resin-modified glass ionomer cements)	Self-adhesive resin cement	Adhesive resin cement (plus separate adhesive)
Ease of use	+ +	+	–
Adhesion to tooth structure	–	+	+ +
Moisture tolerance	+ +	+	–
Resistance against solubility in oral medium	– –	+	+ +
Fluoride release	+ +	–	– –

Fig. 2. Property comparison of conventional cements, self-adhesive resin cements, and adhesive resin cements.

+ + = very high + = high – = low – – = very low

Source: Rating from "Success Simplified" clinicians

For a traditional cementation procedure using a glass ionomer cement, the prepared tooth stump should offer an adequate form of retention and resistance.[2,3] In accordance with *Edelhoff* and *Özcan*, conventional cementation with a water-based cement can be employed when the coronal height of the tooth preparation is 3 mm or more, when a convergence angle (opposing surfaces) between 4° and 10° is established, and when the final preparation is performed with a coarse diamond bur.[4] If those parameters cannot be fulfilled and a conventional cementation is desired, an adhesive buildup to establish the respective parameters in the preparation is required. However, this seems to rarely happen in practice, according to a study reporting an average convergence angle for CAD/CAM full crown restorations of over 26° and showing that over 2/3 of preparations are too conical.[5]

Against this background, a self-adhesive or adhesive procedure might be the safer alternative, but does not generally compensate for improper preparation geometries.[6] In addition, the possibility of adhesive techniques enables tooth-structure-saving preparation geometries,[7,8] with minimally invasive indirect restorations and innovative treatment strategies.[9,10]

The basic principles of adhesion: What do I need to know about adhesive placement of indirect restorations?

Once the decision for an adhesive procedure is made, there are some basic principles to understand. These will help make adhesive bonding of indirect restorations a safe and reliable process – and facilitate our decisions. Basically, we can distinguish three factors:

1. **pretreatment and conditioning of the restoration dependent on the material**
2. **the bonding components and mechanism**
3. **the conditioning of the tooth**

Regarding the restoration side, there are basically three options for pretreatment: Etching with hydrofluoric acid (5%), sandblasting using aluminum oxide particles, or adding a silica layer to the inner surface on the restoration (silicatization). For each of these options, the goal is to enable a chemical bond between the restorative material and the resin cement, which can be mediated either by silane, phosphate based monomers (e.g. MDP), or active monomers. On the tooth side, the pretreatment is dependent on the function and chemistry of the applied adhesive, and either a total etch, selective etch or self-etch technique can be applied. The specific decisions are described in the next sections.

Restoration pretreatment	**Bonding components & mechanism**	**Pretreatment tooth**
▸ Etching	▸ Silane	▸ Total etch
▸ Sandblasting	▸ Phosphate based monomers (e.g. MDP)	▸ Selective etch
▸ Silicatization	▸ Active monomers	▸ Self etch

Fig. 3. Simplified display of options for the conditioning of the restoration, the bonding components and mechanism itself, plus the conditioning on the tooth side.

Restoration pretreatment

The pretreatment of the restoration should be done as the last step before adhesive placement, to avoid contamination of the surface. If the pretreatment is already done before the clinical try-in (e.g. by the dental technician), clear communication and a thorough cleaning after the intraoral try-in are necessary to avoid mistakes – and to avoid limiting the quality of the adhesive connection (Figure 3).

Acid-etching using 5% hydrofluoric acid-gel (HF) is applied on silica-containing restorations to dissolve the glassy phase and to prepare the surfaces for the silane-mediated connection to the luting composite or bonding. It is therefore recommended for silicate ceramics (e.g. lithium-disilicate ceramic, feldspathic ceramic, glass ceramic) and glass particle-based hybrid ceramics (e.g. VITA Enamic®). The etching times are adapted and differ, depending on the composition of the restorative material (e.g. glass-ceramics 60 sec.; lithium disilicate ceramic 20 sec.; VITA Enamic® 60 sec.).

