Restorability and Treatment with the Single-Unit Crown

R. Paul McGraw DDS, FAGD
ABOUT THE AUTHOR

R. Paul McGraw DDS, FAGD

Dr. McGraw received his Doctor of Dental Surgery degree from the University of Missouri at Kansas City, School of Dentistry in 1979, and was awarded the Academy of General Dentistry’s “Fellow of the Academy of General Dentistry” designation in 1993. Dr. McGraw has lectured nationally, and served as the Associate Member Trustee on the Board of the American Academy of Periodontology from 2006 to 2008. Dr. McGraw maintains a restorative dental practice in the Kansas City, Missouri area, focusing on fixed crown and bridge and removable prosthetic reconstruction and implant-supported crown and bridge and prosthetic solutions. Dr. McGraw has no conflicts of interest to declare. He can be reached at pmcgraw@gmail.com.

EDUCATIONAL OBJECTIVES

The overall goal of this course is to provide the reader with information on the considerations and procedural steps involved in treatment with a single crown. After completing this article, the reader will be able to do the following:

1. Review the criteria for restorability with a single full-cover-
age crown.
2. Describe the concept of biologic width, its importance and considerations with respect to crown design.
3. List and describe the steps involved in treatment for a single crown, including the preparation design with respect to general parameters and the restorative material selected.
4. Delineate the main types of impression materials used during treatment for a crown, and describe the impression-taking techniques that may be used for these materials.
5. Review the steps involved in placement of a temporary restoration and in the luting of a permanent crown.

RESTORABILITY AND TREATMENT WITH THE SINGLE-UNIT CROWN

Introduction

Restorative dentistry is both art and science used to restore the dentition that is worn, damaged or missing due to disease, injury, age or failure of previously placed restorations and for esthetics. The restorative procedures vary greatly depending on the complexity of the clinical case; the health, finances and desires of the patient; and the preferences of the clinician. The single-unit, full-crown is one of the most common restorations in dentistry.

Indications for a Single-Unit Crown

A single-unit crown may be indicated for one of several reasons: 1) Adequate tooth structure no longer remains to predictably support an intra-canal filling or restoration; 2) replacement of an existing, failing crown; 3) correction of a functional discrepancy such as a malformed clinical crown or inadequate functional guidance; 4) cosmetic enhancements; and 5) restoration of a single implant.

Inadequate tooth structure typically involves situations in which 2 or more full walls of tooth or 3 or more partial walls have been lost. Longitudinal clinical studies have shown that full-crown restorations have a higher clinical success rate than restored with multi-surface composite or amalgam fillings under these circumstances.1,2 The use of a crown to restore an endodontically treated tooth is particularly critical to a successful outcome when such treatment has resulted in considerable loss of the core structure of the tooth and where fracture of the non-vital tooth is likely. A crown is indicated when endodontics was performed on a substantially debilitated tooth structure (i.e., missing cusps or 1 more axial walls), provided adequate root structure exists to consider reconstruction of the coronal portion of the tooth. At least 2 long-term studies strongly indicate that restoration of an endodontically treated tooth with a full-crown restorations (vs. a direct restoration) is positively associated with the long-term survival of the tooth.1,3

Criteria for Restorability

For a single-unit crown to be viable, there must be sufficient structural remains (or capable of being reconstruct-
ed) for a reliable mechanical connection to the remaining root structure and for it to reliably support occlusion and functional forces. Structural, biological, periodontal and endodontic requirements must also be considered.

The literature contains many references relating to crite-
ria for tooth restorability, although a single list of criteria is lacking. Several literature reviews1-3 and the author’s clinical experience indicate that a number of conditions are met for treatment with a full-crown restoration (Table 1).

Table 1. Criteria for treatment with a full-crown restoration

1) Adequate vertical tooth structure to provide suf-
ficient retention. The minimal ideal axial wall height is considered to be at least 3.4 mm, although shorter wall heights (<3 mm) may be expected to perform in a clinically acceptable manner if properly managed.1
2) Adequate proximal separation between adjacent teeth to allow a closed margin circumferentially.
3) Adequate crown-to-root ratio.
4) The ability to prepare the tooth with a taper of approximately 10-20 degrees from the occlusal or incisal to the gingival margin.1
5) Interproximal contact areas that are sufficiently straight to allow a path of insertion for try-in, final seating and long-term performance.
6) Sufficient inter-occlusal distance for coverage with an adequate thickness of the selected material or materials to afford strength and durability.
7) Sufficient tooth structure to allow margins to be placed in such a manner as to preserve the bio-
logic width1-3 required by the junctional epithelial complex (Figure 1).
8) Adequate periodontal support.
9) A healthy vital tooth free of endodontic pathology, or an endodontically treated tooth free of unre-
solved pathology.
Restorability and Treatment with the Single-Unit Crown

Introduction

Restorative dentistry is both art and science used to restore the dentition that is worn, damaged or missing due to disease, injury, age or failure of previously placed restorations and for esthetics. The restorative procedures vary greatly depending on the complexity of the clinical case; the health, finances and desires of the patient; and the preferences of the clinician. The single-unit, full-coverage crown is one of the most common restorations in dentistry.

Indications for a Single-Unit Crown

A single-unit crown may be indicated for one of several reasons: 1) Adequate tooth structure no longer remains to predictably support an intra-coronal filling or restoration; 2) replacement of an existing, failing crown; 3) correction of a functional discrepancy such as a malformed clinical crown or inadequate functional guidance; 4) cosmetic enhancement; and 5) restoration of a single implant.

Inadequate tooth structure typically involves situations in which 2 or more full walls of tooth or 3 or more partial walls have been lost. Longitudinal clinical studies have shown that full-coverage crowns have a higher clinical success rate than restorations with multi-layer composite or amalgam fillings under these circumstances.1,2 The use of a crown to restore an endodontically treated tooth is particularly critical to a successful outcome when such treatment has resulted in considerable loss of the core structure of the tooth and where fracture of the non-vital tooth is likely. A crown is indicated when endodontics was performed on a substantially debilitated tooth structure (i.e., missing cusps or 1 more axial walls), provided adequate root structure exists to consider reconstruction of the coronal portion of the tooth. At least 2 long-term studies strongly indicated that restoration of an endodontically treated tooth with a full-coverage crown (vs. a direct restoration) is positively associated with the long-term survival of the tooth.3,4

Criteria for Restorability

For a single-unit crown to be viable, there must be sufficient structure remaining (or capable of being reconstruct-
Restorability and Treatment with the Single-Unit Crown

Tooth Preparation

Tooth preparation design is driven primarily by the characteristics of the restorative material and the fabrication method. In general the following parameters apply:

- **Occlusal reduction** – 1.25-1.5 mm for full metal crowns; 2.0-3.0 mm for PFM crowns; and 2.5-3.5 mm for all-ceramic restorations.
- **Axial reduction** – Minimum of 1.5-2.0 mm for PFM crowns, and if full porcelain coverage is planned then the entire surface of the preparation will require reduction adequate to allow material coverage in the range of 2.0-3.0 mm.
- **Convergence angle or taper** – A convergence angle of between 10° and 20° is sufficient for retention and resistance. 8 Preparation height – An ideal occlusosurgical height of at least 3.0 mm for anterior teeth and premolars, and 4.0 mm for molars, is required for retention and occlusal integrity. Shorter preparations may be used, provided that care is taken with preparation design, occlusion and selection of the final luting agent to aid retention.

