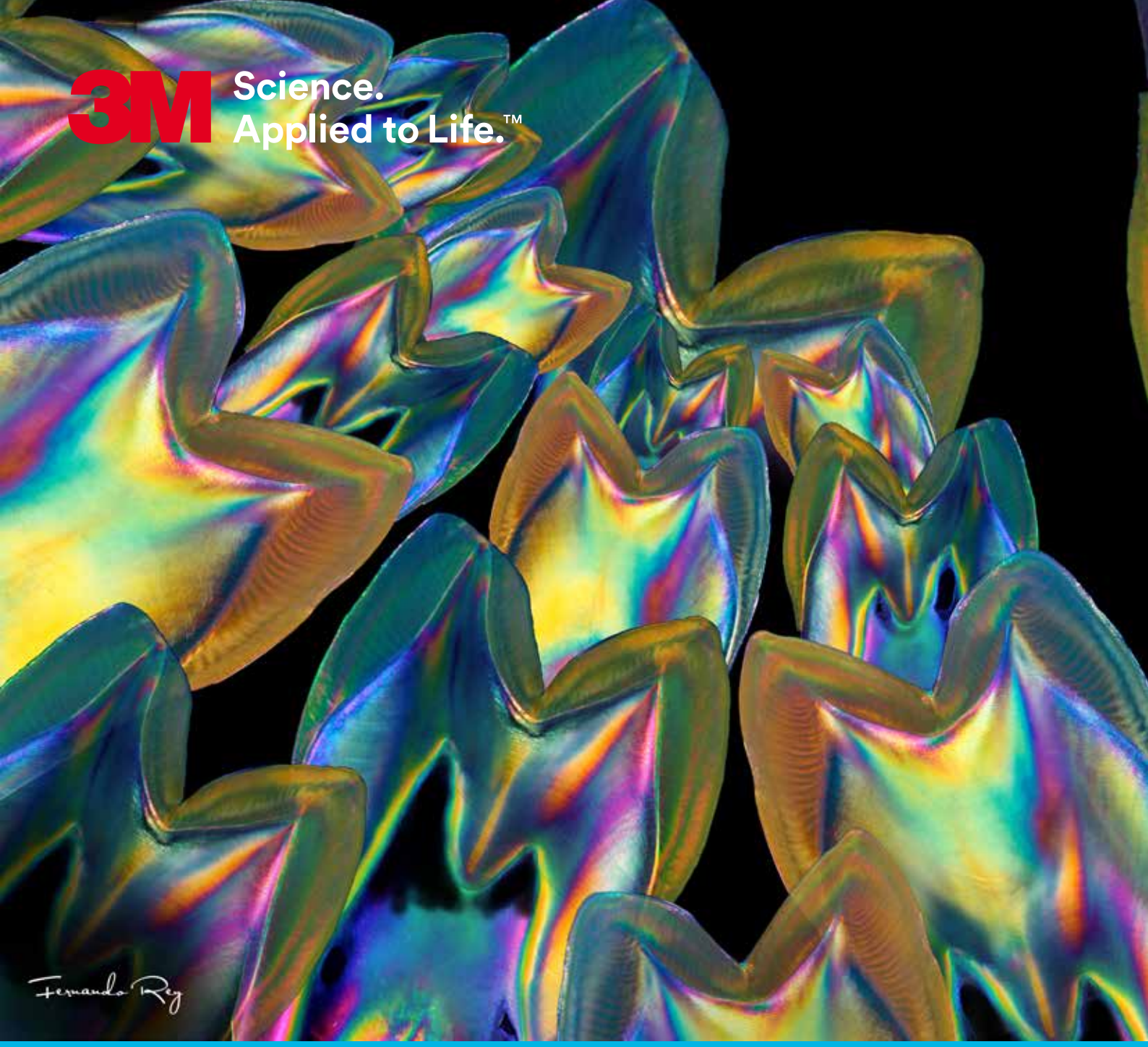

3M℠ Health Care Academy

Success simplified

in the indirect restoration workflow

Preface

More than 500 years ago, Leonardo da Vinci already was profoundly convinced that “simplicity is the ultimate sophistication”. In today’s busy practice environment, this idea is more relevant than ever: it is the simplification and standardization of clinical protocols involving the use of the most suitable materials that lead to efficiency, reliability and predictability so urgently needed in the busy practice environment.

In the past decade, the introduction of countless innovative materials like restoratives and cements, and new processing options has further increased the need for standardization. Having more esthetic, high-performance material options at hand is positive in that it offers new opportunities to achieve better clinical outcomes and fulfill the patients’ increasing demands. At the same time, however, reaching this goal can be challenging as the great number of options creates the need for informed choices, and some of the required clinical procedures might be complicated. Managing these tasks is particularly crucial in times with a limited availability of qualified staff and an increasing financial pressure.

But how is it possible to achieve simplification and standardization in the clinical environment? One important element is the selection and use of high-quality dental materials that ensure fewer steps and ease of use. In this context, 3M is able to help: One of the company’s core competences is applying science to develop innovative products that make life easier for their users. The other decisive factor is the use of suitable techniques and procedures, which ensure that the selected products will reach their full potential. This is especially important for indirect procedures, which are often complex and can be approached in various ways. When a specific clinical protocol is defined and used every time, the workflows become routine procedures and the likelihood of errors to occur during treatment is minimized.

As it is not easy to decide which techniques and protocols are best suited to achieve the desired outcomes, 3M has asked a group of international experts to define the required best practice recommendations and protocols. They will help practitioners decide when and how to use which materials and techniques in order to achieve modern dentistry’s primary goal: Get it right the first time – every time!

The team of five international experts is made up of both, clinicians and academic researchers. Together, they have developed a consensus that is based on the latest scientific findings, but also takes into account the challenges and constraints of a modern dental practice. In this booklet, they present their basic recommendations as well as some selected clinical protocols. The full range of best practice recommendations will be published in a more comprehensive guideline soon.

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About the importance of simplification

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Best-practice recommendations for crown and bridge procedures

Indirect restorative procedures are highly complex. They consist of many different clinical and laboratory steps, and each separate step implies a number of clinical challenges (Fig. 1).

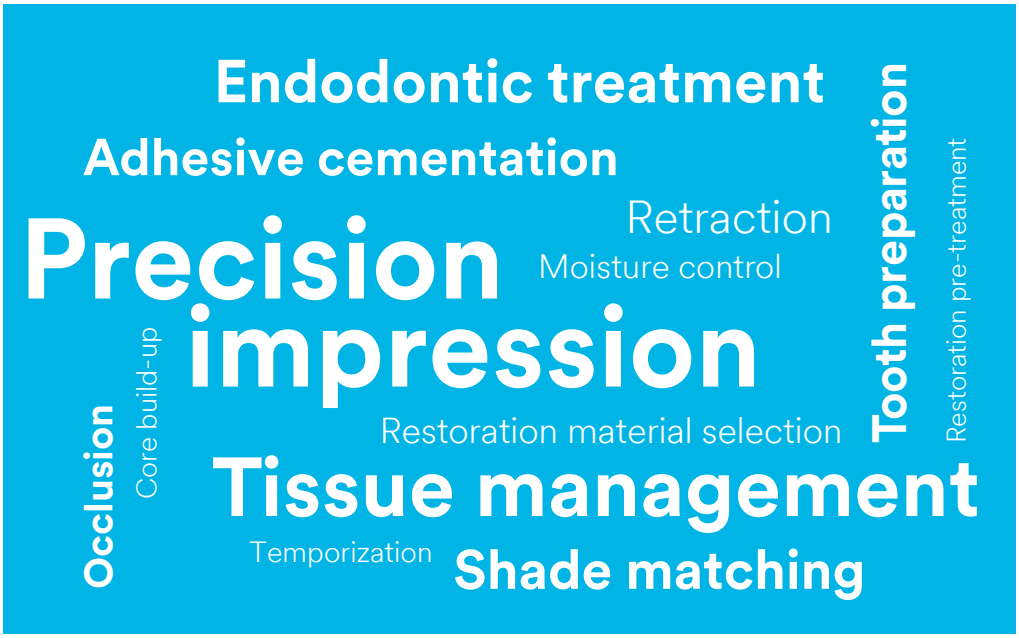


Fig. 1: Examples of critical steps in the indirect restorative procedure.

It is possible to carry out these steps and approach the related challenges in many different ways. A huge number of materials are available for every clinical situation, and various techniques may be adopted to reach the defined treatment goal.

While having options is generally positive, it also creates confusion and uncertainty. Given that new materials are being introduced to the dental market very frequently, it is difficult for dental practitioners to keep up with the latest developments and to make well-founded decisions.

This is why we decided to collaborate with 3M and develop a consensus for best-practice recommendations in prosthodontics based on the latest scientific research findings and on personal long-term experience in the clinical environment. Our objective is to give clinicians an orientation on indication-specific material selection and clinical tips for their successful and highly efficient use.

Basic rules

Guideline development was based on the following three rules:

1. **Select the simplest possible way that still ensures reliable results**
2. **Be as minimally invasive as possible**
3. **Ensure cost-efficiency for the dentist and the patient**

Opting for simplicity without compromising the outcome is important as it allows users to reduce the number of choices to be made and work steps to be carried out, leading to a minimized error risk. This effect is supported by standardization of the clinical protocols: Errors are less likely to occur if the whole team is familiar with every single step of the treatment approach.

The idea of minimal invasiveness is based on the concept of non-maleficence, which should be the underlying principle of every dental treatment. In indirect procedures, it is essential to preserve as much natural tooth structure as possible without compromising the outcome. This means that the least invasive of all equally well-suited treatment options should always be preferred.

Finally, cost-efficiency needs to be taken into account because the financial pressure on dental practices is increasing, as is the number of direct payers among patients. In this context, it is important to understand that the dentist's time is the most valuable factor in the dental office. Saving treatment time by using high-quality materials, which ensure predictable results in a more efficient procedure, is much more cost-effective than reducing the material cost.

Guideline development

With these principles in mind, we developed recommendations for the most crucial aspects of indirect restorative procedures. The most challenging task in the development process was finding the right balance between perfection and simplification. This matter was discussed extensively with the group for every single procedure step, from restorative material selection to cementation.

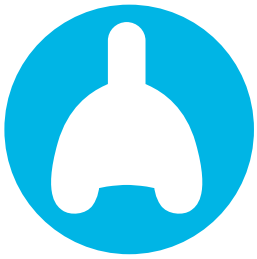
While the complete guideline is yet in the works, this booklet gives its readers a taste of what to expect. It is assumed that dental practitioners make their diagnosis and define the indication. As soon as they start developing a detailed treatment plan, valuable guidance is offered. Seven chapters focus on the following seven procedure steps:

Material selection
Procedure step 1

Foundation restorations (Post & Core)
Procedure step 2

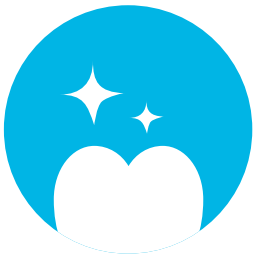
Preperation design
Procedure step 3

Temporization
Procedure step 4



Impression taking
Procedure step 5

Cementation
Procedure step 6



Maintenance
Procedure step 7

Each chapter will discuss the most important options and decision criteria for a specific procedure step. An overview of the selection criteria and factors relevant for the decision(s) to be made is given in the form of a circle. The idea is that in the clinical environment, the dental practitioner will select the differentiating factors – e.g. the substrate, the indication, the number of teeth and the margin position – for each individual case before starting to carry out the next procedure step.

In training and education tools that are currently being developed, each selected path will result in a case-specific recommended clinical protocol. In this booklet, only several examples for case-specific protocols are given mainly for reasons of clarity and comprehensibility. A complete decision tree – represented in a box with different tabs and arrows guiding the way – is available for those procedure steps with a limited number of options.

Material selection
Procedure step 1

The increasing demand for tooth-like restorations has driven forward the fast development in indirect restorative material and manufacturing processes. As a result, a wide range of tooth-colored CAD/CAM materials with varying properties is available today, which gives the restorative team the possibility to select an ideal solution for nearly all indications. However, the availability of a huge number of tooth-colored materials also complicates decision-making and presumes that the involved parties – the clinician, the dental technician and also patients – are very well informed.

Available options and selection criteria

Material selection is one of the most crucial factors in indirect restorative dentistry. It needs to be based on the clinical situation and the desired treatment outcome defined by the restorative team in conjunction with the patient. To tailor the restoration individually to the indication and the patient´s needs, multiple clinical and material-associated parameters have to be considered. In this context, the ultimate ambition of those determining the indication, the form of restoration and the most suitable material should always be clear: to save as much natural tooth structure as possible.