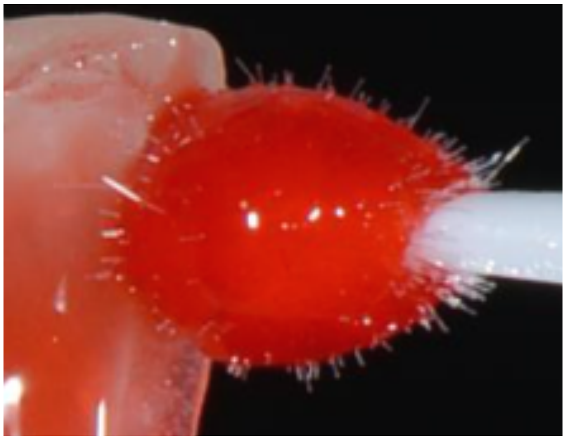


Fig. 4. Application of 5% HF acid-gel to a glass-ceramic restoration.

The instructions for use of the restorative material should be strictly followed. An important handling aspect is to apply the etch-gel evenly with a micro-brush to ensure a homogeneous pretreated inner surface of the restoration and allow for a bond to the entire restoration (Figure 4). Before the silane is applied, the surface has to be cleaned diligently with water rinsing or (if possible) in an ultrasonic bath and subsequently air dried.

Sandblasting is applied to materials that do not contain a glass phase and therefore cannot be pre-conditioned by etching. According to available literature, gentle air abrasion with alumina particles to clean and roughen the surface of oxide ceramics enhances the adhesive MDP-mediated bond.[11]

Sandblasting should be conducted after try-in of the restoration, to avoid any subsequent contamination (e.g. by saliva, etc.). Polished areas like pontics should be protected from sandblasting, for example by a PTFE-tape that is wrapped around the pontic (Figure 5). Additionally, a prior coloration of the inner surface can help to give orientation during the procedure as to where the sandblasting was already performed (Figure 6). Following sandblasting, the restoration must be carefully cleaned by water-rinsing and/or in an ultrasonic bath. Sandblasting can be applied on non-precious metals, zirconia and polymers. If the pretreatment has already been done by the dental laboratory, it is crucial to thoroughly re-clean the restoration after the intra-oral try-in following the manufacturer's specific instructions.

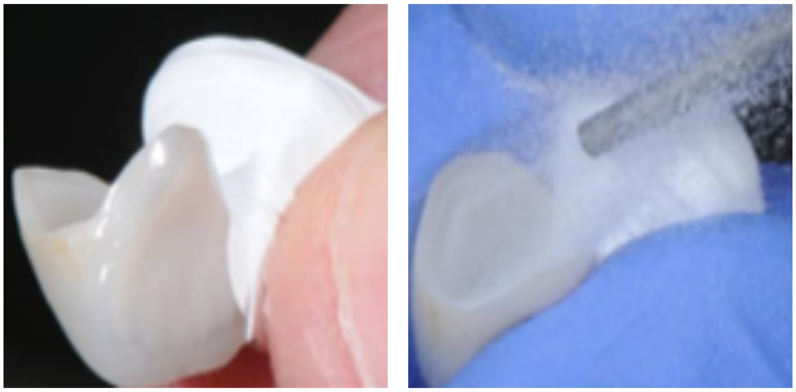


Fig. 5. Left: Pontic area protected by PTFE tape before sandblasting. Right: Gentle sandblasting with aluminum-oxide particles (1-2 bar; grain size < 50µm).

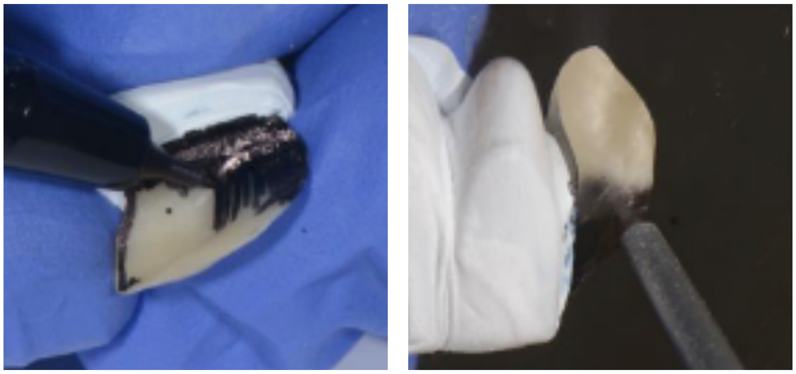


Fig. 6. Colored inner surface areas clearly display the surfaces areas that have not yet been air-abraded.