Restorative Materials for Full-Coverage Crowns

**Metal and Metal Ceramic**

Full-coverage crowns for the adult dentition can be fabricated from a variety of materials. Although crowns may be fabricated exclusively from base, semiprecious and precious alloys, due to esthetic considerations it is more common to use these as a substructure. Feldspathic porcelain can be fired or baked in layers over the cast alloy coping to construct a metal-ceramic restoration. Typically this begins with an opaque ceramic layer, and the “stacking” of layers of progressively translucent porcelain results in a restoration that is esthetically similar to the adjacent teeth.

**All-Ceramic Crowns**

All-ceramic materials include feldspathic porcelain (hand-stacked or “pressed”; CAD/CAM blocks), leucite-reinforced porcelain (pressed or milled) and lithium disilicate. Selection of the restorative material is made by weighing several factors including the location and size of the restoration, strength of the material, margin placement, and periodontium and esthetic goals, as well as the volume, condition and strength of the remaining tooth structure. In general, feldspathic and leucite-reinforced restorations should be used in the anterior region and other low-stress areas only. Metal-ceramic, lithium disilicate and zirconia restorations are indicated in all areas where normal function occurs, including high-stress areas (and provided esthetic requirements are met). All-ceramic restorations may be contraindicated in patients with parafunction or destructive occlusal habits.

Margin Design

This is dictated primarily by the restorative material selected, as well as the esthetic and functional requirements of the case. There are 4 basic margin designs:

1) **Flame or feathered margins** – a gradual decrease in the amount of reduction until the margin “feathers” or “flames” into the unprepared portion of the tooth. In general, this would only be appropriate for a metal crown margin, which can be cast to a very thin finish. The finish line must be clearly identifiable.
2) **Butt margins** – typically the most difficult to reliably close. These have a role when esthetics cannot be compromised by even a hint of metal at the margin.
3) **Chamfered margins** – may utilize anything from a sharp bevel to a curved angle from the axial wall, beveling at the end of the preparation. These can provide a reliably closed margin and allow for adequate reduction for porcelain or ceramic material, as well as providing sufficient bulk for porcelain/ceramic strength.
4) **Beveled shoulders** – suitable for an all-metal or PFM restoration, with the final termination in metal or supported by metal. These provide a thickened marginal base area, allowing for adequate porcelain thickness, and a metal bevel or very slight chamfer. This margin may be particularly applicable where a fine marginal termination is desired, yet a hint of the presence of metal at the margin, just under the gingival crest, may be acceptable.

The tooth preparation guidelines from the ceramic material manufacturer should be followed (typically, but not always, involving a butt or broad chamfer margin) when an all-ceramic crown will be fabricated.

Margin Placement

Though supragingival margin placement is desirable from a periodontal health perspective, subgingival placement of the margin is common and will be clinically successful provided that the biologic width is not violated. Typically, the margin is placed subgingivally at a position approximately 1 mm apical to the gingival crest. In a healthy periodontium, deeper margin placement risks invasion of the biologic width. When requirements such as retention, esthetics or old restoration margins dictate that a margin needs to be placed deeper than 1.0-1.5 mm subgingivally, care should be taken that the margin does not invade the junctional epithelium (which could result in an inflammatory response that is uncomfortable for the patient, esthetic and periodontally unhealthy). If placement of...
Restorability and the use of models, illustrations, computer mock-ups and photographs. In more complex (multi-unit) cases, a diagnostic wax-up is very helpful and allows the clinician to show the patient the proposed clinical and esthetic results in a 3-dimensional format. However, a diagnostic wax-up of a single tooth will frequently convey little difference to the patient. It is the dentist’s responsibility to ensure that a patient understands the treatment, potential positive and adverse outcomes, intended benefit(s), risks, alternative treatments, and costs. All risks and potentially adverse outcomes must be noted along with the patient’s acknowledgement and permission in the permanent patient record. Best practices dictate that a written and signed record be kept for each treatment step as part of Informed Consent. Once the treatment plan has been accepted by the patient, steps include prepreparation procedures; tooth preparation; tissue management; impression taking or digital scanning; temporization (unless a single visit CAD/CAM restoration is planned); fabrication of the final restoration; and luting of the final restoration.

Restorative Materials for Full-Coverage Crowns

Metal and Metal Ceramic

Full-coverage crowns for the adult dentition can be fabricated from a variety of materials. Although crowns may be fabricated exclusively from base, semiprecious and precious alloys, due to esthetic considerations it is more common to use these as a substructure. Feldspathic porcelain can be fired or baked in layers over the cast alloy coping to construct a metal-ceramic restoration. Typically this begins with an opaque ceramic layer, and the “stacking” of layers of progressively translucent porcelain results in a restoration that is esthetically similar to the adjacent teeth.

All-Ceramic Crowns

All-ceramic materials include feldspathic porcelain (hand-stacked or “pressed”; CAD/CAM blocks), leucite-reinforced porcelain (pressed or milled) and lithium disilicate. Selection of the restorative material is made by weighing several factors including the location and size of the restoration, strength of the material, margin placement, and periodontium and esthetic goals, as well as the volume, condition and strength of the remaining tooth structure.

In general, feldspathic and leucite-reinforced restorations should be used in the anterior region and other low-stress areas only. Metal-ceramic, lithium disilicate and zirconia restorations are indicated in all areas where normal function occurs, including high-stress areas (and provided esthetic requirements are met). All-ceramic restorations may be contraindicated in patients with parafunction or destructive occlusal habits.

Tooth Preparation

Tooth preparation design is driven primarily by the characteristics of the restorative material and the fabrication method. In general the following parameters apply:

- Occlusal reduction – 1.25-1.5 mm for full metal crowns; 2.0-3.0 mm for PFM crowns; and 2.5-3.5 mm for all-ceramic restorations.
- Axial reduction – Minimum of 1.5-2.0 mm for PFM crowns, and if full porcelain coverage is planned then the entire surface of the preparation will require reduction adequate to allow material coverage in the range of 2.0-3.0 mm.
- Convergence angle or taper – A convergence angle of between 10˚ and 20˚ is sufficient for retention and resistance. A preparation height – An ideal occlusocervical height of at least 3.0 mm for anterior teeth and premolars, and 4.0 mm for molars, is required for retention and resistance. Shorter preparations may be used, provided that care is taken with preparation design, occlusion and selection of the final luting agent to aid retention.

Tooth Preparation

The decision to pursue restorative treatment is based on a complete diagnosis factoring in all clinically relevant inputs from radiographs, models, patient history, patient desires, photographs and examination. Periodontal and es-

restorative treatment with the single-unit crown

Figure 1. Biologic width

The tissues that tie the gingival epithelial tissue and crestal bone to the root surface of the tooth, providing the attachment mechanism for the supporting tissues.

In addition to meeting the above criteria, the esthetic and functional goals of the full crown must still be accomplished. The first step, diagnosis and treatment planning, is followed by case presentation and acceptance.

Diagnosis and Treatment Planning

The decision to pursue restorative treatment is based on a complete diagnosis factoring in all clinically relevant inputs from radiographs, models, patient history, patient desires, photographs and examination. Periodontal and esthetic considerations will often shape the plan. If required, and depending on the case, periodontal therapy may be undertaken concurrently with, or may precede, restorative therapy. Oral hygiene instruction, regular recall visits and the use of risk-level-appropriate prescription fluorides and rinses will help the patient develop improved oral hygiene habits and provide protection against dental caries.