Clinical parameters

- Destruction of tooth / remaining healthy tooth structure
- Antagonist (material / natural)
- Tooth position
- Bonding possibilities
- Patient’s esthetic demands
- Functional aspects (occlusion, canine guidance)

Material-related parameters

- Mechanical properties
- Optical properties (esthetic potential)
- Minimal wall thickness necessary
- Wear behavior
- Bonding possibilities

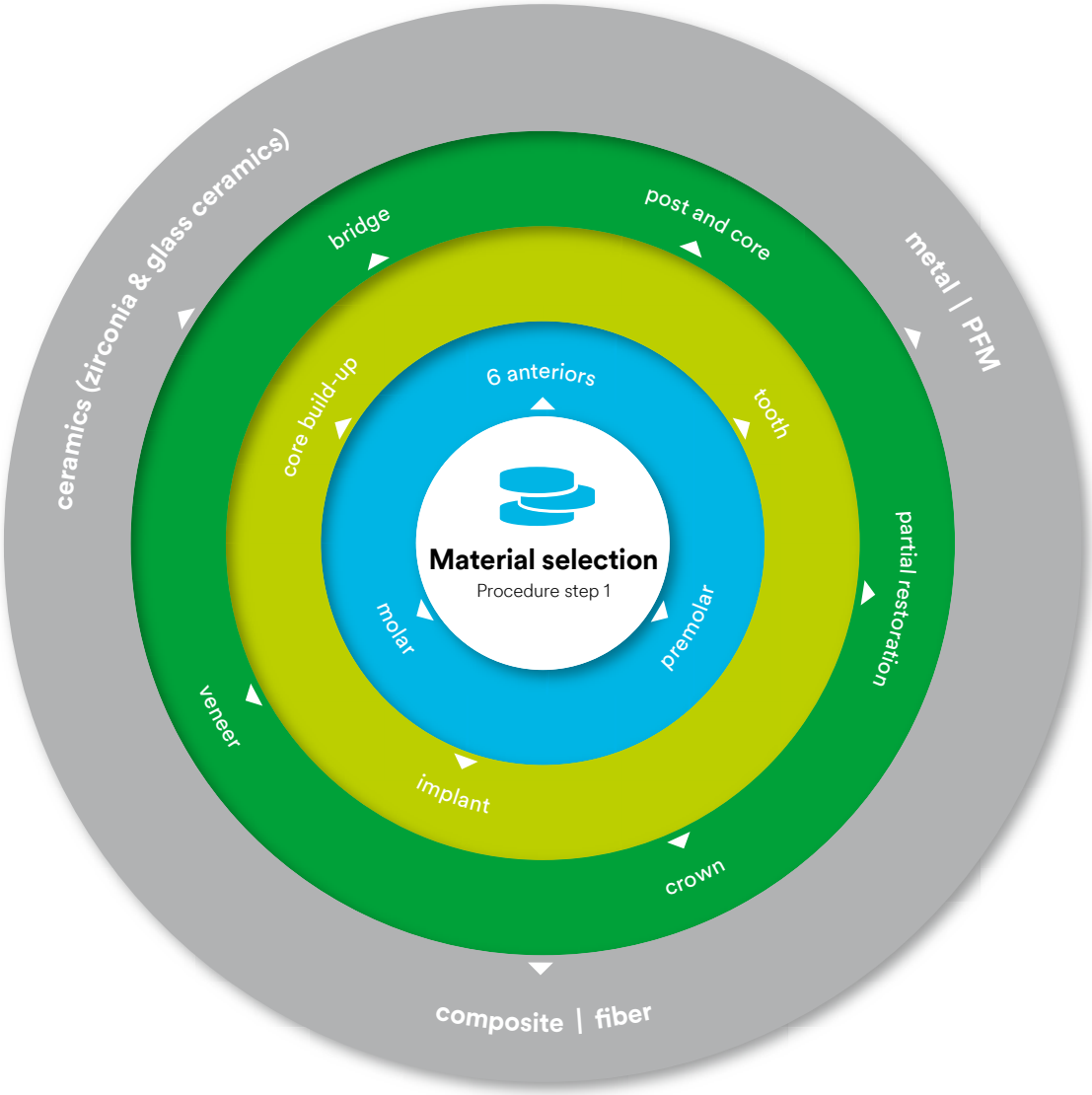


Table 1: Decision criteria and distinctive factors guiding material choice. Based on the case-specific selection of one factor per circle, it will be possible to choose the most suitable material class.

In order to simplify the decision-making process, the material class is usually selected first. Secondly, clinicians and technicians focus on the differences within the material-classes. Crucial factors for the decision are the esthetic demands on one hand and the forces the restoration has to withstand on the other. While the esthetic demand is mainly determined by the location of the restoration in the patient's mouth, it is the position, the substrate and the indication determining the required strength of a material. Selecting the appropriate option for each of the three colored circles shown in Table 1 will result in a recommendation regarding the best suitable material class.

	3-point-flexural strength [MPa]	Translucency	Esthetic potential	Minimum thickness
Silicate ceramics				
Glass Ceramics / Feldspathic Ceramics	< 200	*****	*****	1.5 mm (0.5 mm for veneers)
Lithium Disilicate / Lithium Silicate	360-530	****	****	1.0 to 1.5 mm
Oxide ceramics (e.g. zirconia)				
Translucent Cubic 5Y-TZP Zirconia (e.g. 3M™ Lava™ Esthetic Fluorescent Full-Contour Zirconia)	800[1]	***	***	0.8 mm[1]
Translucent 3Y-TZP Zirconia (e.g. 3M™ Lava™ Plus High-Translucency Zirconia)	> 1.000[1]	**	**	0.3 to 0.5 mm[1]
3Y-TZP Zirconia (e.g. 3M™ Lava™ Frame Zirconia)	> 1.000[1]	*	***** (hand-veneered)	0.3 to 0.5 mm[1] (1.5 mm with veneering porcelain)

Table 2: Different ceramic materials and their relevant properties for material selection.

[1]Values for specific material according to manufacturer recommendation.
All other recommendations and ratings are based on the expert consensus of the five clinicians.

Knowing which material class is the best to reach the defined goals, further factors need to be taken into account and a more detailed analysis is required. Factors such as the individual esthetic demands of the patient and economic aspects should be considered in this context. The widest material range is available in the class of ceramics, which can be subdivided into silicate ceramics (e.g. glass ceramics) and oxide ceramics (e.g. zirconia). Further on, optical properties and the strength of the materials vary widely even within the categories. This leads to significant differences in the esthetic potential and necessary minimum wall thicknesses and therefore invasiveness of the preparation. Mechanical properties and strength also determine if a material can be cemented or if adhesive bonding is mandatory. The most important properties of ceramics that should be taken into consideration during the material selection process are listed in Table 2.

+ recommended +/- possible - not recommended ***** very high **** high *** moderate ** low * very low

Conventional cementation possible?	Pre-treatment of material for adhesive bonding	Posterior crown	Fabrication effort / cost	Anterior crown	Fabrication effort / cost
no	acid-etch with 5 % hydrofluoric acid	**+/-**	*****	**+**	*****
yes	acid-etch with 5 % hydrofluoric acid	**+**	****	**+**	****
yes	sandblasting with alumina[1] (grain size max. 30 – 50 µm, max. 2 bar)	**+**	***	**+/-**	***
yes	sandblasting with alumina[1] (grain size max. 30 – 50 µm, max. 2 bar)	**+**	***	**hand-veneered**	*****
yes	sandblasting with alumina[1] (grain size max. 30 – 50 µm, max. 2 bar)	**hand-veneered**	*****	**hand-veneered**	*****

1. Dental CAD/CAM materials include different kinds of polymer-based materials, hybrid materials, glass ceramics and oxide ceramics. Significant differences in material properties are found not only between, but also within the material classes, which makes them more or less suitable for different indications.

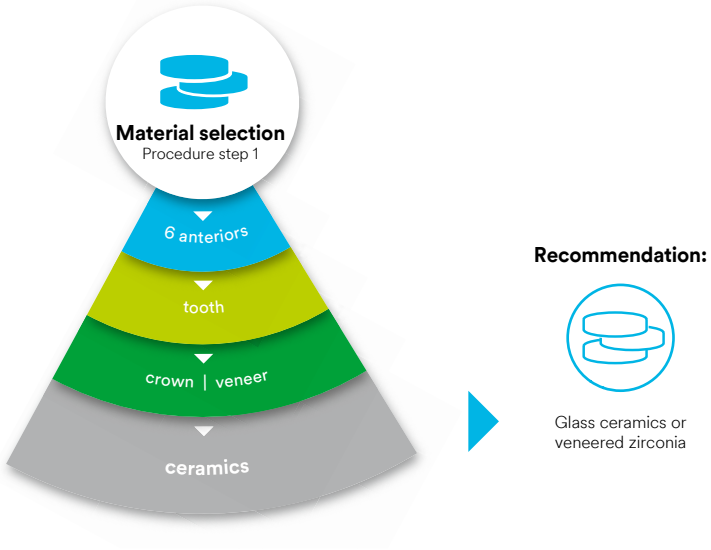
Selected option: Single crown

Regarding single tooth restorations, there are countless material options, from resin-based materials to metal or porcelain fused to metal up to 3Y-TZP Zirconia (3-mol% yttria stabilized tetragonal zirconia polycrystal). Given that saving as much dental hard tissue as possible is the ultimate goal, the material with the lowest possible wall thickness that is still able to fulfill the defined esthetic and functional needs should be applied.

In the anterior region, esthetic demands are particularly high. Therefore, layered feldspathic ceramic crowns or hand-veneered copings made of a stronger material (e.g. 3Y-TZP Zirconia, lithium disilicate) are usually selected. Since porcelain layering is rarely associated with chipping in the anterior region, these options can be recommended in this context. The use of monolithic restorations in the anterior region is often limited by the esthetic appearance and demand.

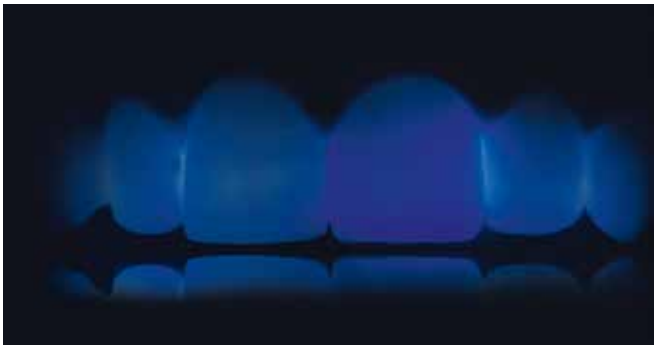
However, the increased chipping risk reported in many countries has caused the current trend towards monolithic restorations in the premolar and molar region. When abandoning a separate porcelain layer, it is also possible to further reduce the invasiveness of the restorations, as thinner wall thicknesses are possible to achieve the same mechanical strength. Suitable options for minimally invasive monolithic restorations can be for example translucent 3Y-TZP Zirconia or even more translucent 5Y-TZP Zirconia (5-mol% yttria stabilized tetragonal full-contour zirconia polycrystal) materials. Besides their non-chipping effect and their low minimum wall thickness, monolithic restorations also offer the benefit of a more efficient production procedure.

Clinical examples

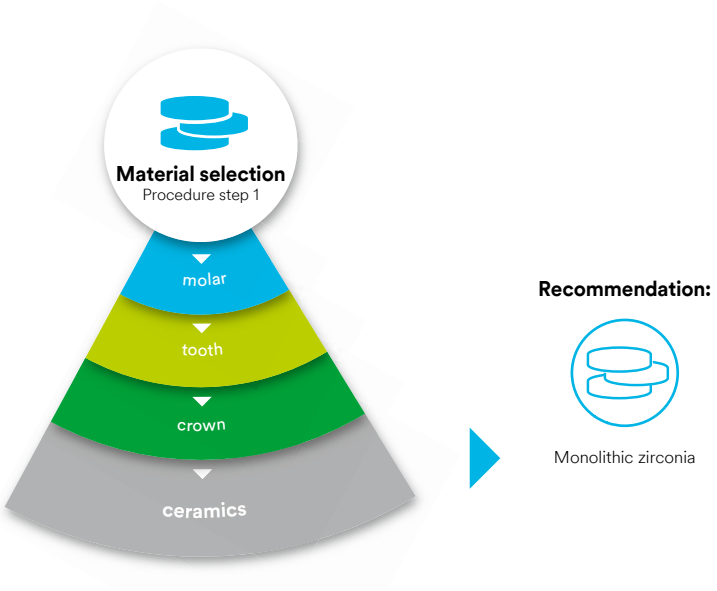


2. Veneer preparation on the left central incisor and crown preparation on the left lateral incisor.

3. Treatment result with a veneer made of feldspathic ceramic and a hand-veneered crown with a coping made of 3M™ Lava™ Frame Zirconia.



4. Translucency of the restorations and the adjacent teeth in transmitted blue light. (Images courtesy of Dr. Carlos Eduardo Sabrosa)



5. Crown preparation in the posterior region.

6. Monolithic crown made of 3M™ Lava™ Esthetic Fluorescent Full-Contour Zirconia in place.

7. Lateral view of the monolithic crown on the first molar (left). Photograph taken under UV light: The zirconia material shows a tooth like fluorescence (right).* (Images courtesy of PD Dr. Jan-Frederik Güth and MDT Hans-Jürgen Stecher)

* Fluorescence determined with light sources simulating natural UV light.

Conclusion

By taking into account specific parameters, it is possible to select a restorative material that is tailored to the specific demands of the individual patient and clinical situation. Innovative CAD/CAM ceramics with enhanced mechanical and optical properties enable the restorative team to reduce the invasiveness of the treatment by eliminating the need for an additional porcelain layer in the posterior region. Different types of zirconia (3Y-TZP or 5Y-TZP) or lithium disilicate ceramic may be used to achieve the goal of minimal invasiveness. In the anterior region, silicate ceramics or hand-veneered zirconia restorations fulfill the higher esthetic demands. The use of monolithic restorations also leads to a streamlined production process that reduces the number of manual work steps and thus increases the efficiency of the procedure.

All in all, being well-informed about the available material options and their properties pays off as it is the basis for the selection of the most suitable material for the individual situation. Working with the best material option, in turn, ensures that the clinician – in close collaboration with the dental technician – is able to obtain the desired treatment outcome in terms of esthetics and function. In this context, it is also important to ensure that the appropriate material pre-treatment is carried out in order to lay the foundation for a strong and long-lasting bond between the tooth and the restoration.

Available 3M products

3M™ Chairside Zirconia

3M™ Lava™ Frame Zirconia (3Y-TZP)

3M™ Lava™ Plus High-Translucency Zirconia (3Y-TZP)

3M™ Lava™ Esthetic Fluorescent Full-Contour Zirconia (5Y-TZP)

Foundation restorations (Post & Core)

Procedure step 2

Before starting an indirect restorative treatment, it is often necessary to take specific measures that help to stabilize the situation and enhance the prognosis of the tooth and the restoration. In this context, two major factors should be taken into account: the patient's oral hygiene status, and the quality and amount of remaining tooth structure. In cases of poor oral hygiene, a hygiene phase with several professional tooth cleaning appointments and measures to improve the compliance of the patient may be useful. If the remaining tooth structure fails to offer the required retention for an indirect restoration, different treatment options are available.

Available options and selection criteria

Especially following endodontic treatment, the tooth may lack sufficient coronal tissue to retain the final restoration, and a core build-up without post may not lead to the desired stability. In this case, the basic options are the use of a glass-fiber or metal post followed by a core build-up, the placement of an endocrown, or – if necessary – orthodontic extrusion. In the worst case, an extensive loss of coronal tissue may require extraction of the tooth followed by placement of an implant.

The selection criteria for each build-up option are different for molars versus anterior teeth and premolars. By assessing the tooth position, amount of coronal tissue, margin position, and – in the incisor and premolar area – specific risk factors, the dental practitioner will be able to make his choice. Recommendations on how to proceed are shown in Table 1.