Clinical tip: Silicatization for intraoral repair and maximum bond strength to metal based restorations

Silicatization (3M™ CoJet™/3M™ Rocatec™) adds a fine silicate layer to the restoration surface before a silane or a silane-containing (universal) adhesive is applied. In contrast to classical aluminum-oxide sandblasting, in this procedure small aluminum-oxide particles, that are covered by a thin layer of silicium dioxide, are blasted onto a surface. Dependent on the impact-energy, either the full particle, or parts of the silica coverage stay on the blasted surface. Figure 7 displays the principle of silicatization.

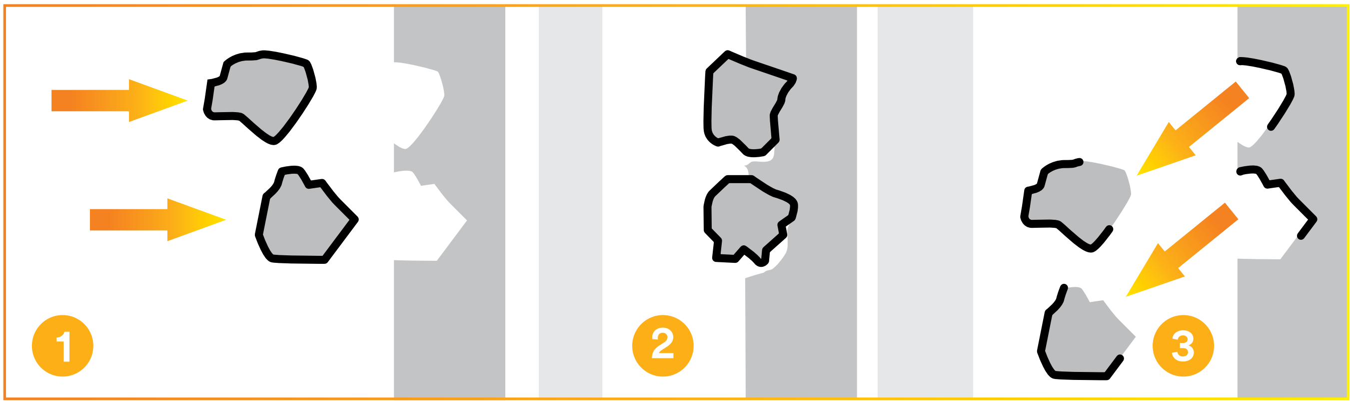


Fig. 7. Principle of silicatization (intraorally, e.g. 3M™ CoJet™, or for laboratories, e.g. 3M™ Rocatec™) to add a silica-layer onto a surface, enabling a silane to bond.

In the laboratory, silicatization (e.g. with 3M™ Rocatec™) can be used to pretreat materials for adhesive placement which exhibit no glass phase (silica) nor hydroxyl-groups on the surface. These are **precious/non-precious metals** and oxide ceramics. Metal restorations benefit from the procedure with an optimized bond strength.

For intraoral repair, silicatization (e.g. with 3M™ CoJet™) can be applied to existing restorations of all material classes, e.g. metal posts (Figure 8), chipped PFM or veneered zirconia restorations, as well as silicate-ceramic restorations[12] – to avoid intraoral application of hydrofluoric acid.

Fig. 8. Example for intraoral silicatization using Cojet for the pretreatment of a pre-existing post.

Figure 9 gives an overview on possible pretreatments in relation to the restorative material.

✓ (green) = recommended pretreatment extraorally
✓ (orange) = recommended for intraoral repair
✗ = not recommended

	Silicate (glass) ceramics	Oxide ceramics (e.g. zirconia)	Resin-based materials	Metal
Acid etching (5% hydrofluoric acid)	✓ (green)	✗	✗	✗
Sandblasting alumina oxide (⌀ <50 µm, ≤ 2 bar)	✗	✓ (green)	✓ (green)	✓ (green)
Silicatization 3M™ Rocatec™/3M™ CoJet™ (⌀ <50 µm, 2 bar)	✓ (orange)	✓ (orange)	✓ (orange)	✓ (green)

Fig. 9. Overview of recommended pretreatment method in relation to restorative material.