Case Presentation

The case presentation may include a verbal discussion and the use of models, illustrations, computer mock-ups and photographs. In more complex (multi-unit) cases, a diagnostic wax-up is very helpful and allows the clinician to show the patient the proposed clinical and esthetic results in a 3-dimensional format. However, a diagnostic wax-up of a single tooth will frequently convey little difference to the patient. It is the dentist’s responsibility to ensure that a patient understands the treatment, potential positive and adverse outcomes, intended benefit(s), risks, alternative treatments, and costs. All risks and potentially adverse outcomes must be noted along with the patient’s acknowledgement and permission in the permanent patient record. Best practices dictate that a written and signed record be kept for each treatment step as part of Informed Consent. Once the treatment plan has been accepted by the patient, steps include prepreparation procedures; tooth preparation; tissue management; impression taking or digital scanning; temporization (unless a single visit CAD/CAM restoration is planned); fabrication of the final restoration; and luting of the final restoration.

Restorative Materials for Full-Coverage Crowns

Metal and Metal Ceramic

Full-coverage crowns for the adult dentition can be fabricated from a variety of materials. Although crowns may be fabricated exclusively from base, semiprecious and precious alloys, due to esthetic considerations it is more common to use these as a substructure. Feldspathic porcelain can be fired or baked in layers over the cast alloy coping to construct a metal-ceramic restoration. Typically this begins with an opaque ceramic layer, and the “stacking” of layers of progressively translucent porcelain results in a restoration that is esthetically similar to the adjacent teeth.

All-Ceramic Crowns

All-ceramic materials include feldspathic porcelain (hand-stacked or “pressed”; CAD/CAM blocks), leucite-reinforced porcelain (pressed or milled) and lithium disilicate. Selection of the restorative material is made by weighing several factors including the location and size of the restoration, strength of the material, margin placement, and periodontium and esthetic goals, as well as the volume, condition and strength of the remaining tooth structure.

In general, feldspathic and leucite-reinforced restorations should be used in the anterior region and other low-stress areas only. Metal-ceramic, lithium disilicate and zirconia restorations are indicated in all areas where normal function occurs, including high-stress areas (and provided esthetic requirements are met). All-ceramic restorations may be contraindicated in patients with parafunction or destructive occlusal habits.

Tooth Preparation

Tooth preparation design is driven primarily by the characteristics of the restorative material and the fabrication method. In general the following parameters apply:

- Occlusal reduction – 1.25-1.5 mm for full metal crowns; 2.0-3.0 mm for PFM crowns; and 2.5-3.5 mm for all-ceramic restorations.
- Axial reduction – Minimum of 1.5-2.0 mm for PFM crowns, and if full porcelain coverage is planned then the entire surface of the preparation will require reduction adequate to allow material coverage in the range of 2.0-3.0 mm.
- Convergence angle or taper – A convergence angle of between 10˚ and 20˚ is sufficient for retention and resistance. A preparation height – An ideal occlusocervical height of at least 3.0 mm for anterior teeth and premolars, and 4.0 mm for molars, is required for retention and resistance. Shorter preparations may be used, provided that care is taken with preparation design, occlusion and selection of the final luting agent to aid retention.

Occlusal reduction – 1.25-1.5 mm for full metal crowns; 2.0-3.0 mm for PFM crowns; and 2.5-3.5 mm for all-ceramic restorations.

Axial reduction – Minimum of 1.5-2.0 mm for PFM crowns, and if full porcelain coverage is planned then the entire surface of the preparation will require reduction adequate to allow material coverage in the range of 2.0-3.0 mm.

Occlusal reduction – 1.25-1.5 mm for full metal crowns; 2.0-3.0 mm for PFM crowns; and 2.5-3.5 mm for all-ceramic restorations.

Convergence angle or taper – A convergence angle of between 10˚ and 20˚ is sufficient for retention and resistance.

Preparation height – An ideal occlusocervical height of at least 3.0 mm for anterior teeth and premolars, and 4.0 mm for molars, is required for retention and resistance. Shorter preparations may be used, provided that care is taken with preparation design, occlusion and selection of the final luting agent to aid retention.

Margin Design

This is dictated primarily by the restorative material selected, as well as the esthetic and functional requirements of the case. There are 4 basic margin designs:

1) Feathered margins – a gradual decrease in the amount of reduction until the margin “feathers” or “flames” into the unpurposed portion of the tooth. In general, this would only be appropriate for a metal crown margin, which can be cut to a very thin finish. The finish line must be clearly identifiable.

2) Butt margins – typically the most difficult to reliably close. These have a role when esthetics cannot be compromised by even a hint of metal at the margin.

3) Chamfered margins – may utilize anything from a sharp bevel to a curved angle from the axial wall, beveling at the end of the preparation. These can provide a reliably closed margin and allow for adequate reduction for porcelain or ceramic material, as well as providing sufficient bulk for porcelain/ceramic strength.

4) Beveled shoulders – suitable for an all-metal or PFM restoration, with the final termination in metal or supported by metal. These provide a thickened marginal base area, allowing for adequate porcelain thickness, and a metal bevel or very slight chamfer. This margin may be particularly applicable where a fine marginal termination is desired, yet a hint of the presence of metal at the margin, just under the gingival crest, may be acceptable.

The tooth preparation guidelines from the ceramic material manufacturer should be followed (typically, but not always, involving a butt or broad chamfer margin) when an all-ceramic crown will be fabricated.

Margin Placement

Though supragingival margin placement is desirable from a periodontal health perspective, subgingival placement of the margin is common and will be clinically successful provided that the biologic width is not violated. Typically, the margin is placed subgingivally at a position approximately 1 mm apical to the gingival crest. In a healthy periodontium, deeper margin placement risks invasion of the biologic width. When requirements such as retention, esthetics or old restoration margins dictate that a margin needs to be placed deeper than 1.0-1.5 mm subgingivally, care should be taken that the margin does not invade the junctional epithelium (which could result in an inflammatory response that is uncomfortable for the patient, esthetic and periodontally unhealthy). If placement of
Once established, a practical advantage for a specific liquid hemostatic agent.

Retraction cord is most commonly used, available either with pre-impregnated epinephrine, ferric sulfate or aluminum sulfate to promote hemostasis or as cord that can then be dipped into the liquid hemostatic agent. Depending on preference, 1 or 2 cords may be placed into the sulcus using a thin-bladed, blunt-tipped instrument. In one study, operators were unable to perceive any clinical differences between epinephrine-impregnated and aluminum chloride-impregnated cords, and there is no clear reference establishing a practical advantage for a specific liquid hemostatic agent.

Enhancement of the "trough" around the tooth just below the margin, but well clear of the gingival crestal tissues, may be accomplished with a low-power diode laser, avoiding the need for additional retraction. If care is taken to minimize the amount of energy imparted to the tissue, healing is fast, painless and typically without loss of gingival height. Mechanical retraction may be supplemented with the use of a laser in cases where hemorrhage control considerations exist. Diode lasers used to "toughen" the area immediately adjacent to the tooth and below the marginal terminations of the preparation impart far less energy to the tissues than electrosurgery, which is now less commonly used, and pose less risk of gingival damage and subsequent recession.

Final Impressions

Intra-oral impressions must provide an undistorted representation of the prepared tooth/teeth, the adjacent teeth and tissues, and the shape of the arch. These impressions may be taken with an elastomeric material, or made using an optical scanner to create a digital representation of the same structures, which is then used to create a model for crown fabrication or to create a CAD/CAM restoration. A third option is to take a traditional elastomeric impression that may then be scanned using optical scanning systems. It is necessary to have a solid model upon which to seat the final restoration and verify margins, occlusion and contacts prior to final delivery to the patient. The section below discusses the use of a traditional impression material for laboratory fabrication of a single crown.