Foundation restorations (Post & Core): Procedure step 2

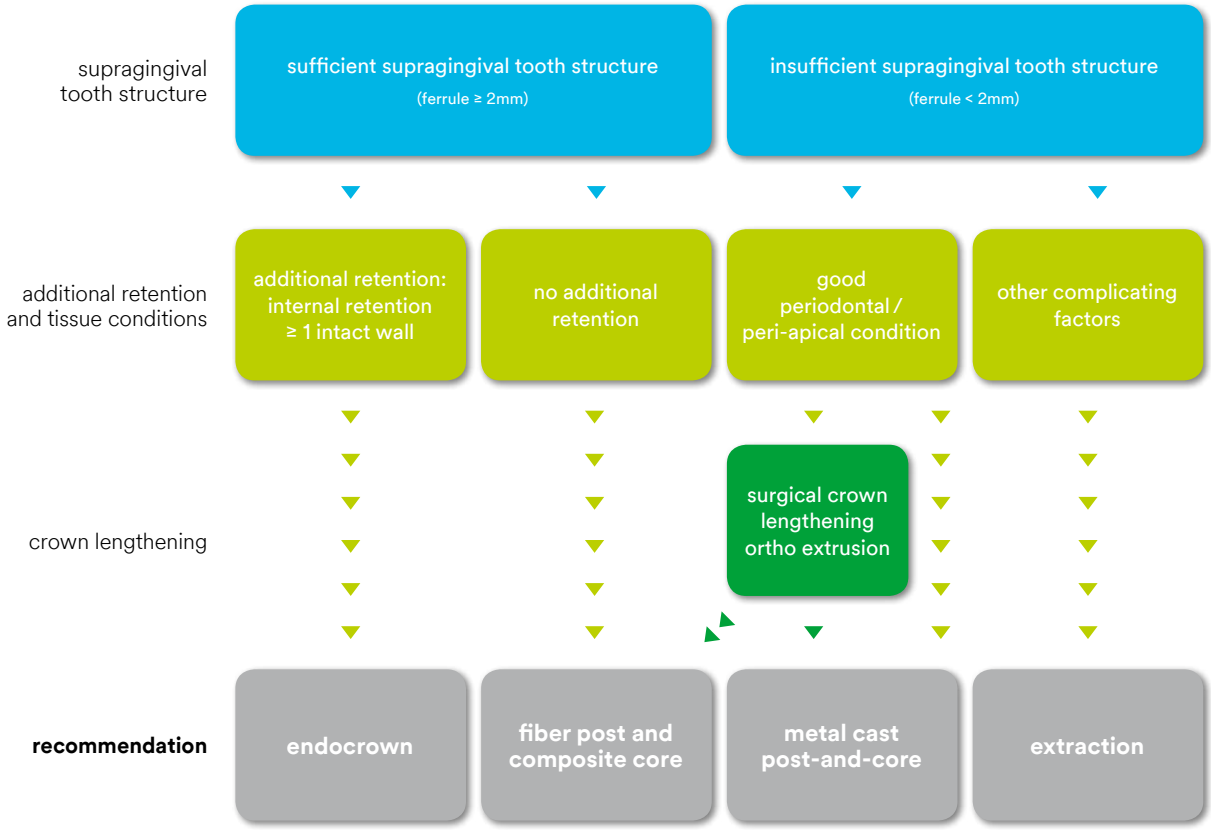
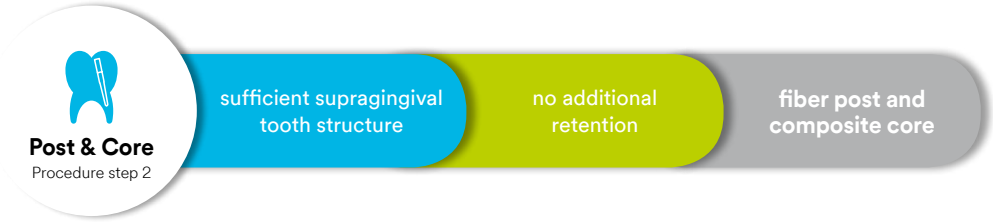


Table 1: Considerations for decision-making: Post-and-core procedure.

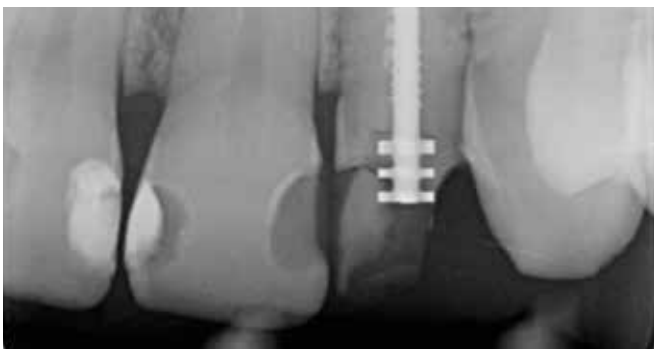
Clinical procedure

One of the possible clinical procedures – the placement of a glass fiber post in a lateral incisor with extensive loss of coronal tissue and a ferrule partially over 2 mm – is described below in a patient case. As recommended in this clinical situation, a glass-fiber post was placed. The treatment procedure was simplified with the aid of several products that were developed to work together and reduce the number of work steps.



Fiber post and composite core

1. Patient with his maxillary left lateral incisor presented with a fracture after trauma.



2. X-ray of the initial situation revealing a metal screw post.

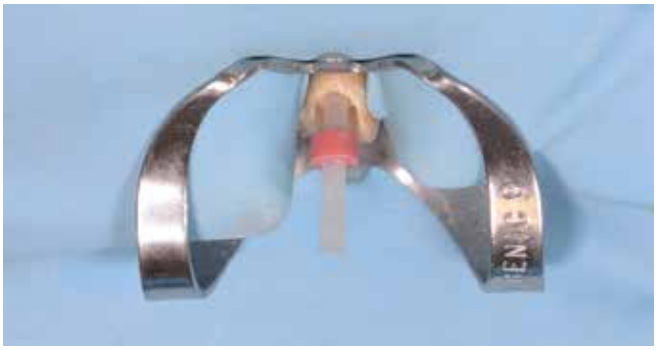
3. Post and crown removed for an endodontic revision.

4. Clinical situation following the removal of the post and the crown.

5. Occlusal view with overlapping soft tissue. Cords and paste will not be sufficient for retraction of the gingiva to expose the margins.

6. Situation after removal of the overlapping soft tissue using electro-surgery.

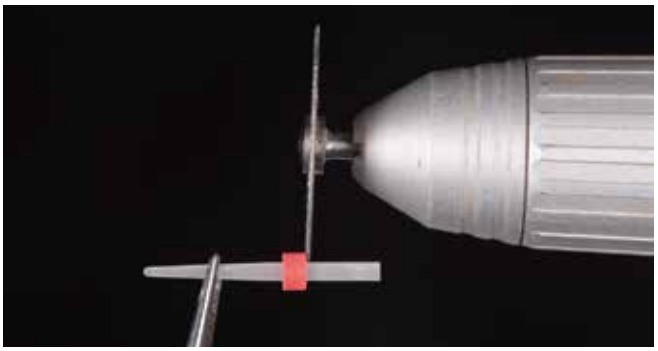
7. Determination of the drilling depth based on an X-ray. Apically, 4 mm of the root canal filling must be left untouched.



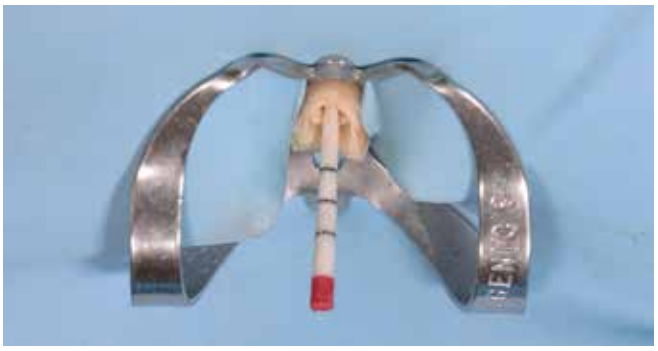
8. Try-in of a 3M™ RelyX™ Fiber Post size 2 (red) and marking of the final length following root canal preparation using drills from the same system.

TIP

The ratio of the post in the canal versus in the build-up is ideally 2/3 to 1/3.



9. Extraoral shortening of the post using a diamond disk.



10. Drying with a paper tip after rinsing of the root canal with a 2.5 % sodium hypochlorite solution and rinsing with water.

11. Application of 3M™ RelyX™ Unicem 2 Self-Adhesive Resin Cement into the root canal using an endo tip prior to placing the shortened post.

TIP

With 3M™ RelyX™ Unicem 2 Self-Adhesive Resin Cement, no separate etching, priming or bonding is needed in the root canal. Pre-treatment of the post is also not required for cementation.

12. Application of 3M™ Scotchbond™ Universal Adhesive to the post and the tooth structure. The universal adhesive should be rubbed in for 20 seconds, air-dried not less than 5 seconds until no more ripples are observed and the solvent is evaporated, and light-cured for 10 seconds.

13. Build-up of the core with 3M™ Filtek™ One Bulk Fill Restorative in the shade A3. The material may be placed in layers of up to 5 mm.

14. Core build-up ready for preparation.

15. Situation after preparation.
(Images courtesy of Dr. Stefan Vandeweghe)

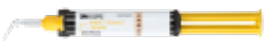
Conclusion

When retention is insufficient in the context of post-endodontic restorative treatment, the placement of a fiber post is often a suitable option. Important preconditions include a 2-mm ferrule in anterior teeth and premolars, and at least one remaining wall in molars with a subgingival margin position and no space in the pulp chamber.

In this procedure, success is simplified by use of a post-and-core system that enables the dental practitioner to reduce the number of work steps. The product combination shown here, for example, simplifies cementation in the root canal, adhesive application and core build-up. Most important for predictable results, however, is a standardization of the clinical protocols in the dental office. The criteria for decision-making presented here lay the foundation for a long life of the planned indirect restoration.

Available 3M products

Cement



3M™ RelyX™ Unicem 2 Self-Adhesive Resin Cement

Post

3M™ RelyX™ Fiber Post 3D Glass Fiber Post

Adhesive

3M™ Scotchbond™ Universal Adhesive

Composite

3M™ Filtek™ One Bulk Fill Restorative

Preparation design
Procedure step 3

Preparation quality has a decisive impact on the longevity of the final restoration. Carrying out tooth preparation in the desired way, however, is often a challenging task. Biology needs to be respected on the one hand, and the production process and material requirements on the other. The situation is further complicated by the availability of a huge number of different instruments, which are suitable for certain geometrical forms – e.g. occlusal onlay preparations.

In order to simplify decision making in tooth preparation, standardization is – again – the most promising approach. In this context, it is essential to determine the number of different designs used in specific clinical situations, and the number of instruments needed to obtain the desired results. Especially with regard to this task, it is good to remember that less is often more.

Available designs and selection criteria

Available options include crown preparations, preparations for inlays, onlays, partial crowns, tabletops, veneers and different kinds of bridges. Three main factors determine the preparation design: the indication, the amount of healthy tooth structure and the selected restorative material.

With respect to the remaining tooth structure, the basic rule is to avoid substantial loss of hard tissue. Hence, clinicians should always select the most conservative form of tooth preparation that can be realized in a specific case. In order to simplify the following procedure steps, the preparation margin should be placed in a supragingival position whenever possible.

The selected restorative material has an impact on the preparation design in that it requires a minimum wall thickness and specific connector strength (for bridges). With regard to brittle glass ceramics and zirconia, these parameters are dependent mainly on the flexural strength of the material. With increasing strength, the required thickness of the material decreases. When a porcelain layer is added (veneering), additional space is required, which must also be taken into account when selecting the preparation design. The minimum wall thicknesses of different restorative materials are listed in Table 1.

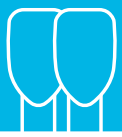
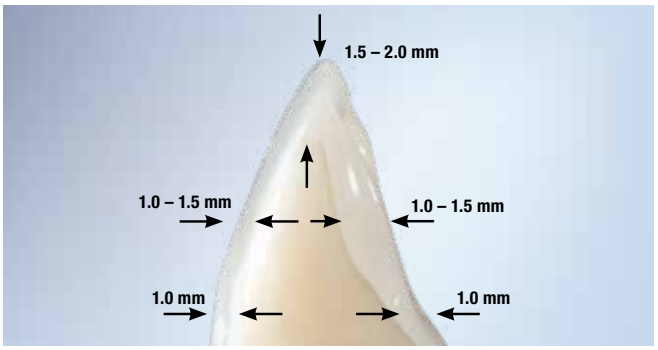
Material	Anterior 	Posterior 
3Y-TZP Zirconia (e.g. 3M™ Lava™ Plus High-Translucency Zirconia)[1]	0.3 mm	0.5 mm
5Y-TZP Full-contour Zirconia (e.g. 3M™ Lava™ Esthetic Fluorescent Full-Contour Zirconia)[1]	0.8 mm	0.8 mm
Lithium Disilicate (e.g. IPS e.max® CAD, Ivoclar Vivadent)	1.0 to 1.5 mm	1.0 to 1.5 mm
3Y-TZP Zirconia plus veneering porcelain (e.g. 3M™ Lava™ Frame Zirconia)[1]	1.5 to 2.0 mm	1.5 to 2.0 mm
Porcelain fused to metal	1.5 to 2.0 mm	1.5 to 2.0 mm

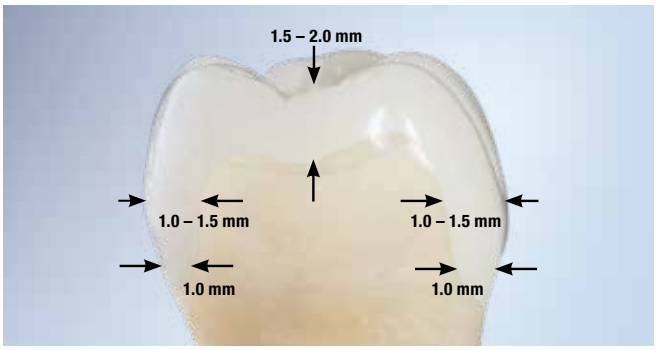
Table 1: Minimal necessary wall thickness for material stability.

[1]Values for specific material according to manufacturer recommendation.

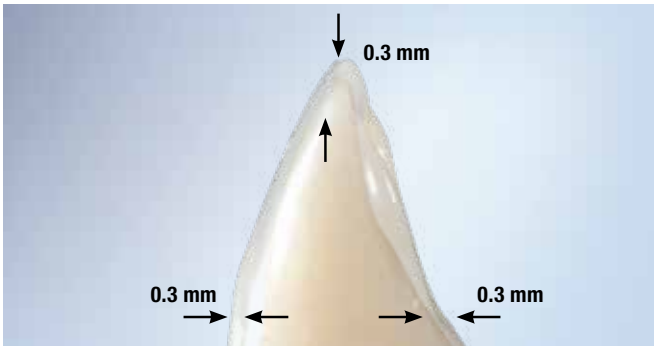
The following images reveal how an ideal crown preparation design in incisors and molars is used to realize ideal material thicknesses. Figures 1 and 2 show prepared teeth below veneered 3Y-TZP Zirconia copings, and Figures 3 and 4 show prepared teeth under monolithic 3Y-TZP Zirconia copings.