Bonding mechanism: Silane and MDP

Regarding the adhesive principles or the bonding mechanism on the restoration side, two connecting agents need to be known: 1) silane and 2) phosphate based monomers like MDP. They are either ingredients of a universal adhesive, a separate priming agent or, in the case of MDP, contained in the self-adhesive resin cement itself.

Silanes offer the possibility to form a stable chemical bond to the surface of a silicate based restorative material. The silane methacrylate chemically bonds to the previously etched silicate-ceramic (or silicated surface of an alternative material), providing a chemical bond to the polymers of the adhesive or resin cement. Figure 10 displays the principle of the silane agent.

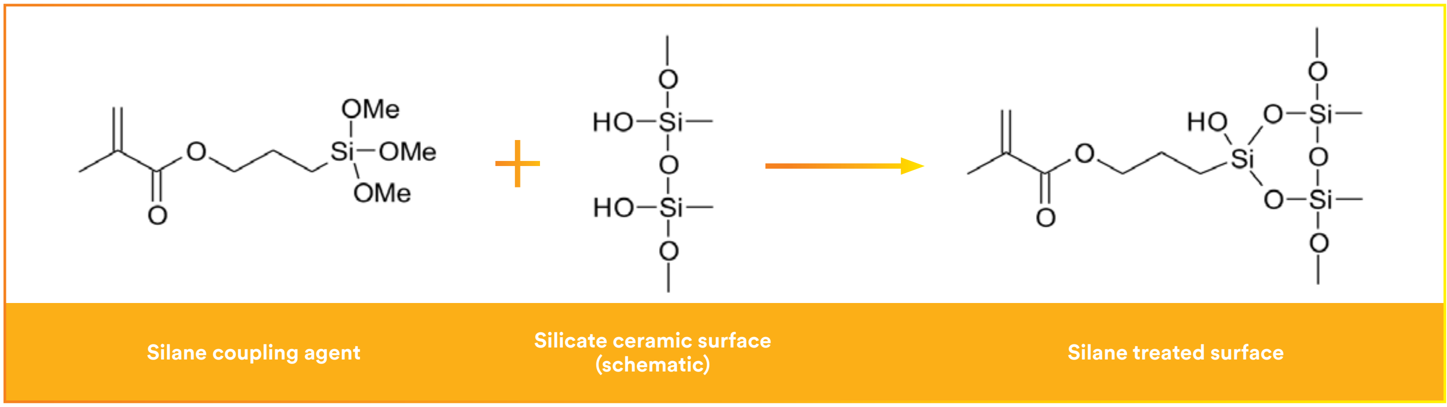


Fig. 10. Principle of silane bond to silicate-containing surfaces

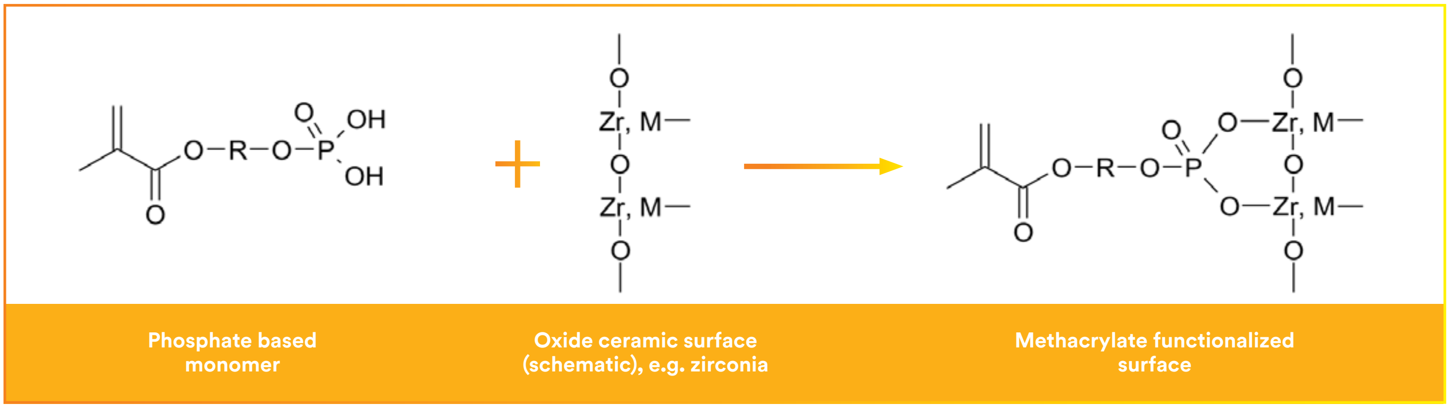


Fig. 11. Principle of the phosphate-mediated bond to oxide ceramics.

The chemical bond to oxide ceramics (e.g. zirconia) and the resin cement is mediated by phosphate based monomers like **methacryloyloxydecyl phosphate (MDP)**. These molecules contain a phosphate ester group on the one side – able to chemically bond to the oxide ceramic – and a methacrylate group on the other side – able to bond to the resin monomers. According to the literature available, it is highly recommended to sandblast the oxide ceramic gently before applying the MDP-containing-primer or luting composite,[12] in order to archive a reliable connection. Figure 11 shows the principle of the phosphate-mediated bond to oxide ceramics. As phosphoric acid may block the surface sites needed for bonding with a phosphate based monomer, it is very important to avoid cleaning the oxide ceramic surface with phosphoric acid, e.g. after try-in.

Today, modern universal adhesive systems do not only contain silane and phosphate based monomers like MDP, but also further ingredients such as active monomers (including amino- and hydroxyl-groups) and polyfunctional monomers for crosslinking. Acidic components such as MDP are responsible for the self-etch properties. All in all, those modern adhesives do not only bond to tooth structures, but also to almost all restorative materials. Due to this complexity, the components of one adhesive system are well-matched to each other – and it is therefore important to not mix components of different adhesive systems.

Tooth conditioning: Do's and don'ts