Final impressions and tray selection

Final impressions for indirect restorations are typically made using either a polyether (PE) or vinyl polysiloxane (VPS) impression material. These offer 1) accuracy and stability for an extended period of time (up to several weeks in the case of VPS); 2) the ability to pour more than 1 model from an impression; 3) transportation to the laboratory without physical deterioration (assuming proper handling); and 4) the ability to reliably disinfect the impression. Regardless of whether PE or VPS material is employed, impression tray selection remains an important factor. Proper adaptation of a tray to prevent over-seating, high-centering and subsequent flexing of the tray material is critical. The impression tray must not be allowed to rest prematurely on tissues in such a way as to deflect the shape of the tray even minimally, as that would inevitably change the shape of the resulting models in an unpredictable manner. Fabricated and stock trays are available, and selection should consider the impression material that will be used as well as the complexity of the case. More complex multi-unit restorative and implant-related cases favor the use of a fabricated custom tray. Characteristics of an ideal tray can be found in Table 2.

Impression material selection

Impression materials are available with a variety of working and setting times. Selection of a standard set material rather than a rapid set material helps avoid a common impression-taking error: inadvertently exceeding the working time of the selected material(s). Doing so typically leads to an impression with incomplete homogenization of the material phases and with distortions caused by seating one phase of material over another that has already reached its primary setting point and is no longer capable of flowing properly. Further, these are sometimes difficult to recognize, resulting in an inaccurate impression and model, and an ill-fitting restoration. A longer working and setting time is particularly important in complex multi-unit cases where syringing impression material around preparations and then seating the tray takes more time than for a single-unit crown case. In all situations, the impression field must be free of debris, bleeding and moisture.

Polyether (PE) Impression Materials

With PE materials, a 1- or 2-stage impression process may be employed. For the single-stage PE impression, the impression tray is filled with heavy-bodied material by the assistant, while the operator proceeds to syringe light- or extra-light-bodied material into the sulcus around the preparation, also using an air syringe to gently blow the material around and into the sulcus. Additional extra-light-bodied material or regular light-bodied material is then added around the preparation as preferred.

The heavy-bodied material in the tray is then lightly "topped" with light-bodied material, positioned over the arch with the preparation and held in position as described above. A "putty wash" 2-stage technique using both a putty and light-body material is common when VPS material is used. VPS putty is placed in a stock tray and then placed in the patient's mouth over the prepared tooth/teeth and arch, with the retraction cord still in place. A layer of plastic spacer (acyllic packing spacer; food wrap or other plastic sheeting) may be placed over the surface of the putty in order to create a "space" for the second stage. A rapid-set material is suitable for the putty stage. If no spacer is used, then space should be created in the putty material using a lab bur in a handpiece or lathe, such that the putty provides several tooth-borne stops but contains space for the second lighter-body wash material that will accurately record the tissues. The lighter-body material is syringed around the preparation and gently blown into the sulcus with an air syringe (with a low airflow to avoid blowing the material away), with additional material then being syringed into the preparation and onto the adjacent teeth while the tray is filled by the assistant with the heavier-body material. The tray is then seated and held in place manually or stabilized by light pressure applied to cotton rolls or rolled gauze strategically placed to stabilize the tray throughout the recommended setting time.

<table>
<thead>
<tr>
<th>Table 2. Characteristics of an ideal impression tray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal flexibility</td>
</tr>
<tr>
<td>Full coverage of prepared and adjacent teeth as</td>
</tr>
<tr>
<td>required</td>
</tr>
<tr>
<td>Sufficient internal space for adequate though not</td>
</tr>
<tr>
<td>excessive thickness of material</td>
</tr>
<tr>
<td>Does not impinge on soft tissues</td>
</tr>
<tr>
<td>Does not flex when positive stops (if present)</td>
</tr>
<tr>
<td>contact with the teeth</td>
</tr>
</tbody>
</table>

Vinyl polysiloxane (VPS) Impression Materials

With VPS materials, a 1- or 2-stage impression process may be employed. For the single-stage VPS impression, the impression tray is filled with heavy-bodied material by
the margin would potentially invade the biologic width, advance consideration should be given to “crown lengthening” prior to restorative treatment, which then enables the margin to be placed more apically without invading the biologic width. If crown lengthening is performed after restorative treatment, a predictable esthetic outcome is by no means certain.

### Tissue Management

For restorations with subgingival margins, tissue retraction, hemostasis and moisture control are essential in order to visualize and capture the crown margin and adjacent tissues with an impression. In all situations, moisture control is required. Retraction methods available include retraction cord, laser troughing, and clay-based or silicone retraction materials. Clay-based and silicone retraction materials have both demonstrated clinically effective retraction and hemostasis when used correctly.\(^{11,12}\) Retraction cord is most commonly used, available either with pre-impregnated ephinephrine, ferric sulfate or aluminum sulfate to promote hemostasis or as cord that can then be dipped into the liquid hemostatic agent. Depending on preference, 1 or 2 cords may be placed into the sulcus using a thin-bladed, blunt-tipped instrument. In one study, operators were unable to perceive any clinical differences between ephinephrine-impregnated and aluminum chloride-impregnated cords,\(^{13}\) and there is no clear reference establishing a practical advantage for a specific liquid hemostatic agent.

Enhancement of the “trough” around the tooth just below the margin, but well clear of the gingival crestal tissues, may be accomplished with a low-power diode laser, avoiding the need for additional retraction. If care is taken to minimize the amount of energy imparted to the tissue, healing is fast, painless and typically without loss of gingival height. Mechanical retraction may be supplemented with the use of a laser in combination with 1 or 2 phases of material. For the 2-phase technique, the retraction cord still in place. A layer of plastic spacer (acrylic packing spacer, food wrap or other plastic sheeting) may be placed around and into the sulcus. Additional extra-light-bodied material or regular light-bodied material is then added around the preparation and gently blown into the sulcus with an air syringe (with a low airflow to avoid blowing the material away), with additional material then being syringed into the preparation and onto the adjacent teeth while the tray is filled by the assistant with the heavier-body material. The tray is then seated and held in place manually or stabilized by light pressure applied to cotton rolls or rolled gauze strategically placed to stabilize the tray throughout the recommended setting time.

### Impression material selection

Impression materials are available with a variety of working and setting times. Selection of a standard set material rather than a rapid set material helps avoid a common impression-taking error: inadvertently exceeding the working time of the selected material(s). Doing so typically leads to an impression with incomplete homogenization of the material phases and with distortions caused by seating one phase of material over another that has already reached its primary setting point and is no longer capable of flowing properly. Further, there are sometimes difficult to recognize, resulting in an inaccurate impression and model, and an ill-fitting restoration. A longer working and setting time is particularly important in complex multi-unit cases where syringing impression material around preparations and then seating the tray takes more time than for a single-unit crown case. In all situations, the impression field must be free of debris, bleeding and moisture.

### Polyether (PE) Impression Materials

With PE materials, a single-stage process is employed to create a “space” for the second stage. A rapid-set material is suitable for the putty stage, while the operator proceeds to syringe light-body or extra-light-bodied material into the sulcus around the preparation, also using an air syringe to gently blow the material around and into the sulcus. Additional extra-light-bodied material or regular light-bodied material is then added around the preparation as preferred.

The heavy-bodied material in the tray is then lightly “topped” with light-bodied material, positioned over the arch with the preparation and held in position as described above. A “putty wash” 2-stage technique using both a putty and light-body material is common when VPS material is used.