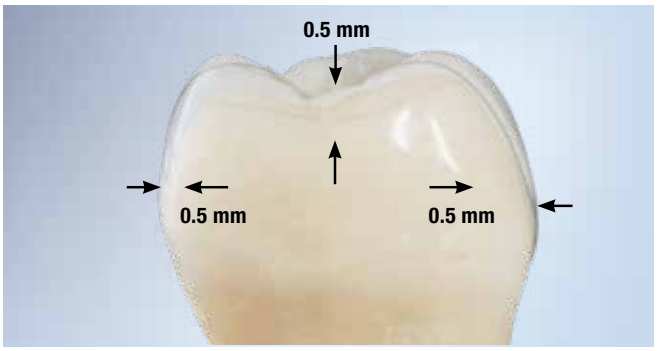
1. Recommended preparation for a veneered anterior crown made of 3M™ Lava™ Plus High-Translucency Zirconia.



2. Recommended preparation for a veneered posterior crown made of 3M™ Lava™ Plus High-Translucency Zirconia.
(Images courtesy of Dr. Carlos Eduardo Sabrosa)



3. Recommended preparation for a monolithic anterior crown made of 3M™ Lava™ Plus High-Translucency Zirconia: Minimum wall thickness of 0.3 mm.



4. Recommended preparation for a monolithic posterior crown made of 3M™ Lava™ Plus High-Translucency Zirconia: Minimum wall thickness of 0.5 mm.
(Images courtesy of Dr. Carlos Eduardo Sabrosa)

Crown preparation: Clinical parameters and essential instruments

Over the years, the basic principles for crown preparations remained the same. In general, it is recommended to place the margin in a supragingival position, and to create:

- a circumferential continuous and clearly visible chamfer or rounded shoulder,
- convergence angles between 6 and 15 degrees,
- an abutment height of 4 mm if conventional cementation is desired,
- no bevels nor undercuts,
- and rounded occlusal and incisal edges.

5. Example of a high-quality anterior tooth preparation for a crown.
(Image courtesy of Dr. Paulo Monteiro)

While many different types of instruments for tooth preparation are available on the market, only two geometrical forms are required:

- Shoulder (flat end taper) bur
- Chamfer (round end taper) bur

A smooth surface structure, ideal for adhesive bonding (needed with non-retentive preparation designs and low-strength ceramics), is easily obtained using carbide burs. For restorations relying on micromechanical retention, a rough surface is required, which is best created with diamond cutting instruments.

Recommendations for guided structure removal

One of the biggest challenges in the context of conservative tooth structure removal is estimating how much space needs to be, or has already been, removed. A purely visual check of the preparation depth is usually insufficient. Therefore, it is important to use specific tools or instruments that support guided tooth structure removal.

Possible options:

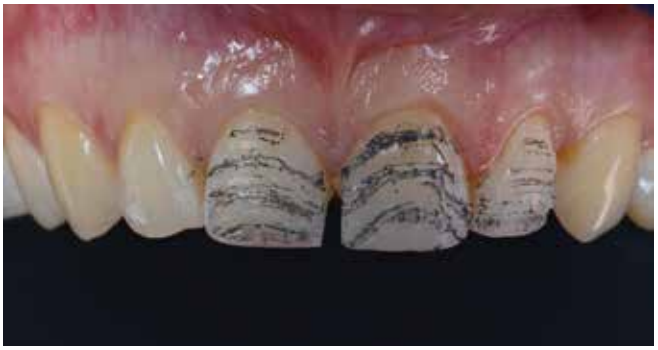
- Preparation though a mock-up and use of specific instruments with depth cutters
- Use of a silicone index to check the space created

6. Wax-up on a model.

7. Silicone index produced on the model with wax-up.

8. Sliced silicone index in the patient's mouth.

9. Use of the index to check how much space is created in different areas of the tooth.
(Images courtesy of Dr. Carlos Eduardo Sabrosa)



10. Preparation through a mock-up using instruments with depth cutters to ensure minimally invasive structure removal.
(Image courtesy of PD Dr. Jan-Frederik Güth)

Conclusion

Being as conservative as possible and providing the best possible support for the selected restorative material – these are the main goals every clinician should have in mind when selecting the preparation design. Its implementation is usually less complex than it seems at first thought, as the basic forms have remained the same for all restorative materials and differences exist only with regard to the required space. With modern restoration materials and adhesive bonding possibilities, which enable a less invasive approach to the preparation design, it is recommended to preserve as much tooth structure as possible.

Temporization
Procedure step 4

While the importance of temporary restorations is often underestimated, they fulfill many different functions which are crucial to the final treatment outcome. They provide interim protection to the underlying tooth structure, function and esthetics. In addition, the provisional restoration can help to condition the gingival tissues prior to making the final impression. If the soft tissue is healthy and well adapted, it will ease the impressioning and cementation procedure, with a positive impact on the treatment outcome including pink and white esthetics. Finally, yet importantly, within complex rehabilitations, the temporary is also used as a basis for the production of the final restoration, a “mock up” allowing for a therapeutic clinical test drive. In order to accomplish these tasks, the selected material should meet certain requirements in terms of marginal quality, mechanical strength, as well as mechanical and dimensional stability.

Available options and selection criteria

Four main material options for temporary restorations are available:

- Conventional materials based on methacrylate resins (e.g. Unifast III GC)
- Materials based on bis-acrylic / composite resins (e.g. 3M™ Protemp™ 4 Temporization Material)
- Pre-formed composite crowns (e.g. 3M™ Protemp™ Crown Temporization Material)
- Industrially fabricated PMMA disc (CAD/CAM production)

While the first three options are designed for direct production techniques, PMMA milling discs require the use of an indirect computer-aided production procedure. Some important factors in deciding which material to use are esthetics (site in the mouth); duration of the temporization phase (short-term = up to four weeks versus long-term = 4 weeks to 12 months); size of restoration (short or long-span bridges); and the amount of available tooth structure (Table 1).

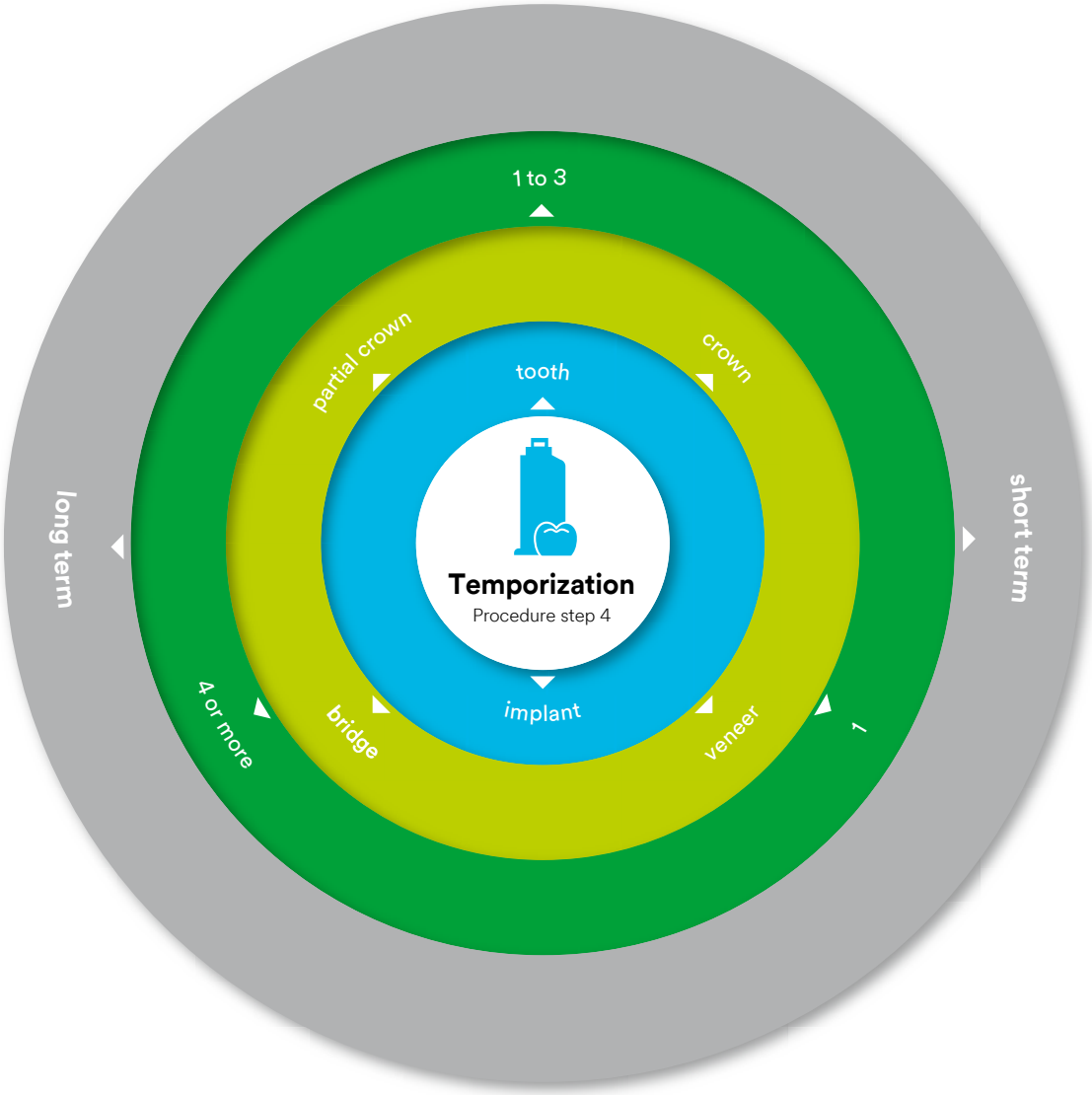


Table 1: Decision criteria and distinctive factors guiding the selection of the temporization material and technique.

If the pre-existing anatomy of the tooth is available and the temporization period will be completed within one year (usual short-term and long-term temporization), a bis-acrylic resin is the recommended material option using a direct matrix. Bis-acrylic materials have high mechanical strength and dimensional stability, superior esthetics, a lower setting temperature and polymerization shrinkage (for a precise fit) as well as better mixing quality as they may be delivered through an automix syringe. In comparison, conventional acrylics offer good fracture resistance and lower cost, but are generally inferior in strength as well as in dimensional stability and more difficult to use. Nowadays, CAD/CAM PMMA is the material of choice for indirect temporary restorations where the highest strength is needed.

If the pre-existing anatomy is not available at the beginning of treatment, there are different options to choose from. Usually, a matrix is produced on the basis of a wax-up and it is recommended to use bis-acrylic. One option available for a single-unit restoration in the posterior region is a pre-formed composite crown (3M™ Protemp™ Crown). This material is an excellent option for single unit crown and partial coverage restorations, where its high strength and moldability is advantageous when more conservative preparations have been made. Again, for any long-term temporization that takes longer than a year, the CAD/CAM procedure using PMMA discs is a viable option.

1. Crown made of 3M™ Protemp™ Crown Temporization Material. (Image courtesy of Dr. Paulo Monteiro)

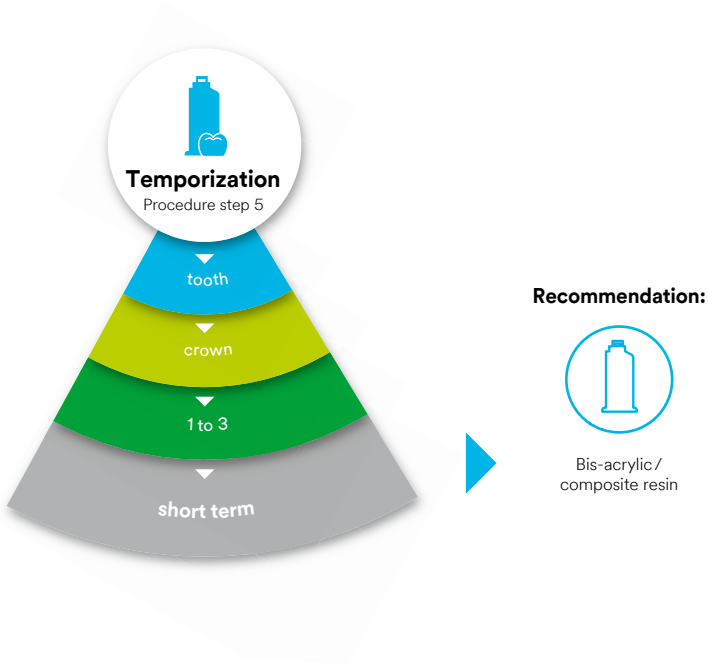
For cementation of the temporary restorations, a temporary cement (e.g. Temp-Bond™ NE, Kerr; 3M™ RelyX™ Temp NE Temporary Cement) is usually applied. Whenever the selected material for the definitive placement of the final restoration is resin cement, a temporary cement that does not contain eugenol is to be used. For long-term temporization, the use of permanent conventional or self-adhesive cements should be taken into consideration.

Clinical procedure: Direct fabrication of temporaries

The production of temporaries with bis-acrylic resin – e.g. 3M™ Protemp™ 4 Temporization Material – is simple, easy and predictable. In this case, a preliminary impression is used as a matrix, and the provisional restoration is ready within a few minutes.

2. Material combination recommended by 3M: 3M™ Imprint™ 4 Preliminary Impression Material and 3M™ Protemp™ 4 Temporization Material. (Image courtesy of Dr. Akit Patel)

Otherwise, a matrix can be produced in the laboratory based on a wax-up. When using Protemp 4 material, finishing and polishing is not necessary on the buccal or labial surfaces other than to simply wipe the outer surface with alcohol to remove its thin oxygen-inhibition layer. Shaping and occlusal adjustments precede as normal. The following clinical examples reveal how the material may be used to meet specific demands in different clinical situations. The last example shows an alternative temporization option for single teeth – the placement of a self-supporting, malleable, light-curable composite crown.



Case 1

3. Preliminary impression taken with a handmix putty as an alternative to 3M™ Imprint™ 4 Preliminary prior to tooth preparation.

4. Use of 3M™ Astringent Retraction Paste for hemostasis prior to repositioning of the impression filled with temporization material in the mouth.

TIP

The use of retraction cords and / or pastes in this treatment phase will contribute to an enhanced marginal quality of the temporary restoration, which, in turn, will provide favorable soft tissue conditions during impression and cementation.