The general aim of pre-conditioning the tooth structure using 30-40% phosphoric acid is an increase of surface and/or modification of the dentine smear-layer. Generally, there are three alternatives regarding the pretreatment of the tooth structure, especially in regards of the dentine areas: total etch of dentine and enamel, selective etch of enamel, or the application of self-etch systems.

The decision is very dependent on the adhesive system to be used. Whereas the total-etch-and rinse-systems aim to remove the dentine smear-layer, self-etch-systems contain acidic monomers that infiltrate the smear-layer and modify it together with the hydrophobic bonding components so that the resin cement can bond. Selective enamel etching prior to the application of a mild universal adhesive seems to be an advisable strategy for optimizing bonding.[13]

Besides the selection of an adequate etching-mode, the individual handling of the procedures is of highest importance and is dependent on the knowledge, skills and decisions of the dentist. Figure 12 presents some general "do's and don'ts."

DO:

- **Mechanically clean**
  e.g. pumice slurry,
  3M™ Clinpro™ Glycine Prophy Powder
- **Rinse**
- **Lightly air dry**
  – surface slightly moist (glossy appearance)
  – applies when working with or without adhesive

DON'T:

Never use:

- **H2O2**
- **EDTA**
- **Eugenol**
- **Sodium bicarbonate**

If usage cannot be avoided, thoroughly rinse with water:

- Dentin sealants
- Desensitizer
- Astringents
- Scanning powder
- Disinfectants

Fig. 12. Do's and Don'ts for the clinical handling of the tooth before and during adhesive bonding of an indirect restoration.

A general issue that also might cause post-operative sensitivity is overdrying the tooth, especially etched dentin areas. The collagen layer which is exposed after etching will collapse if it is dehydrated and form a solid substrate. Some adhesives are not capable of fully infiltrating the collapsed collagen, resulting in an incomplete hybrid layer – which in turn can lead to post-operative sensitivity and reduced bond strength. Also, further substances that are under regular clinical use can impair the adhesive procedure and the curing of the adhesive and cement (Figure 12).

For the try-in of restorations, water-based substances (glycerin- / hydrogel-based) should be preferred over silicone-based ones, because their residues can be more easily removed from the tooth and restoration.