### Vinyl polysiloxane (VPS) Impression Materials

With VPS materials, a 1-or 2-stage impression process may be employed. For the single-stage VPS impression, the impression tray is filled with heavy-bodied material by the assistant, while the operator proceeds to syringe light- or extra-light-bodied material into the sulcus around the preparation, also using an air syringe to gently blow the material around and into the sulcus. Additional extra-light-bodied material or regular light-bodied material is then added around the preparation as preferred.

The heavy-bodied material in the tray is then lightly “topped” with light-bodied material, positioned over the arch with the preparation and held in position as described above. A “putty wash” 2-stage technique using both a putty and light-body material is common when VPS material is used. VPS putty is placed in a stock tray and then placed in the patient’s mouth over the prepared tooth/teeth and arch, with the retraction cord still in place. A layer of plastic spacer (acrylic packing spacer, food wrap or other plastic sheeting) may be placed over the surface of the putty in order to create a “space” for the second stage. A rapid-set material is suitable for the putty stage. If no spacer is used, then space should be created in the set putty material using a lab bur in a handpiece or lathe, such that the putty provides several tooth-borne stops but contains space for the second light-body wash material that will accurately record the tissues. The lighter-body material is syringed around the preparation and gently blown into the sulcus with an air syringe. Additional light-bodied material should then be syringed into the sulcus, around the preparation and onto the adjacent teeth as the putty-filled tray is lightly filled with...
Restorability and Treatment with the Single-Unit Crown

The light-bodied material by the assistant. (Note that some clinicians prefer to create escape holes through the tray and putty material so that the second-stage, light-bodied material can extrude, avoiding distortion of the tray/putty material as it is seated.) The impression tray is firmly seated to force material into the sulcular areas but without distorting the tray, and the tray is held in place as described above. With both a PE and VPS impression, after the setting time is completed the tray is removed with a quick “snap” and the impression washed and inspected under bright light and magnification to check for complete capture of all required details. If the impression is acceptable, it is disinfected and prepared for transport for pouring of the die and model. An alginate (irreversible hydrocolloid) or VPS-based alginate substitute impression material can be used for the opposing dentition. Although more expensive than alginate, the latter is dimensionally stable for longer and multiple models can be created with the same impression.

Temporization and Options

A temporary crown provides coverage for the exposed dentin, protects it from bacteria and thermal insult, maintains the interproximal contacts and integrity of the arch form, supports and stabilizes the opposing teeth to prevent super-eruption, and provides biological contours from the margin to the occlusal/incisal edge, thereby supporting healthy gingival tissues and promoting cleansability.17

Use of a matrix/index aids the creation of an anatomically acceptable temporary crown. The matrix may be a commercially prefabricated shell crown, a silicone matrix fabricated intra-orally or in the laboratory, a wax matrix, an alginate or alginate substitute impression that was taken preoperatively of the tooth being restored (if sufficient structure and contours existed) or a vacuum-formed resin material. If an impression is used for the matrix, an alginate substitute results in a smoother surface than when an alginate is used and also permits fabrication of a second temporaroy using the same matrix should this become necessary. Otherwise than the prefabricated shell crown or vacuum-formed resin options, which transmit light, all other options require that a self-cure material be used for the temporary crown. When there is adequate time and if preferred, a matrix can be made in the laboratory on a pre-operative model that can then be placed over a minimally prepared tooth on an additional model or on the same model, forming a thin-walled or “shell” temporary, which can then be taken to the patient’s mouth and relined on the prep.

A coating of lubricant such as petroleum or cocoa butter may be applied to the preparation and the adjacent teeth. If used, this should be carefully thinned with air or using a small brush, cotton pellet or swab. The use of lubricant is recommended in cases with a composite buildup or where proximal composite restorations have been placed in immediately adjacent teeth. The matrix is filled in the area of the preparation with shade-appropriate acrylic, or bis-acrylic composite (bis-acryl—a composite-based resin material)—then seated over the preparation.

If acrylic is used, the matrix should be removed prior to final set and the temporary crown removed and promptly repositioned over the preparation, with pressure in the direction of the margins to prevent setting distortion of the acrylic and pull-away of the temporary margins from the preparation. This technique also ensures that the temporary crown can be removed from the preparation without fracturing as it encounters undercut at adjacent teeth. With bis-acryl, the matrix should be removed as soon as initial set is achieved and the temporary crown carefully lifted from the tooth to prevent hardening of the material in the undercut at adjacent teeth. The temporary crown may be allowed to complete its set out of the mouth, but the margins and adjacent contact undercuts should be adjusted as soon as possible to allow for reseating and finishing. A thin-bladed plastic instrument may be inserted from the facial or lingual approaches to shape and minimize the undercut (before an initial material set is achieved).

Bis-acryl has been shown to have higher fracture toughness,18 flexural strength and edge strength.16 On the other hand, acrylic materials have greater strength against occlusal loads than bis-acryl and maintain strength better over time.20 The latter are frequently the easiest to use, are available in an automix cartridge (requiring no mixing) and have only a minimal exothermic reaction (i.e., reduced production of heat during curing and thus less potential for pulpal insult).19,20 Bis-acryl materials also have lower polymerization shrinkage, favoring a good fit, and typically present with good initial esthetics and lifelike translucency. Stain kits are also available that can be used to enhance patient-specific esthetics with these materials. It is also the case that using a clear coating designed for temporary restorations, whether acrylic resin or bis-acryl, will help produce a smooth, glistening surface that also reduces roughness (and the potential for biofilm buildup). Void/reparis in acrylic and bis-acryl can be treated by adding acrylic to the former and composite to the latter.

Cementing the Temporary Restoration

The goal of temporary cementation is to protect the tooth and retain the temporary crown reliably yet allow for easy atraumatic removal of the temporary crown and easy cleanup. Temporary cements utilizing zinc oxide eugenol are palliative to the prepared tooth (reducing sensitivity), antibacterial in nature, effectively retain the temporary crown on a sufficiently retentive preparation and are easy to use. Disadvantages are that the eugenol can interfere with composites and acrylics as well as the polymerization and bond strength24 of resin-based materials used for cementation of the permanent restorations; and if the temporary restoration is required for a longer period of time, they can cause both acrylic and bis-acrylic temporary restorations to become less resilient and have reduced microsurface hardness.20 Non-eugenol temporary cements are available, including formulations that contain potassium nitrate to reduce postoperative sensitivity (since the palliative effect of eugenol is absent). Temporary polyalkoxysiloxane, resin and glass ionomer cements have also become available, each with different handling characteristics.

Temporary cementation should use enough cement to thoroughly coat (but not fill) the internal surface of a well-fitting temporary restoration. The preparation should be dry and debris-free. The temporary crown should be placed and allowed to set under compression. Attempting to remove setting cement too early will smear the cement on the tissue and on the surface of the polished temporary crown, making them difficult to clean and leaving an unsightly film. Waiting for the initial set of the cement will typically allow excess cement to be removed without smearing and without leaving any in the sulcus or interproximally. Thorough cement removal is essential to preserve proximal tissue health and reduce inflammation. Such inflammation could also lead to gingival recession and exposure of the crown margins and root surface, complicating delivery of an esthetic long-term result. Final cleanup should include flossing and final verification of the contacts and occlusion. Patients should be advised that staining of temporary restorations can occur with tea, coffee, cola and spicy foods. Composite-based resin materials have been shown to be less susceptible to staining than acrylic resin materials.21

The Seat Visit and Cementation of the Final Restoration

At the seat visit for the final crown, the temporary restoration can be removed using a surgical towel clamp, a hemostat or one of several commercially available instruments for this specific purpose. Gentle rotating and twisting force should be used to break the temporary cement bond while lifting the restoration occlusally or incisally. Complete removal of the retained temporary cement is required. Extended rotational pressure along with displacing pressure in the direction directly opposite to the path of insertion is better than attempting to use a “quick snap,” or forced removal. Even with temporary cements, a new buildup or a weak or over-prepared tooth can be dislocated or fractured when excessive force is used to remove the temporary restoration. When composite buildups or post and core buildups are present on the tooth being restored, resin temporary crowns should be used only with caution, as they can bond to these and be destructively difficult to remove.