5. Dispensing of the bis-acrylic resin (3M™ Protemp™ 4 Temporization Material), which offers a 40-second working time, into the preliminary impression.

TIP

Syringe around the margins after matrix is filled for optimal marginal imprint.

TIP

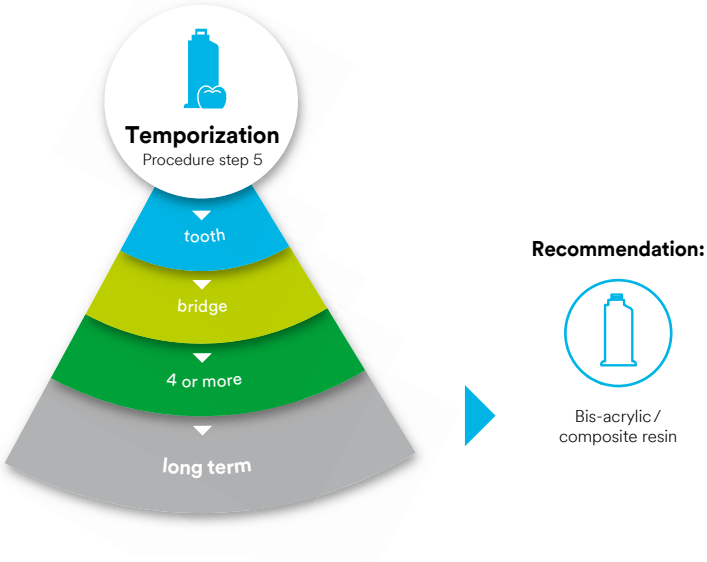
Intra-orally remove excess from neighboring undercuts whilst setting (wait until clean cuts can be made).

6. Temporary removed from the impression after final setting. Removal from the mouth is possible after 1:40 to 2:50 minutes from the onset of mixing, while the material should be left in the impression for 5:00 minutes after start of mixing before it is removed from the matrix.

7. The oxygen inhibition layer is simply removed with a gauze pad soaked with ethanol.

8. Resulting temporary crown after gingival and occlusal finishing and polishing.

9. Temporay in place.
(Images courtesy of
Dr. Carlos Eduardo Sabrosa)



Case 2

10. Situation after tooth preparation.

11. Impression of the prepared teeth used for the production of a model and a wax-up in the laboratory.

12. Dispensing of 3M™ Protemp™ 4 Temporization Material into the matrix produced in the laboratory on the basis of the wax-up. Thanks to a high dimensional stability of the material, it is also very well suited for multi-unit temporaries.

TIP

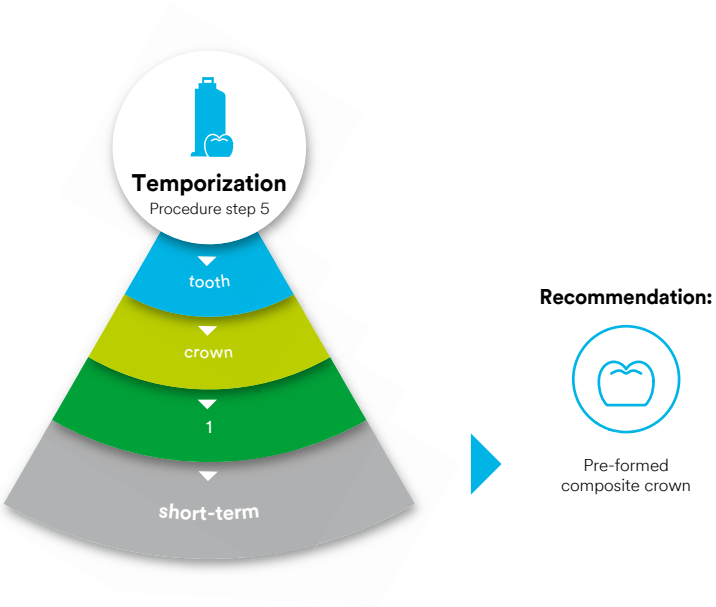
To prevent void formation, it is essential to fill from the bottom up and to always keep the mixing tip immersed in the material.

13. Placement of the matrix filled with resin into the patient's mouth. The matrix may be removed after 1:40 to 2:50 minutes from the onset of mixing.

14. Temporary immediately after its removal from the matrix.

15. Temporary restoration in the patient's mouth.

16. Final restorations.
(Images courtesy of PD Dr. Jan-Frederik Güth)



Case 3

17. Initial situation with a fractured restoration that needs to be replaced.

18. Prepared abutment tooth ready for the precision impression and for placement of the prefabricated, malleable composite crown for temporization.

19. Crown made of 3M™ Protemp™ Crown Temporization Material placed in the patient's mouth after trimming, intraoral fitting and adaptation to the adjacent and opposing teeth, light curing and finishing.

20. Final restoration in place.
(Images courtesy of
Dr. Paulo Monteiro)

Conclusion

The temporization phase plays an important role within the indirect restorative workflow. Bis-acrylic resins have advantages in their strength and esthetics, which make them versatile for most direct temporization procedures. When single-unit posterior restorations are produced, the pre-formed composite crown may also be a suitable option for temporization.

In order to produce a temporary with a precise marginal fit that supports the healing and correct contouring of the soft tissues, clinicians should have a dry and well-retracted field. It is therefore recommended to use mechanical and chemical tissue management techniques by means of retraction cords, astringents and / or pastes for effective tissue displacement and hemostasis (margin position dependent).

As in the other procedure steps, standardization is a decisive measure. It brings routine into the selected procedures and helps eliminate potential sources of error.

Available 3M products

3M™ Imprint™ 4 Preliminary VPS Preliminary Impression Material

3M™ Protemp™ 4 Temporization Material

3M™ Protemp™ Crown Temporization Material

3M™ RelyX™ Temp NE Temporary Cement

3M™ Sof-Lex™ Contouring and Polishing Discs

3M™ Sof-Lex™ Diamond Polishing System

3M™ Astringent Retraction Paste

Impression taking
Procedure step 5

In the impression taking procedure, several different materials and techniques are available. Elastomers are the best materials to comply with the requirements needed for indirect restorations. Polyether, for example, produces highly accurate results in a single step using one or two different viscosity materials (monophase or one-step). Vinyl polysiloxane (VPS) is the most widely used material for one- or two-step techniques, again using two different viscosities. In many clinical situations, digital impression taking is now a predictable method that facilitates a direct transfer of the intraoral situation into the virtual world of CAD/CAM procedures.

Hence, while there are some restrictions, there is usually more than one possible technique to success and the decision is often based on individual preferences; however, some are recommended more than others. In this context, standardization appears to be the most decisive factor for success. Using the same materials and workflow every time will lead to mastering techniques and delivery of a quality impression and facilitate collaboration and communication with the dental laboratory. The most important piece of information is the impression, a prerequisite for predictable results in achieving best fitting restoration for marginal integrity and fewest chairside adjustments.

In the following, clinical recommendations are given separately for preparation steps like gingiva management and tray selection, as well as for impression taking itself. Each choice should be based on the following criteria: Substrate (tooth or implant), indication, margin position, and number of prepared teeth (Table 1).

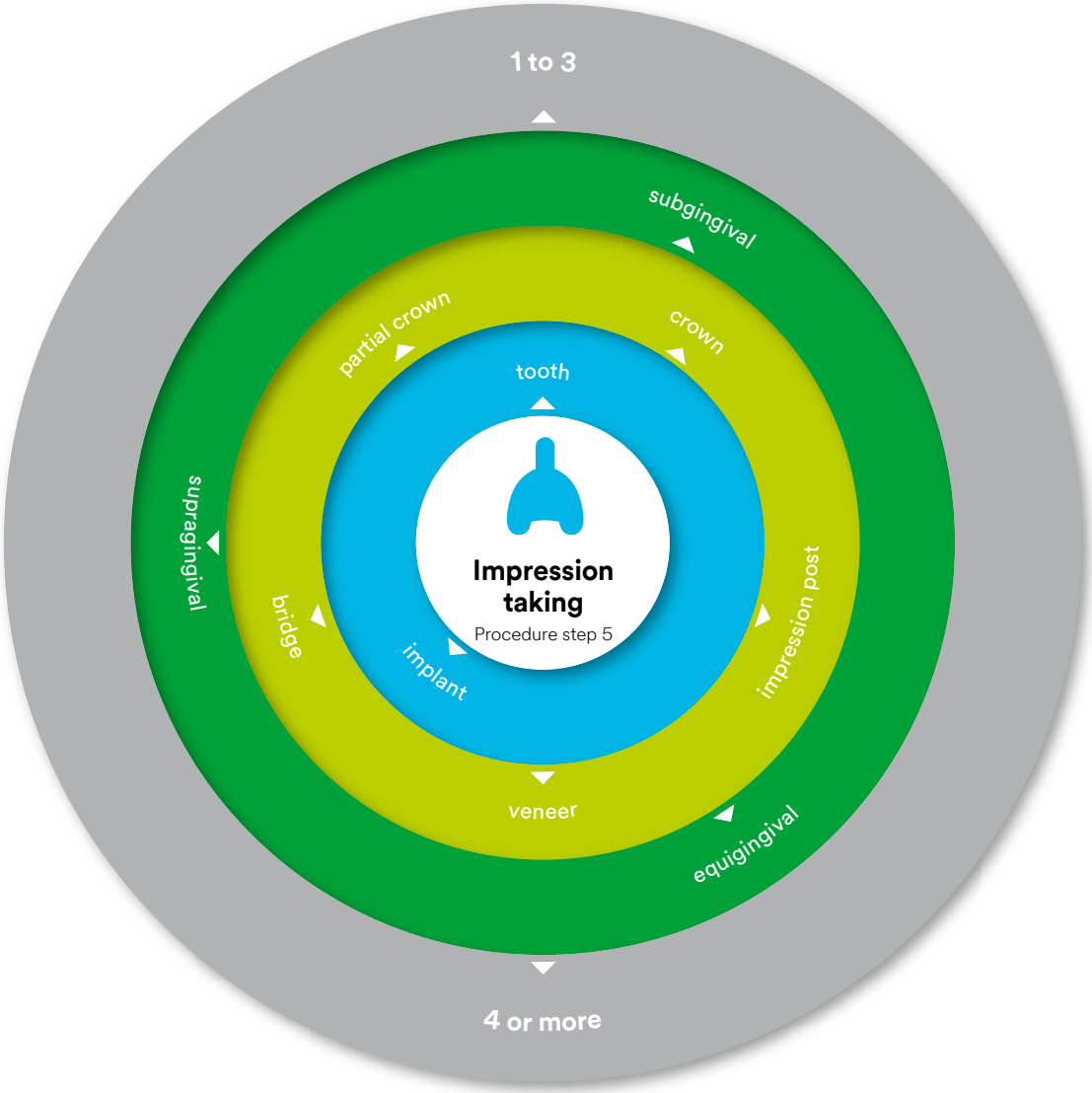


Table 1: Decision criteria and distinctive factors guiding the selection of the best suitable technique for retraction and hemostasis, the impression tray and the impression material.

1. Retraction and hemostasis

Healthy tissues are an important basis in allowing the clinician to capture an accurate impression. Hence, the process should be postponed whenever the soft tissue shows signs of marked inflammation. In this case it is recommended to condition the gingiva with a provisional restoration and optimization of home cleaning regime. Impression taking should be delayed for a minimum of two weeks or until the soft tissue environment has improved. This way, a high-quality impression is ensured.

As the impression material is only able to reproduce what is visible and not covered by tissue, the dentist needs to ensure that the preparation margins are accessible and a 360° ridge of material can flow beyond the margins. Depending on the margin position, different procedures are recommended for management of the gingiva, as shown in Table 2.

✓ recommended (✓) possible ✕ not recommended

Margin Position	3M™ Astringent Retraction Paste	Single cord (braided / knitted + AlCl)	Double cord (braided / knitted + AlCl)
Supra-gingival	✓	(✓)	✕
Equi-gingival	✓ (for hemostasis, used on top of cord)	✓	(✓)
Subgingival	✓ (for hemostasis, used on top of cord)	(✓) (in cases with thin gingiva biotype)	✓

Table 2: Summary of clinical recommendations for appropriate gingiva management.

Recommendations from the expert group:

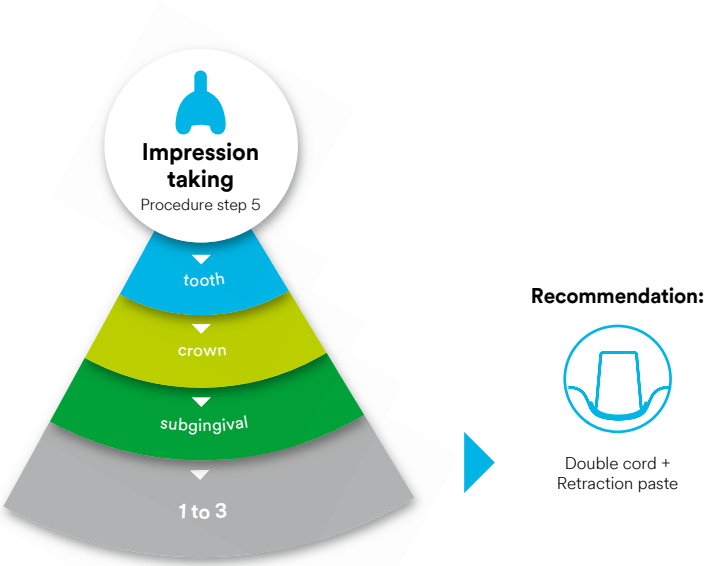
Supra-gingival margin position: If the margin is in a supragingival position, it is not usually necessary to retract the gingiva, however, this is dependent on the proximity of the margin in relation to the gingiva. For some retraction and for hemostasis, single cord (braided or knitted) and / or 3M Astringent Retraction Paste may be used.

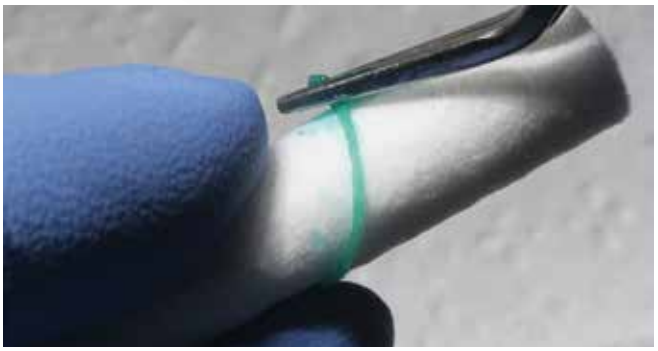
Equigingival margin position: If the preparation margin is at the level of the gingiva, at least one retraction cord (braided or knitted, soaked with aluminum chloride) should be used. The double-cord technique is not recommended in patients with thin gingival biotype if working in the esthetic zone. Astringent Retraction Paste may be used as an adjunct for retraction and hemostasis on top of the first cord.