Regarding the mechanical cleaning of the surface, small brushes with pumice slurry can be used for the occlusal areas and the walls (Figure 13). For the sensitive marginal area on the preparation line close to the gingiva, a foam pellet can be used to carefully clean these sensitive areas (Figure 14).

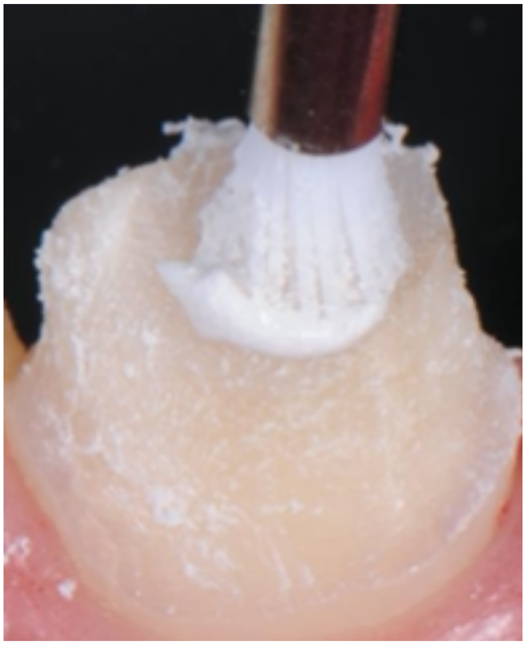
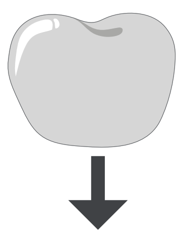
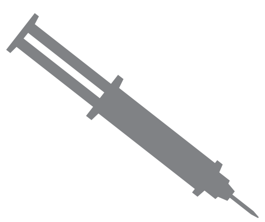
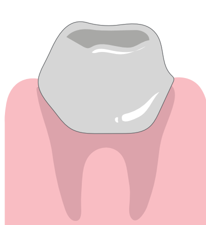


Fig. 13. Mechanical cleaning of the occlusal and circumferential areas using a small brush and pumice slurry.

Fig. 14. Mechanical cleaning of the sensitive areas close to the gingiva using a foam pellet and pumice slurry.

Overview of Existing Pretreatment and Cementation Workflows

This guide summarizes the most crucial steps and key components for pretreating the restoration and the tooth, based on the selected restoration material and the corresponding options for cementation.*

	Restoration material:	Zirconia (e.g. 3M™ Lava™ Esthetic, 3M™ Lava™ Plus)						Silicate (Glass) Ceramic Lithium disilicate (e.g. IPS e.max®) Feldspathic ceramics (e.g. VITABLOCS® Mark II) Hybrid materials based on glass ceramics (e.g. VITA ENAMIC®)						Composite (e.g. Tetric® CAD) Resin nano-ceramic (e.g. CeraSmart®)	
Restoration	Pretreatment	Sandblast (<50µm, 1-2 bar)						Acid etch (5% HF)						Sandblast (<50µm, 1-2 bar)	
Restoration	Cleaning	Ultrasonic water / alcohol bath						Ultrasonic water / alcohol bath						Ultrasonic water	
Restoration	Clean after try-in	Follow manufacturer IFU						Follow manufacturer IFU						Follow manufacturer IFU	
Restoration	Conditioning				Universal adhesive **	Universal adhesive **	Universal adhesive **				Universal adhesive **	Universal adhesive **	Universal adhesive **	Universal adhesive **	Universal adhesive **
Cement	Cementation	Conventional (retentive prep)	Self-adhesive resin	Self-adhesive resin	Adhesive resin	Adhesive resin	Adhesive resin	Conventional* (retentive prep)	Self-adhesive resin*	Self-adhesive resin*	Adhesive resin	Adhesive resin	Adhesive resin	Adhesive resin	Adhesive resin
Tooth	Pretreatment				Universal adhesive **	Universal adhesive **	Universal adhesive **				Universal adhesive **	Universal adhesive **	Universal adhesive **	Universal adhesive **	Universal adhesive **
Tooth	Pretreatment			Selective etch ***		Selective etch ***	Total etch ***			Selective etch ***		Selective etch ***	Total etch ***	Selective etch ***	Total etch ***
Tooth	Cleaning	Mechanical cleaning with pumice slurry, water rinse, slightly dry						Mechanical cleaning with pumice slurry, water rinse, slightly dry						Mechanical cleaning with pumice slurry, water rinse, slightly dry	