Evaluating the final restoration

The form, shade and value of the crown should first be...
the light-bodied material by the assistant. (Note that some clinicians prefer to create escape holes through the tray and putty material so that the second-stage, light-bodied material can extrude, avoiding distortion of the tray/putty material as it is seated.) The impression tray is firmly seated to force material into the sulcular areas but without distorting the tray, and the tray is held in place as described above. With both a PE and VIPS impression, after the setting time is completed the tray is removed with a quick “snap” and the impression washed and inspected under bright light and magnification to check for complete capture of all required details. If the impression is acceptable, it is disinfect and prepared for transport for pouring of the die and model. An alginate (irreversible hydrocolloid) or VIPS-based alginate substitute impression material can be used for the opposing dentition. Although more expensive than alginate, the latter is dimensionally stable for longer and multiple models can be created with the same impression.

Temporization and Options

A temporary crown provides coverage for the exposed dentin, protects it from bacteria and thermal insult, maintains the interproximal contacts and integrity of the arch form, supports and stabilizes the opposing teeth to prevent super-eruption, and provides biological contours from the margin to the occlusal/incisal edge, thereby supporting healthy gingival tissues and promoting cleansability.17

A temporary crown can be made in the laboratory on a pre-operative model that can then be placed over a minimally prepared tooth on an additional model or on the same model, forming a thin-walled or “shell” temporary, which can then be taken to the patient’s mouth and relined on the prep. A coating of lubricant such as petrolatum or cocoa butter may be applied to the preparation and the adjacent teeth. If used, this should be carefully thinned with air or using a small brush, cotton pellet or swab. The use of lubricant is recommended in cases with a composite buildup or where proximal composite restorations have been placed in immediately adjacent teeth. The matrix is filled in the area of the preparation with shade-appropriate acrylic, or bis-acryl composite (bis-acryl—a composite-based resin material)—then seated over the preparation. If acrylic is used, the matrix should be removed prior to final setting and the temporary crown removed and promptly repositioned over the preparation, with pressure in the direction of the margins to prevent setting distortion of the acrylic and pull-away of the temporary margins from the preparation. This technique also ensures that the temporary crown can be removed from the preparation without fracturing as it encounters undercut at adjacent teeth. With bis-acryl, the matrix should be removed as soon as initial set is achieved and the temporary crown carefully lifted from the tooth to prevent hardening of the material in the undercuts at adjacent teeth. The temporary crown may be allowed to set out of the mouth, but the margins and adjacent contact undercuts should be adjusted as soon as possible to allow for reseating and finishing. A thin-bladed plastic instrument may be inserted from the facial or lingual direction directly opposite to the path of insertion and force should be used to break the temporary cement bond allowing to set under compression. Attempting to remove setting cement too early will smear the cement on the tissues and on the surface of the polished temporary crown, making them difficult to clean and leaving an unsightly film. Waiting for the initial set of the cement will typically allow excess cement to be removed without smearing and without leaving any in the sulcus or interproximally. Thorough cement removal is essential to preserve proximal tissue health and reduce inflammation. Such inflammation could also lead to gingival recession and exposure of the crown margins and root surface, complicating delivery of an esthetic long-term result. Final cleanup should include flossing and final verification of the contacts and occlusion. Patients should be advised that staining of temporary restorations can occur with tea, coffee, cola and spicy foods. Composite- or bis-acryl-based resin materials have been shown to be less susceptible to staining than acrylic resin materials.21

The Seating and Cementation of the Final Restoration

The goal of temporary cementation is to protect the tooth and retain the temporary crown reliably yet allow for easy atraumatic removal of the temporary crown and easy cleanup. Temporary cements utilizing zinc oxide eugenol are palliative to the prepared tooth (reducing sensitivity), antibacterial in nature, effectively retain the temporary crown on a sufficiently retentive preparation and are easy to use. Disadvantages are that the eugenol can interfere with composites and acrylics as well as the polymerization and bond strength23 of resin-based materials used for cementation of the permanent restorations; and if the temporary restoration is required for a longer period of time, they can cause both acrylic and bis-acryl temporary restorations to become less resilient and have reduced microsurfice hardness.24 Non-eugenol temporary cements are available, including formulations that contain potassium nitrate to reduce postoperative sensitivity (since the palliative effect of eugenol is absent). Temporary polyacid ester, resin and glass ionomer cements have also become available, each with different handling characteristics. Temporary cementation should use enough cement to thoroughly coat (but not fill) the internal surface of a well-fitting temporary restoration. The preparation should be dry and debris-free. The temporary crown should be placed and allowed to set under compression. Attempting to remove setting cement too early will smear the cement on the tissues and on the surface of the polished temporary crown, making them difficult to clean and leaving an unsightly film. Waiting for the initial set of the cement will typically allow excess cement to be removed without smearing and without leaving any in the sulcus or interproximally. Thorough cement removal is essential to preserve proximal tissue health and reduce inflammation. Such inflammation could also lead to gingival recession and exposure of the crown margins and root surface, complicating delivery of an esthetic long-term result. Final cleanup should include flossing and final verification of the contacts and occlusion. Patients should be advised that staining of temporary restorations can occur with tea, coffee, cola and spicy foods. Composite- or bis-acryl-based resin materials have been shown to be less susceptible to staining than acrylic resin materials.21

The form, shade and value of the crown should first be...
Restorability and Treatment with the Single-Unit Crown

The general requirements for an ideal luting cement can be found in Table 3.

Table 3. Characteristics of an ideal luting cement

<table>
<thead>
<tr>
<th>Feature</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secure retention of the restoration to the tooth</td>
<td>Adequate, no leakage</td>
</tr>
<tr>
<td>Ability to bond to the tooth and to all restorative materials</td>
<td>Secure, no bond failure</td>
</tr>
<tr>
<td>Durable seal of the microgap between the restoration and tooth</td>
<td>Complete, no voids</td>
</tr>
<tr>
<td>High strength</td>
<td>Strong, no failure</td>
</tr>
<tr>
<td>Thin film thickness</td>
<td>Thin, no distortion</td>
</tr>
<tr>
<td>Esthetic compatibility</td>
<td>Aesthetic, non-interfering</td>
</tr>
<tr>
<td>Lack of solubility, sealing the margin against microleakage</td>
<td>Tight, no solubility</td>
</tr>
<tr>
<td>No/low shrinkage during setting</td>
<td>Stable, no change</td>
</tr>
<tr>
<td>Low coefficient of expansion</td>
<td>Low, no expansion</td>
</tr>
<tr>
<td>No/minimal exothermic reaction</td>
<td>No heat generation</td>
</tr>
<tr>
<td>Biocompatibility</td>
<td>Biocompatible, non-toxic</td>
</tr>
<tr>
<td>Lack of toxicity</td>
<td>Non-toxic, no irritation</td>
</tr>
<tr>
<td>Radiopacity</td>
<td>Radiopaque, non-carcinogenic</td>
</tr>
<tr>
<td>Palliative for perioperative sensitivity</td>
<td>Palliative, no discomfort</td>
</tr>
</tbody>
</table>