Subgingival margin position: In this case, the best possible results are obtained using the double-cord technique. Again, braided or knitted retraction cords soaked with aluminum chloride should be used. Astringent Retraction Paste may be used as an adjunct for retraction and hemostasis on top of the second cord (space permitting) and / or after removal of the second, where bleeding may persist.

Clinical procedure – retraction

Selection criteria for choosing the right tissue management technique should take into account the margin position, gingiva biotype and the amount of bleeding. Regardless of the technique, the tissues need to be respected and therefore any displacement should be carried out with minimum trauma. One of the recommended procedures – the use of the double-cord technique on a molar with a subgingival crown margin – is illustrated in the following clinical photographs.





1. Excess aluminum chloride removed from a pre-soaked retraction cord using a cotton roll.

2. Placement of the first retraction cord (size 00, GingiKNIT+, Kerr). This cord should NOT be removed during impression taking (this also applies to the single-cord technique).

3. Occlusal view with the first cord barely visible in the sulcus.

4. Occlusal view with the second, thicker cord placed on top of the first one.

TIP

Always choose the largest possible size that will fit into the sulcus. A periodontal probe to gauge the sulcus width and depth may be used to determine the cord size.

5. Application of 3M™ Astringent Retraction Paste into the sulcus (to stop bleeding whilst maintaining tissue retraction after removal of the second cord).

6. 3M™ Astringent Retraction Paste applied on top of the first cord.

7. Complete removal of the paste after 2 min incubation time with air-water spray and suction.

8. Situation ready for the precision impression. 3M™ Astringent Retraction Paste offers a hemostatic effect and some retraction. (Images courtesy of Dr. Akit Patel).

2. Impression tray selection

For precision impressions, a rigid, sturdy impression tray made of metal, acrylic or plastic should be selected. Rigidity is an important property, as deformation of the tray and / or material will lead to inaccuracies in the final impression. The use of a non-perforated rigid plastic tray is highly recommended with uniform space (2 to 3 mm) around the teeth.

9. Rigid, non-perforated metal and plastic trays are recommended in most cases. (Source: 3M Oral Care)

Whenever the trays do not offer the desired fit, stops and supports may be added. VPS putty, composite tray or impression compound material may be used to place dorsal stops, occlusal stops and palatal support.

10. Placement of dorsal stops on a metal tray ...

11. ... using Green Stick Impression Compound (DPI). (Images courtesy of Dr. Akit Patel)

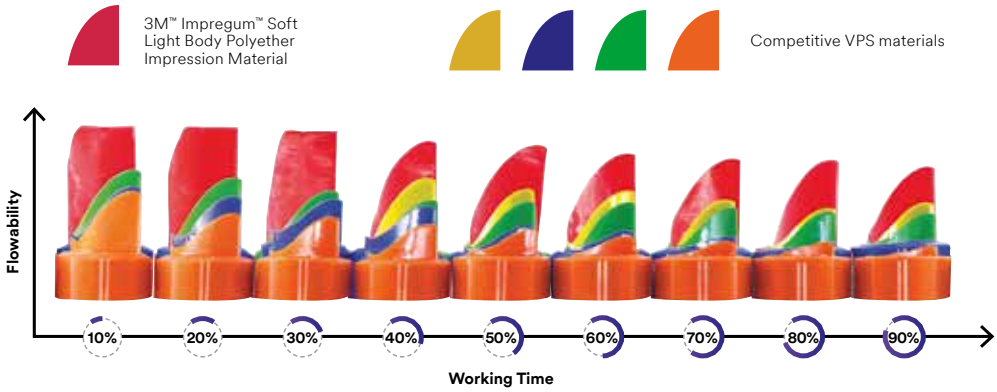
For metal and rigid plastic trays, the use of a tray adhesive is mandatory. Clinicians should be careful to use an adhesive that is compatible with the selected impression material, i.e. polyether tray adhesive for polyether impression materials and VPS tray adhesive for VPS materials. Only rigid plastic trays with an internal fleece such as the 3M™ Impression Tray do not need any tray adhesive. An alternative option is the production of custom trays for example in complex cases, an abnormal arch form or patients with pronounced gag reflexes.

12. Single-use 3M™ Impression Tray designed with a fleece strip, which eliminates the need for a tray adhesive. (Source: 3M Oral Care)

3. Impression material and technique

There are primarily two materials that are widely accepted for precision impressions: Polyethers and A-type (addition-cured) silicones (VPS). Due to their low cost, C-type silicones (condensation-cured) are also still being used in some dental practices. However, their material-inherent high polymerization shrinkage leads to an inferior dimensional accuracy of the impression and therefore their use is not recommended for precision work.

Polyether impression materials are hydrophilic by their inherent chemical nature, which supports precise capturing of detailed surfaces in the moist oral environment. In addition, they offer a constant flowability throughout the working period, with a rapid set in the end resulting in high predictabilty and reliable accuracy. Other properties of polyether include its very low shrinkage, a good elastic recovery, high rigidity, tear strength and dimensional stability. Polyether impression materials are suitable for monophase and 1-step techniques. When the medium-body material is used in the monophase technique, the material exhibits shear thinning, so the material acts in the same way as a light bodied viscosity material to capture fine detail reproduction.



13. Shark-fin challenge throughout the working time: The higher the fin, the better the flowability of the impression material. The best result by far is obtained with 3M™ Impregum™ Polyether Soft Light Body Impression Material. (Image courtesy of Dr. Carlos E. Sabrosa)

A-type silicones – also known as VPS impression materials – are hydrophobic (i.e. water-resistant). By the addition of surfactants (wetting agents), it is possible to increase the material's hydrophilicity even in the unset state. In addition, there are great variations of the flow behavior during the working time offered by different materials with a flow reduction seen especially towards the end of the working time. General advantages of VPS are their superior elastic recovery, high dimensional stability over time, and neutral taste.

14. Hydrophilicity of VPS materials: Water droplet applied to the interface of two unset light body VPS impression materials 40 sec. after start of mixing. The water droplet is clearly attracted by the more hydrophilic 3M™ Imprint™ 4 VPS Impression Material (far right). (Source: 3M Oral Care internal data. Data available on request at 3M Oral Care)

Generally, polyether and VPS impression materials are suitable for making impressions of natural teeth and implants. Due to the higher hydrophilicity and constant flow behavior of polyethers, they may show a superior reproduction of the relevant details, especially in more complex cases where extra working time is needed. Based on this assumption, they are often preferred in clinically challenging situations and recommended for implant cases with multiple units. Our recommendation is that if a VPS impression material is used, the clinician should select a product, which is hydrophilic in the unset state and offers good flow properties; e.g. 3M™ Imprint™ 4 VPS Impression Material.

+ superior – inferior

	Polyether	VPS
Constant flowability	+	–
Rigidity	+	–
Intrinsic hydrophilicity	+	–
Universal applicability	+	–
Storage stability	–	+
Mouth removal	–	+

Table 3: Comparison of polyether vs. VPS impression materials based on the expert consensus.

✓ recommended ✕ not recommended

	Monophase technique	1-step technique	2-step technique
Polyether	✓	✓	✕
VPS	✕	✓	✓

Table 4: Overview of recommended impression techniques per material.

The **material viscosity** should be chosen depending on the technique used. The following are recommendations for an optimized outcome:

Monophase technique: medium body in syringe and tray (polyether)

One-step technique: medium / heavy body in tray and light body wash in syringe and optionally, in the tray (polyether or VPS)

Two-step technique: putty in tray and light body in syringe and in tray (VPS)

	Monophase technique	1-step technique	2-step technique
Polyether	Medium body	Medium / heavy body + light body	–
VPS	–	Medium / heavy body + light body	Putty + light body

Table 5: Technique-dependent material viscosity recommendations.

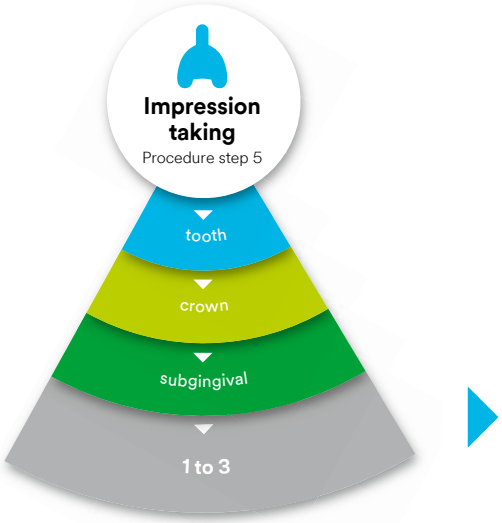
Finally, the **working and setting times** may be selected depending on the number of prepared teeth or implants. Working speed is an operator-dependent factor that needs to be selected individually. The recommendations below are based on the experts' experience.

✓ recommended ✕ not recommended

	1 to 3 prepared teeth or implants	4 or more prepared teeth or implants
Fast Set (Super Quick)	✓*	✕
Regular Set (Regular)	✓	✓

Table 6: Choice of material regarding setting time, based on number of units.

* for monophase (medium body) materials, it is recommended to use the super quick material for single-unit cases only.



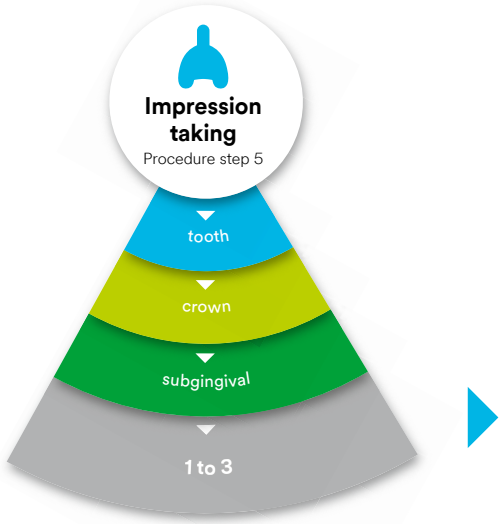
Recommendation:

Polyether

Fast set

15. 1-step impression taken with 3M™ Impregum™ Super Quick Polyether Impression Material (Heavy Body and Light Body).

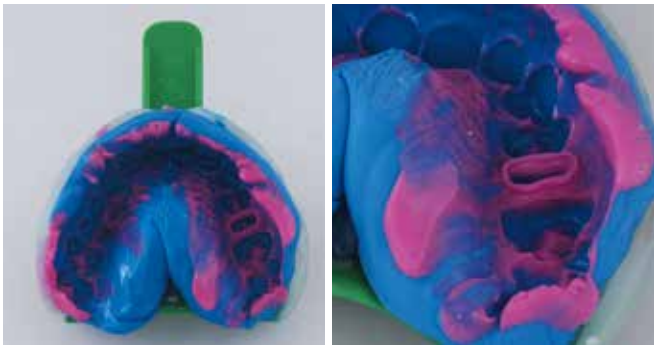
Excellent representation and good control possibility of the relevant details.
(Images courtesy of PD Dr. Jan-Frederik Güth)



Recommendation:

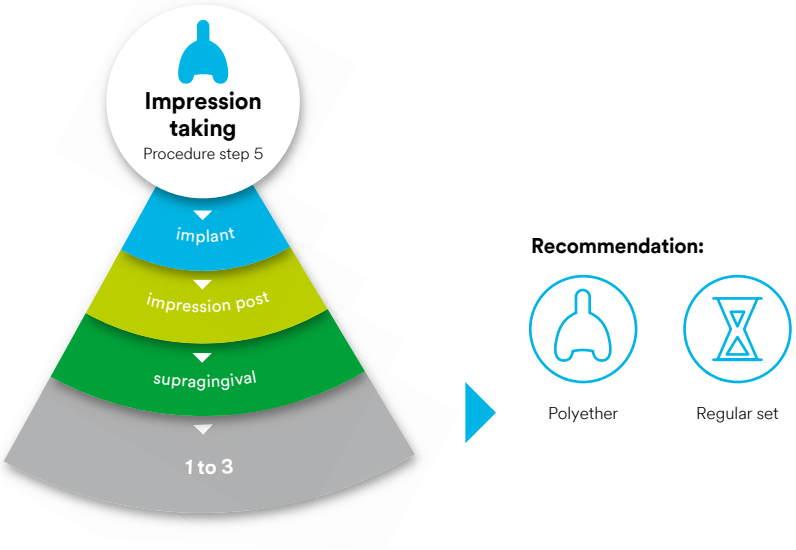
VPS

Fast set



16. Impression taken with 3M™ Imprint™ 4 Penta™ Heavy Body and 3M™ Imprint™ 4 Light Body VPS Impression Material in the 1-step technique. This impression material is also able to capture the relevant details very precisely.
(Source: Dr. Carlos E. Sabrosa)

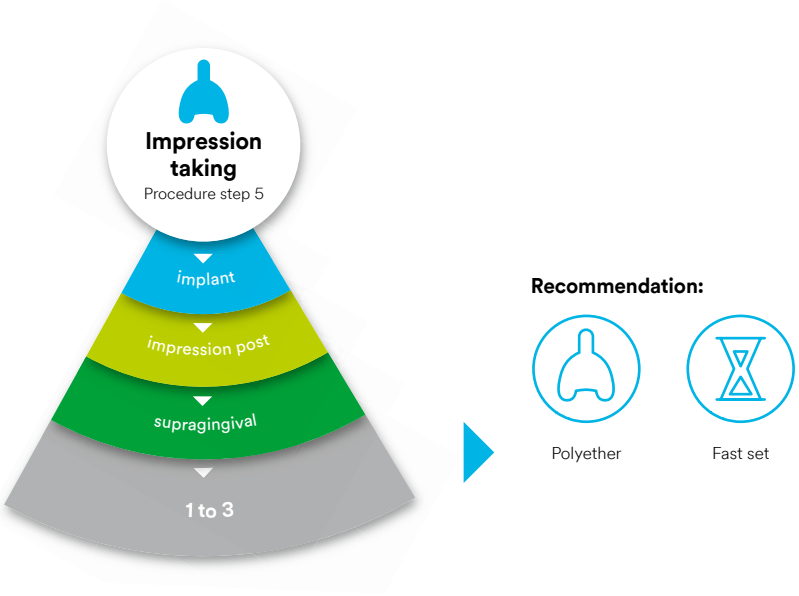
The recommended implant impression techniques include: open tray (direct) pick-up; closed tray (indirect) transfer; closed tray (direct) snap-on. They work well with any polyether and for single-implant cases also with heavy and light body VPS impression materials.