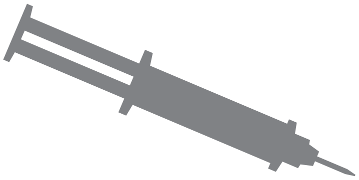
*If flexural strength >350 Mpa **Needs to contain silane, MDP-like molecules, and moisture-regulating agent ***Use etchant with 30-40% phosphoric acid

NOTE: The recommendations are limited to selected key steps and components and do not replace the detailed instructions for use. In addition, these rules refer to generic material classes. While being in line with the instructions for use of many of the available products on the market, the guidelines may differ for specific brands and products available today or in the future. Always refer to the instructions for use of the manufacturer for a detailed step-by-step procedure.

Download the guide (PDF)

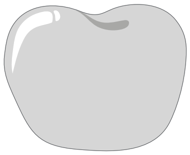
Conclusion: The principles of cementation for your practice

Cementation can appear to be a complex and confusing topic. However, once one understands some of the basic principles behind the way the different materials involved work and interact, the topic becomes much more approachable. By following a few ground rules and taking advantage of modern, simplified materials, we can help minimize the risk of errors and ensure a reliable bond for our restorations – for the benefit of our patients.



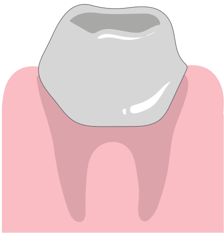
Technique and product selection:

- When using weaker restoration materials (e.g. silicate ceramics with a flexural strength below 350 MPa) and in cases of non-retentive preparations, an adhesive procedure is required. However, this does not compensate for improper preparation geometries.
- Full-ceramic FDPs should be (self-) adhesively bonded due to the high shear forces.
- The ability to control moisture, which is especially important for adhesive procedures, should be evaluated before deciding for a restoration material and related cementation procedure.
- Modern material options like universal adhesives and cements help to reduce the complexity by combining different functions and reducing components as well as procedure steps.
- It is highly recommended to "stay within one adhesive system," because the materials and the underlying chemistry are well-matched to each other.



Restoration pretreatment:

- Silicate (glass) ceramic restorations require pretreatment with acid etching (5% HF acid), whereas oxide ceramics (zirconia), metal restorations and resin-based materials require sandblasting (<50µm, 1-2 bar).
- If pretreatment is done before try-in, e.g. by the dental laboratory, it is crucial to re-clean the restoration after the intra-oral try-in, following the manufacturer's instructions.
- When adhesively bonding to zirconia, it is imperative to avoid cleaning the restoration with phosphoric acid, as phosphoric acid blocks the bonding sites.
- For optimal bond strength, don't overdry the primed restoration material.



Tooth conditioning and cleaning:

- The tooth should be mechanically cleaned, rinsed off and lightly air-dried.
- Don't overdry the tooth. Overdrying can increase the risk of post-op sensitivities and may reduce bond strength.
- Avoid chemical substances that can negatively impact the bonding quality (Figure 12).
- For best long-term marginal stability, a selective etch procedure is recommended when working with self-etch-adhesive systems or self-etch resin cements.

About the author

Prof. Jan-Frederik Güth
DMD, PhD | Munich

Jan-Frederik Güth holds the position of Deputy Director of the Department of Prosthodontics at the University Hospital of the Ludwig-Maximilians University Munich. He obtained his Dr. med. dent. Degree in 2008 and his postdoctoral lecture qualification ("Habilitation") in 2014 from the same University. In 2013 he was a visiting researcher at the University of Southern California (with Pascal Magne) and is specialized in the field of Prosthodontics (DGPro, the German Association of Prosthodontics) and Implantology (especially Implant Prosthetics; DGI). His main field of attention and research are digital impression technology and workflows, CAD/CAM, esthetics and prosthetic materials.

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3M Oral Care
2510 Conway Avenue
St. Paul, MN 55144-1000 USA

Phone 1-800-634-2249
Web 3M.com/dental