The patient presented with a lower first molar that had recently received endodontic treatment (Figure 2). In consultation with the patient, and after a full examination and diagnosis, the patient elected for a replacement crown prior to periodontal therapy. At the first treatment visit, an alginate substitute impression was first taken in a quadrant stock tray to which tray adhesive had been applied. This impression would serve as a matrix for fabrication of the temporary crown. The old crown was then removed and a composite core build-up was created using blue contrasting composite and, together with the margins, the tooth was prepared such that functional, biologic and esthetic demands were met.
evaluated, followed by the marginal fit and contacts (and adjustment of contacts if indicated and clinically acceptable). The margins must be closed and consistent with the merging margin-tooth surface interface. Overhanging or bulky margins are not permissible. If margins are short of the preparation margin, the restoration should be rejected and remade from a new impression and die/model. Remaking a restoration on a model from the original impression is likely to return a restoration with the same shortcomings. If a return to the laboratory is required for modification of these parameters, the results of the evaluation of all other parameters should be communicated as well.

Final cementation

Luting cements include zinc phosphate, polycarboxylate, composite resin, compomer and resin-modified glass ionomer cements. Polycarboxylate and zinc phosphate are now less frequently used than before, due to the potential for sensitivity and the solubility (at the margins) of zinc phosphate cement, the higher film thickness of polycarboxylate compared to other cements, and the availability of superior phosphates.

Traditional and more contemporary luting cements are dual- or light-cured, the set can be initiated by exposing the cement restoration away from the margins. Removal of all cement and particulate material from the surface of the restoration margins and the proximal subgingival and interproximal tissues is crucial to the long-term healing and health of the gingival tissues. A final check of the restoration using dental floss assists in the removal of cement from interproximal areas. The occlusion should again be checked to ensure that proper occlusion exists and that normal excursive movements are properly supported but non-interfering. Adjustments made to porcelain, metal or ceramic surfaces should be polished and left with a bioesthetic finish and a smooth transition to the tooth surface. This also reduces the risk of bacterial/ plaque accumulation.

Specific instructions for oral hygiene around full coverage restorations should be given. This may include regular brushing and flossing and the use of interproximal cleaners or brushes, and may also include the application of in-office topical fluorides and prescription level fluoride toothpastes.

Case Study

The patient presented with a lower first molar that had recently received endodontic treatment (Figure 2). In consultation with the patient, and after a full examination and diagnosis, the patient elected for a replacement crown prior to periodontal therapy. At the first treatment visit, an alginate substitute impression was first taken in a quadrant stock tray to which tray adhesive had been applied. This impression would serve as a matrix for fabrication of the temporary crown. The old crown was then removed and a composite core build-up was created using blue contrasting composite and, together with the margins, the tooth was prepared such that functional, biologic and esthetic demands were met.

The general requirements for an ideal luting cement can be found in Table 3.

A clean preparation can be enhanced using air abrasion or etching with 50 μm aluminum oxide if desired. Adequate gingival bleeding and moisture control are absolute necessities. For all-ceramic crowns, the intaglio surface must be prepared per the restorative material manufacturer’s guidelines, if this is required—either hydrofluoric acid and silanation for lithium disilicate, glass ceramic or leucite restorations for the indicated length of time, or air abrasion for other ceramics and again as directed. The selected cement should be placed in the crown, ensuring coverage of all the restoration’s margins, and the crown should then be seated firmly and held under compression until the initial set of the cement material is accomplished. With resin cements that are dual- or light-cured, the set can be initiated by exposing the cement on the facial and lingual surfaces of the tooth to curing light for a few seconds, allowing for initial removal of the bulk excess cement. Note that if the restorative material does not transmit light (either because it is alloy-based or because all-ceramic is too thick), the margins will be light-cured; the luting cement must be able to self-cure/dual-cure if being used for such restorations. Only the non-resin cements, an explorer or scaler can be used to tease the cement restoration away from the margins.

Table 3. Characteristics of an ideal luting cement

| Secure retention of the restoration to the tooth | Ability to bond to the tooth and to all restorative materials |
| Durable seal of the microgap between the restoration and tooth | High strength |
| Thin film thickness | Esthetic compatibility |
| Lack of solubility, sealing the margin against microleakage | No/low shrinkage during setting |
| Low coefficient of expansion | No/minimal exothermic reaction |
| Biocompatibility | Lack of toxicity |
| Radiopacity | Palliative for perioperative sensitivity |

Figure 2. Pre-operative view

Figure 3. Path of insertion from above with packed retainer cord in place

Figure 4. Taper and interocclusal space
Retraction cord was then placed in the gingival sulcus and moisture control obtained. The path of insertion, taper and adequate interocclusal space can be observed in Figures 3 and 4. The impression was made using VPS material in a single-stage, two-phase technique with a heavy-body and light-body layer of VPS. After adhesive was first applied to the tray and while the assistant was loading it, the retraction cord was removed and the area was dried. Then, lighter-body VPS was syringed around the preparation, lightly air-blown to help it flow into the sulcus, and more lighter-body material was syringed around and over the preparation and adjacent teeth (Figures 5-7). The impression tray was then carefully seated, stabilized until the end of the setting time, then removed with a quick snap. The impression was then examined to ensure it was satisfactory (Figures 8-9). An impression of the opposing arch was taken using alginate substitute.

The matrix was then filled with bis-acryl, lubricant applied to the preparation and adjacent teeth to prevent the bis-acryl from adhering, and the matrix seated over the preparation. The matrix was removed as soon as initial set was achieved, the margins and adjacent contact undercut adjusted and the temporary allowed to set. The temporary restoration was then trimmed and finished using fine diamonds and finishing burs, and a varnish coating was applied with an applicator brush and light-cured to ensure the surface was as smooth as possible (Figures 10-11).

Once the fit had again been checked, non-eugenol temporary cement was placed in the temporary crown which was then seated. After the initial set of the cement, excess was removed while it was still tacky and after the final set floss was used to help remove residual cement interproximally and the crown margins and sulcus checked to ensure that no cement remained (Figures 12-13). The occlusion was checked using articulating paper and minor adjustments made. Figure 14 shows the finished temporary crown which was well-fitting and esthetically satisfactory, as well as smooth and glossy which would help prevent the accumulation of biofilm and stain.

At the seat visit for the permanent crown, the temporary restoration was then removed, the temporary crown cleaned and polished, and a non-eugenol cement was used to cement the permanent crown in place. The occlusion was checked and adjusted as necessary. The permanent crown was then finished and polished to a high gloss.

Figure 5. Syringing lighter-body VPS around the preparation

Figure 6. Gently air blowing the VPS material before adding additional lighter-body VPS

Figure 7. Syringing on additional lighter-body VPS material

Figure 8. Seated and stabilized final impression

Figure 9. Final impression

Figure 10. Trimming the temporary restoration

Figure 11. Light-curing the clear varnish coating

Figure 12. Removal of excess cement while cement is still tacky

Figure 13. Removal of excess cement interproximally

Figure 14. Finished temporary crown
Retraction cord was then placed in the gingival sulcus and moisture control obtained. The path of insertion, taper and adequate interocclusal space can be observed in Figures 3 and 4. The impression was made using VPS material in a single-stage, two-phase technique with a heavy-body and light-body layer of VPS. After adhesive was first applied to the tray and while the assistant was loading it, the retraction cord was removed and the area was dried. Then, lighter-body VPS was syringed around the preparation, lightly air-blown to help it flow into the sulcus, and more lighter-body material was syringed around and over the preparation and adjacent teeth (Figures 5-7). The impression tray was then carefully seated, stabilized until the end of the setting time, then removed with a quick snap. The impression was then examined to ensure it was satisfactory (Figures 8-9). An impression of the opposing arch was taken using alginate substitute.