17. Open custom tray (direct) pick-up with two impression posts in place.

18. 3M™ Impregum™ Penta™ Medium Body Polyether Impression Material using monophase technique.

19. Detailed impression with impression posts. (Images courtesy of Dr. Akit Patel)



20. Closed tray (indirect) transfer using an impression post

21. Syringing of 3M™ Impregum™ Penta™ Soft Quick Medium Body Polyether Impression Material around the post.

22. Impression taken in the monophase technique with coping in-situ. (Images courtesy of Dr. Akit Patel).

Conclusion

When planning to take precision impressions, the clinician needs to make several decisions: to manage the soft tissues atraumatically, to choose the correct tray for optimum support and flowability of the material; to match the material and technique correctly to the indication in order to obtain the desired result.

With so many variables in the procedure, it is essential to standardize procedures. This should include checking several factors before and after the impression. Before, clinicians should ensure that:

- there is uniform space (2 to 3 mm) around the teeth
- all distal teeth are included
- path of insertion and removal is rehearsed
- any necessary undercuts are blocked out

Afterwards, they should check if:

- all required details (teeth, prep and margins) are recorded
- impression material is sealed to the tray

With these factors in mind, it will be possible to provide highly accurate impressions to the dental laboratory.

Available 3M products

1. Retraction and hemostasis

3M™ Astringent Retraction Paste

2. Tray

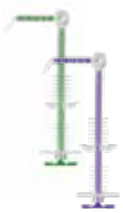
3M™ Impression Tray

3. Impression taking

3M™ Imprint™ 4
VPS Impression Material

3M™ Impregum™
Polyether Impression Material

3M™ Pentamix™ 3
Automatic Mixing Unit



3M™ Intra-Oral Syringe
Green / Purple

Cementation
Procedure step 6

Different restorative materials – different cementation needs: dental practitioners are often facing difficulties when they want to place a tooth-colored ceramic restoration. Due to distinctions in the mechanical properties and chemical composition, requirements regarding substrate pretreatment and cement type vary widely. However, the situation is not as complex as it might seem at first, provided that some basic principles are respected. The goal is to select a limited number of products, which cover all possible indications. In conjunction with a standardization of procedures, this measure helps reduce the risk of possible errors in the process (Table 1).

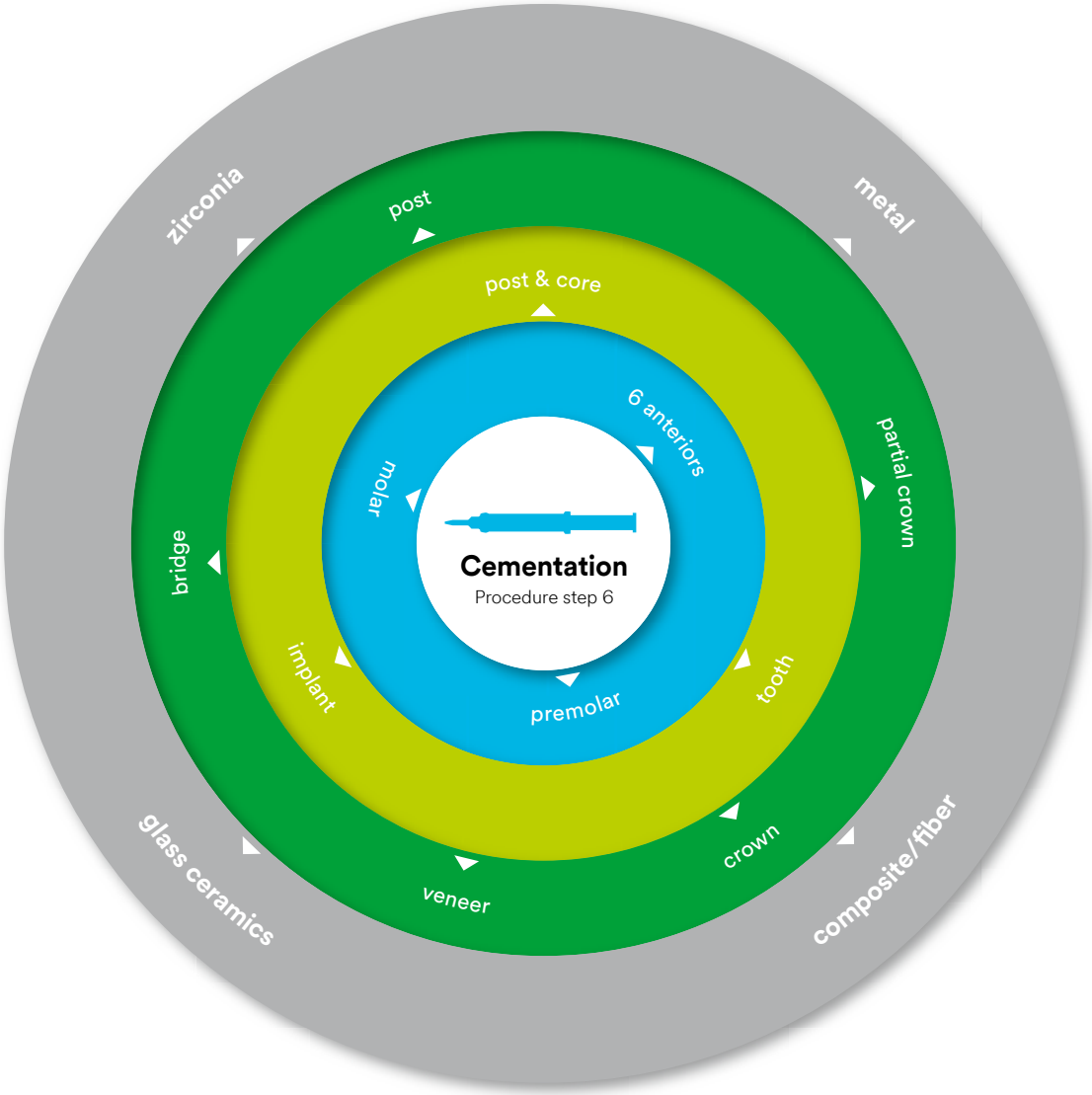


Table 3: Decision criteria and distinctive factors guiding cement selection.

Available options and decision criteria

For choosing the best suitable cementation solution, the material class and flexural strength on the one hand, and the preparation design on the other are important. Focusing on ceramic restorations, there is a need to distinguish between oxide ceramics like zirconia, and silicate ceramics such as feldspathic ceramics and lithium disilicate. With regard to the preparation design, dentists need to distinguish between designs that ensure macro-mechanical retention (e.g. crowns) and those which are non-retentive (e.g. veneers).

The kind of pre-treatment – etching with hydrofluoric acid or sandblasting – is dependent on the existence of a glass-phase in the restorative material. The desired micro-retentive surface is obtained by etching only if enough etchable particles are present. Otherwise, air particle abrasion is required. Following air particle abrasion, the intaglio of the restoration needs to be cleaned e.g. with sodium hypochlorite and rinsed with water. Phosphoric acid is not suitable in this context. Recommendations are summarized in Table 2.

✓ recommended ✕ not recommended

	Silicate (Glass) ceramics	Oxide ceramics	Resin-based materials
Hydrofluoric acid etching and silane	✓	✕	✕
Sandblasting with alumina (grain size max. 50 µm, pressure 1 to 2 bar)	✕	✓	✓

Table 2: Recommendations regarding the pre-treatment of the restorative material.

Cements are divided into three categories: conventional cements including resin modified glass ionomer cements (RMGI), self-adhesive resin cements, and resin cement systems (provided with a separate adhesive). Conventional cements like zinc phosphate, glass ionomer cements and RMGIs offer relatively low adhesion values, but the benefit of simple intraoral handling. The highest adhesion values are obtained with resin cements that use a separate adhesive – at the expense of a more complex procedure. In order to combine the benefits of both cement classes, the self-adhesive cements were developed. They offer a somewhat lower adhesion than adhesive resin cements, but are easy to use as there is no need for a separate pretreatment of the tooth structure. Table 3 reveals the differences between the cement categories with regard to several clinically relevant properties.

++ very high + high - low -- very low

	Conventional cement (e.g. glass ionomer cement or RMGI)	**Self-adhesive resin cement**	**Resin cement** (plus adhesive)
Ease of use	++	+	-
Adhesion to tooth structure	-	+	++
Moisture tolerance	++	+	-
Resistance against solubility in oral medium	--	+	++
Fluoride release	++	-	--

Table 3: Summary of cement properties depending on the category.
Ratings in the table are based on the expert consensus of the five clinicians.

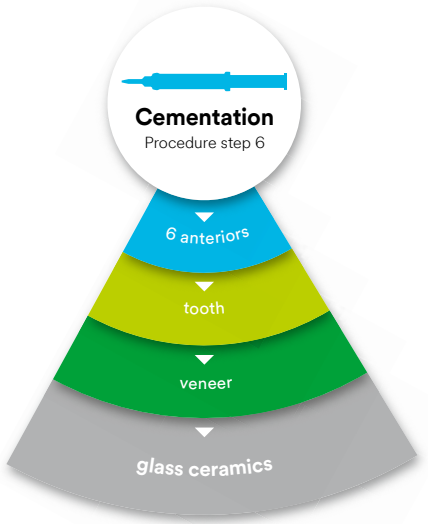
The selection of one cement from each category will lead to the desired simplification. **Conventional cements** are recommended for cementing metal-ceramic crowns and bridges to teeth and crowns to implant abutments. In the latter case, the low bond strength is beneficial as it facilitates excess removal, which is important as undetected excess causes a particularly high risk around implants.

Self-adhesive resin cements are the material of choice for all other indications that do not require ultimate bond strength, e.g. oxide ceramic crowns and bridges placed on teeth. They are also indicated for glass ceramic restorations with a retentive design.

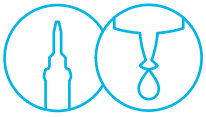
Adhesive resin cements are preferred in clinical situations with a non-retentive preparation design and for low-strength ceramics. They perform particularly well when bonding to enamel is essential, e.g. in situations with a limited bonding surface (e.g. Maryland bridges). There are dual-cure and light-cure options available. The light-cure only resin cements offer the advantage of an unlimited working time which is particularly beneficial in challenging procedures such as veneer placement.

Clinical procedure

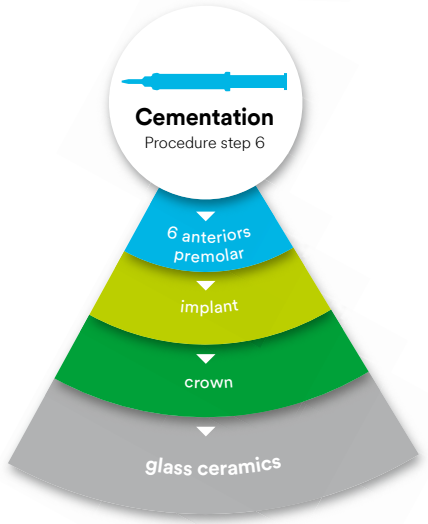
In order to demonstrate the clinical procedure for all three cement options, a patient case was selected that involves different indications for ceramic restorations placed on teeth and implants in the maxilla. The patient had multiple insufficient restorations that needed to be replaced. During previous treatments in alio loco, massive amounts of tooth structure had been removed.



Recommendation:

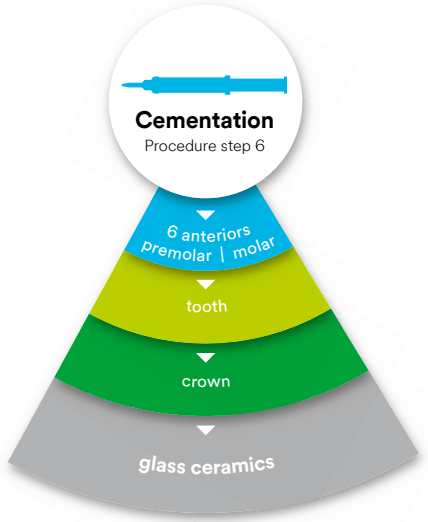


Adhesive resin cement



Recommendation:

Conventional cement



Recommendation:

Self-adhesive resin cement

1. Multiple inadequate restorations in the maxilla and mandible require replacement. Planned procedure for the maxilla: placement of implants with zirconia custom abutments in the regions of the right lateral incisor and second premolar, and the fabrication of twelve single crowns and two laminate veneers made of lithium disilicate.

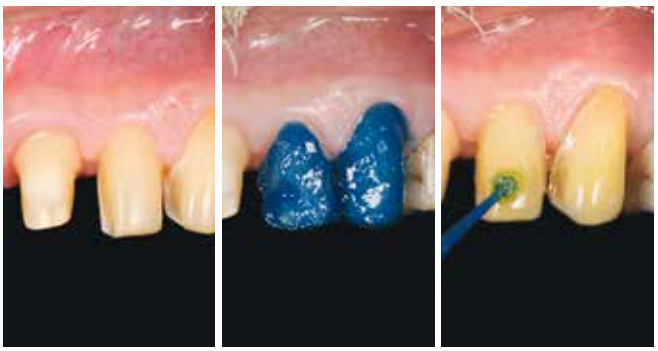
2. Occlusal view of the maxilla after successful healing of the implants, endodontic pretreatment, the placement of fiber posts and composite build-up where required.

3. Sandblasting of the abutments made of 3M™ Lava™ Frame Zirconia in order to create a micro-retentive surface for cementation of the crowns. Sandblasting is followed by polishing of the emergence profile area. Etching with hydrofluoric acid is not effective with zirconia.

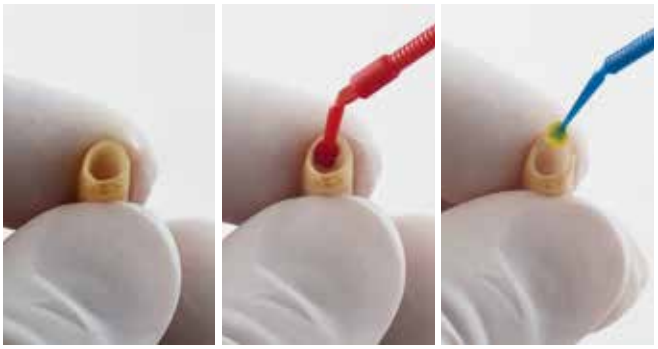
TIP

It is essential that all tooth surfaces are cleaned with oil-free pumice paste prior to cementation.

4. Situation after placement of the abutments, impression taking and cleaning of all teeth in the maxilla with an oil-free pumice paste for removal of any temporary cement residues, thorough rinsing with water and drying.



5. Adhesive pretreatment of the left lateral incisor and canine. After etching of the enamel with phosphoric acid, 3M™ Scotchbond™ Universal Adhesive is applied, rubbed in for 20 seconds and air-dried until the solvent has evaporated.



6. Conditioning of the restorations: The silicate ceramic material is etched with hydrofluoric acid and rinsed with water. After five minutes of cleaning in an ultrasonic bath, 3M™ Scotchbond™ Universal Adhesive is applied to the restorations, functioning as a silane primer.

7. Application of three different cements: 3M™ RelyX™ Unicem 2 Automix Self-Adhesive Resin Cement is used for the crowns on natural teeth. 3M™ Ketac™ Cem Plus Resin-Modified Glass Ionomer Cement is the product of choice for the cementation of crowns to implant abutments and 3M™ RelyX™ Ultimate Adhesive Resin Cement in combination with 3M™ Scotchbond™ Universal is used for the veneers.

TIP

For simplified excess removal, Ketac Cem Plus and RelyX Unicem cements may be tack cured. The curing time is at least 5 seconds for Ketac Cem Plus cement, and a maximum of 2 seconds for the self-adhesive resin cement. Afterwards, it is possible to easily cleanup the excess in large gel like pieces.

8. Final treatment result. (Images courtesy Dr. Carlos E. Sabrosa)

TIP

For highly esthetic margins, excesses of RelyX Ultimate cement should be wiped off immediately, followed by light curing under a layer of glycerin gel to avoid oxygen inhibition layers. Tack-curing is not recommended as this type of cement cures very quickly and is more difficult to remove.

Conclusion

Cementation of CAD/CAM restorations can be easy if the number of products used is reduced and the indications are clearly defined. In this case, it is only necessary to focus on two material properties – their strength and the presence of glass particles – to decide which pre-treatment and cement is the one to choose.

Theoretically, it is also possible to use an adhesive resin cement every time, which would simplify selection, but complicates some of the clinical procedures.

Available 3M products

3M™ Ketac™ Cem Plus
Resin Modified Glass Ionomer Cement

3M™ RelyX™ Unicem 2
Self-Adhesive Resin Cement

3M™ RelyX™ Ultimate
Adhesive Resin Cement

+

3M™ Scotchbond™
Universal Adhesive

3M™ RelyX™ Veneer
Veneer Cement

+

3M™ Scotchbond™
Universal Adhesive

Available resources

Watch the videos

Step-by-step videos for cementation procedures

Maintenance
Procedure step 7

Long-term success of indirect restorations is not only dependent on the right decisions and a proper execution of procedures during treatment, but also on suitable measures taken in the post-treatment phase. Preventive measures include the development of good oral hygiene practices at home and a regular recall schedule in the dental office. Reactive measures should be taken when small defects become apparent including polishing and repair with composite resin. The recommended clinical protocols may be different depending on the restorative material in use and the type as well as the size of the defect. This section gives several examples on how to proceed in specific clinical situations.

Oral hygiene practices

Medium and long-term studies show that ceramic restorations are a forgiving treatment option for patients struggling with oral hygiene. Still, it is essential that patients adhere to the recommended techniques of regular brushing and flossing to prevent early aging of the restoration and maintain its quality. In addition, patients should be encouraged by the clinical staff to attend dental recall and professional tooth-cleaning appointments once every six to twelve months. During the recall appointment, the clinician can evaluate the oral hygiene status and the quality of the existing restorations besides hard and soft tissue conditions. Based on the findings, the need for interventional measures is assessed.

While at the moment, the decisions are usually based on a clinical examination alone, digital technologies are already available that enable clinicians to monitor restorations over time. By taking an intraoral scan at every recall and superimposing the different data sets, it is possible to detect small changes in the soft tissue, the restoration and the adjacent or opposing teeth. This allows clinicians to intervene at an early stage before clinical problems are present.

Professional tooth cleaning

Professional tooth cleaning is an essential part of every recall. In this context, care should be taken not to harm the restoration and to minimize the risk for chipping or fractures. Clinicians should only carry out mechanical intervention such as scaling and polishing in absence of inflammation and plaque.

The following protocol is recommended by the experts:

1. Removal of calculus or cement excesses with a curette or scaler in gentle tactile movements parallel to the gingiva (movement in root-crown direction might cause chipping of ceramic restoration margins)

2. Supra- and subgingival plaque and stain removal using air-polishing with a low-abrasive prophy powder (e.g. 3M™ Clinpro™ Glycine Prophy Powder)

Instruments and materials not recommended for patients with ceramic restorations are

- Sonic or ultrasonic scalers, which might cause chipping or fracture

- Abrasive air-polishing powder (e.g. sodium bicarbonate), as it tends to roughen the surface and increases the staining potential

How to remove marginal discoloration

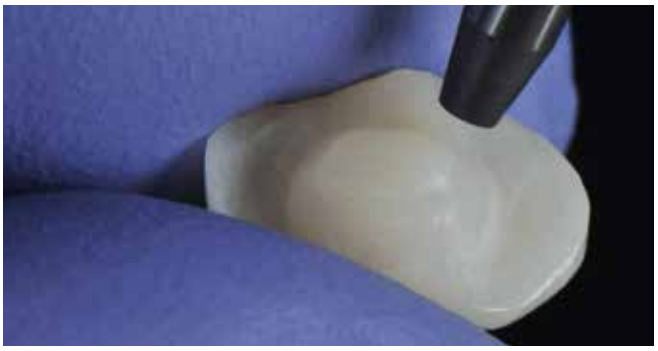
Marginal staining is a clinical sign of microleakage. As soon as some discoloration starts to appear at the margin, the area should be smoothened to restore the esthetic appearance and prevent progression of the phenomenon. For this purpose, the clinician should expose the margin and make the area to be polished accessible by placing a retraction cord or paste. Afterwards, a ceramic polishing rubber point may be used to polish the margins. If polishing paste is applied, an extra fine aluminum oxide paste should be selected. It is possible to protect the gingiva with a composite spatula during polishing. Afterwards, the retraction cord is carefully removed and the area is rinsed with water to clean the area from debris and excess paste.

1. Rubber polishing point for ceramic restorations.

Repair of ceramic restorations

Common complications that occur with indirect restorations include chipping, fracture, postbonding cracks and debondings. In many cases, intraoral repair of the affected restorations is possible. All repair or rebonding procedures strictly require thorough cleaning of the restorative material and roughening of the surface. Sandblasting is the most common procedure used in this context.

2. Fractured crown. In this case, there is no getting around replacement.



3. Sandblasting is not only a recommended pre-treatment of zirconia and resin-based restorations prior to their placement, but also used intraorally to provide a favorable surface for bonding in the context of repair.
(Images courtesy of Dr. Paulo Monteiro)

When chipping occurs, the size and the esthetic impact of the defect determine if polishing is sufficient or repair necessary. Small chipping defects with no metal frameworks showing through may be polished. Medium and large defects usually require repair. Repair procedures differ slightly depending on the restorative material in use. The decision criteria are summarized in Table 1.

Maintenance
Procedure step 7

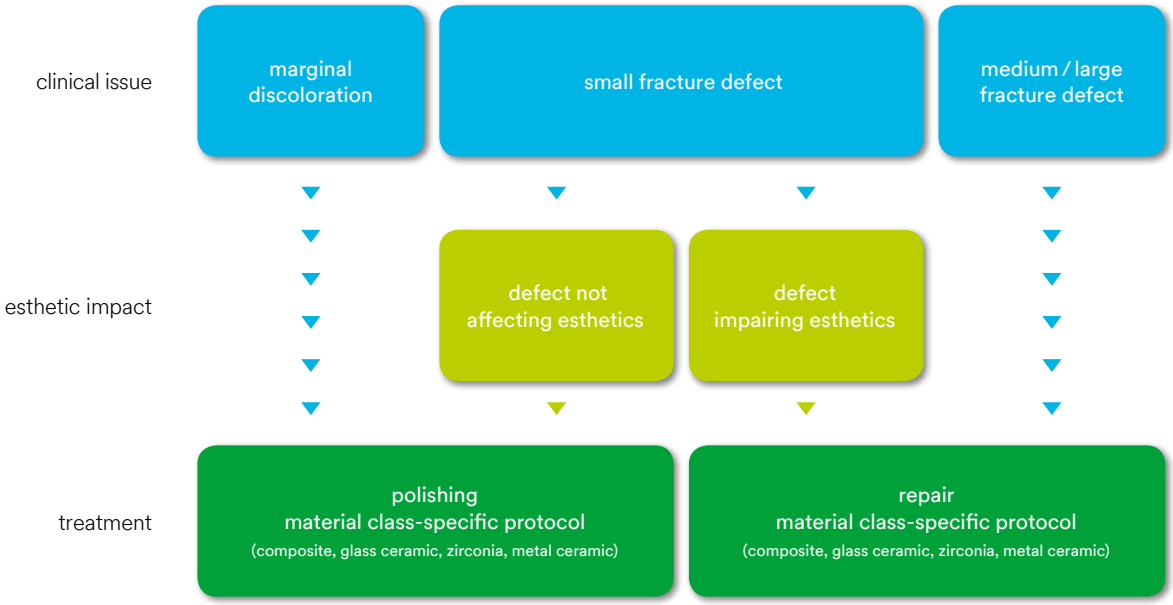
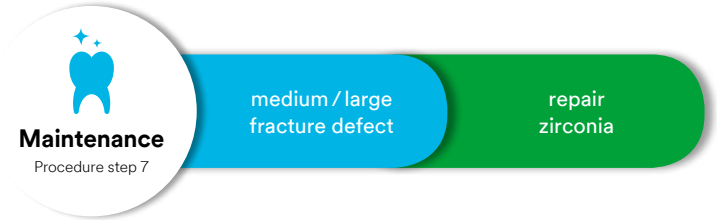


Table 1: Polishing or repair? Criteria for decision-making.

The polishing procedure in case of chipping is similar to that described for removal of marginal staining. If the defect is located at the restoration margin and close to the soft tissue, the area needs to be exposed with retraction paste or a retraction cord. A ceramic polishing rubber point and extra fine polishing paste are suitable for polishing. Finally, thorough rinsing and cleaning is important.



A repair procedure of a zirconia restoration with a medium-sized to large defect should be carried out as follows:

1. Shade selection
2. Isolation of the affected tooth with rubber dam
3. Protection of exposed adjacent teeth with a metal strip
4. Sandblasting of the chipped area and the margin (alumina < 50 µm, max 2 bar, 90° angle)
5. Rinsing with water and drying
6. Use of a metal / zirconia primer (MDP) as recommended by the manufacturer*
7. Application of an adhesive as recommended by the manufacturer, e.g. 3M™ Scotchbond™ Universal Adhesive is rubbed in for 20 seconds and then treated with a gentle stream of air to ensure evaporation of the solvent. The adhesive looks stable on the tooth when the solvent is gone.
8. Application of the composite resin as needed
9. Finishing and polishing of the area

*If 3M™ Scotchbond™ Universal Adhesive is used, step 6 is obsolete as zirconia primer is included.

Conclusion

The recommended cleaning and repair protocols help to maintain a high quality of indirect restorations over time, which may lead to an extended life span of the restoration and the need for fewer replacements. This, in turn, serves the ultimate goal of preserving as much natural tooth structure as possible and enables the clinician to effectively prevent tooth loss in the long term.

Available 3M products

3M™ Clinpro™
Glycine Prophy Powder

3M™ Clinpro™ Prophy Paste

3M™ CoJet™ System
Adhesive Repair and Pretreatment prior to Cementation

3M™ Scotchbond™
Universal Adhesive

3M™ Filtek™
Universal Restorative

3M™ Filtek™ Supreme XTE Flowable
Flowable Composite

3M™ Elipar™ DeepCure-S
LED Curing Light

3M™ Sof-Lex™ Contouring and Polishing Discs

3M™ Sof-Lex™
Diamond Polishing System

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Paulo Monteiro obtained his degree as a Doctor of Dental Medicine at the Instituto Superior de Ciências da Saúde in Caparica (ISCSEM), Portugal. Here, he started to develop a passion for esthetic dentistry. In 2005, the author completed post-graduation programs in Esthetic and Restorative Dentistry at the ISCSEM. He also obtained a Master's degree in Dental Medicine at the same Institute. He is a Coordinator and Professor of the Restorative post-graduation program Esthetic and Restorative Dentistry at Instituto Universitário Egas Moniz and has an exclusive dental practice in Lisbon that focuses on esthetic and cosmetic dental treatments.

Akit Patel graduated from Guy's Hospital Dental Institute in 2002. He then completed a Prosthodontics specialist programme at UCL (University College London) Eastman Dental Hospital and Institute and received his Master's in Clinical Dentistry (Fixed and Removable Prosthodontics) in 2008 with distinction and award for clinical and academic excellence. He was awarded the Membership in Restorative Dentistry by the Royal College of Surgeons of England in 2009. Dr. Patel is a specialist prosthodontist and works in private specialist practice focusing on Implant, Esthetic & Reconstructive Dentistry. He is also a Clinical Senior Teaching Fellow at UCL Eastman Dental Institute, a lecturer at Bristol University, and an ITI Fellow.

Carlos Eduardo Sabrosa received his DDS in 1992 from the State University of Rio de Janeiro Dental School (Brazil) and the Clinical Advanced Graduate Studies (CAGS) in Prosthodontics from Boston University Goldman School of Dental Medicine in 1996. He earned the Steven Gordon Research / Clinical Award in 1995 and 1996 and the Tylman Research Grant Award in 1993 from the American College of Prosthodontics. Dr. Sabrosa also received his MSD and DScD in Prosthodontics/ Biomaterials from Boston University Goldman School of Dental Medicine in 1997 and 1999, consecutively. He has a private practice, focused in Oral Rehabilitation and Implantology, in Leblon, Rio de Janeiro, Brazil and is a visiting professor at Instituto Universitário Egas Moniz in Portugal.

Stefan Vandeweghe completed his studies in dentistry at Ghent University in 2006 and subsequently specialized in oral implantology. In 2010, he obtained his PhD with his thesis “Factors affecting bone remodeling around surface-modified Southern Implants”. From 2010 to 2011, Dr. Vandeweghe was a postdoctoral researcher at the University of Malmö, Sweden, before he returned to Belgium, where he started his private practice with his wife Charlotte. In addition, he continued his research at Ghent University, where he became Professor and Head of the department of Reconstructive Dentistry in 2017.

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