The matrix was then filled with bis-acryl, lubricant applied to the preparation and adjacent teeth to prevent the bis-acryl from adhering, and the matrix seated over the preparation. The matrix was removed as soon as initial set was achieved, the margins and adjacent contact undercut adjusted and the temporary allowed to set. The temporary restoration was then trimmed and finished using fine diamonds and finishing burs, and a varnish coating was applied with an applicator brush and light-cured to ensure the surface was as smooth as possible (Figures 10-11).

Once the fit had again been checked, non-eugenol temporary cement was placed in the temporary crown which was then seated. After the initial set of the cement, excess was removed while it was still tacky and after the final set floss was used to help remove residual cement interproximally and the crown margins and sulcus checked to ensure that no cement remained (Figures 12-13). The occlusion was checked using articulating paper and minor adjustments made. Figure 14 shows the finished temporary crown which was well-fitting and esthetically satisfactory, as well as smooth and glossy which would help prevent the accumulation of biofilm and stain.

At the seat visit for the permanent crown, the temporary
restoration was carefully removed and the preparation and margins thoroughly cleaned of all residual cement (Figure 15). The laboratory-fabricated crown was fully evaluated and found to be well-fitting and to provide an excellent emergence profile for easy placement. Glass ionomer luting cement was selected and a preventive protocol was instituted that would help maintain oral health and help prevent the occurrence of secondary caries. Further appointments were made for the remaining treatment plan needs.

While the luting cement was still tacky, excess cement was removed easily with a hand instrument. Residual cement was then removed after the final set, including interproximal and proximal with the use of dental floss, before rechecking the occlusion and showing the patient the esthetic result (Figures 16-17). The patient was advised on home care and a preventive protocol was instituted that would help maintain oral health and help prevent the occurrence of secondary caries. Further appointments were made for the remaining treatment plan needs.

Summary
When all the steps are followed, and the final restoration is determined to fit properly, comfortably and esthetically, years of satisfactory function with excellent comfort, oral health and esthetics can be anticipated.

References

Webliography
restoration was carefully removed and the preparation and margins thoroughly cleaned of all residual cement (Figure 15). The laboratory-fabricated crown was fully evaluated and found to be well-fitting and to provide an excellent shade match. Glass ionomer luting cement was selected as the luting agent. The luting cement was applied to the intaglio surface of the crown, the preparation was isolated to control moisture and gently dried until it was only hydrated (slightly moist). The crown was then seated and stabilized with cotton rolls while it was setting.

While the luting cement was still tacky, excess cement was removed easily with a hand instrument. Residual cement was then removed after the final set, including interproximals with the use of dental floss, before rechecking the occlusion and showing the patient the esthetic result and the satisfaction with function, comfort, oral health and esthetics can be anticipated. While the luting cement was still tacky, excess cement was removed easily with a hand instrument. Residual cement was then removed after the final set, including interproximals with the use of dental floss, before rechecking the occlusion and showing the patient the esthetic result and the satisfaction with function, comfort, oral health and esthetics can be anticipated.
1. A single-unit crown may be indicated due to __________.
   a. Inadequate tooth structure remaining to support an intracoronal restoration
   b. An existing, failing restoration
   c. A functional discrepancy
   d. All of the above

2. In order for a crown to be indicated when endodontics was performed on a substantially debilitated tooth structure, __________ must be present.
   a. At least two root canals
   b. Adequate root structure
   c. A resin-filled root canal
   d. All of the above

3. For a full-coverage crown, the minimal ideal axial wall height is considered to be at least __________.
   a. 2.3 mm
   b. 3.4 mm
   c. 4.5 mm
   d. 5.6 mm

4. The __________ must be preserved when preparing margins.
   a. Structural width
   b. Biologic width
   c. Periodontal width
   d. All of the above

5. One of the requirements for a full-coverage crown is __________.
   a. Adequate periodontal support
   b. Adequate crown-to-root ratio
   c. Interproximal contacts that allow a path of insertion for the crown
   d. All of the above

6. Best practices dictate that a written and signed record be kept for each treatment step as part of __________.
   a. Informed Agreement
   b. Informed Consent
   c. Professional Contracts
   d. All of the above

7. The __________ is one of the considerations in selecting a restorative material.
   a.esthetic goals
   b. margin placement
   c. strength of the restorative material
   d. All of the above

8. Bis-acryl materials __________ than acrylic.
   a. have lower polymerization shrinkage
   b. Typically present with good initial aesthetics
   c. have higher fracture toughness
   d. All of the above

9. All-ceramic restorations may be contraindicated in patients with __________.
   a. Class I molar relationship or missing anterior teeth
   b. Parafunction or destructive occlusal habits
   c. Minimal saliva and missing anterior teeth
   d. All of the above

10. When preparing a tooth for a full-coverage crown, the occlusal reduction should be greater for __________ than for __________.
    a. PFM, all-ceramic
    b. All-ceramic, PFM
    c. All-ceramic, PFM
    d. None of the above

11. __________ margins are typically the most difficult to reliably close, although they have a role when esthetics cannot be compromised by even a hint of metal at the margin.
    a. Chamfer
    b. Butt
    c. Feathered
    d. All of the above

12. A subgingival margin is typically placed at a position approximately __________ apical to the gingival crest.
    a. 0.5 mm
    b. 1.5 mm
    c. 2.5 mm

13. If placement of a margin would potentially invade the biologic width, advance consideration should be given to __________ prior to restorative treatment.
    a. gingivectomy
    b. crown lengthening
    c. Orthodontic treatment
    d. All of the above

14. Proper adaptation of an impression tray is critical to prevent __________.
    a. over-seating
    b. High-centering
    c. Subsequent flexing of the tray material
    d. All of the above

15. Clay-based and silicone retraction materials have both demonstrated clinically effective __________, when used correctly.
    a. Hemostasis and moisture control
    b. Retraction and hemostasis
    c. Retraction, hemostasis and moisture control
    d. None of the above

16. __________ is essential in order to visualize and capture the crown margin and adjacent tissues with an impression.
    a. Tissue retraction
    b. Hemostasis
    c. Moisture control
    d. All of the above

17. Intra-oral impressions must provide an undistorted representation of __________.
    a. The prepared tooth/teeth
    b. The adjacent teeth and tissues
    c. The shape of the arch
    d. All of the above

18. More complex multi-unit restorative and implant-related cases favor the use of a __________.
    a. stock tray
    b. Fabricated custom tray
    c. Vacuum-formed tray
    d. All of the above

19. __________ is a characteristic of an ideal impression tray.
    a. Minimal flexibility
    b. Lack of impingement on soft tissues
    c. Sufficient internal space for an adequate thickness of impression material
    d. All of the above

20. Prior to seating a crown, the __________ should be evaluated.
    a. Form, shade and value
    b. Marginal fit
    c. Contacts
    d. All of the above

21. Use of a matrix/index aids the creation of __________.
    a. An impression
    b. Crown lengthening
    c. Orthodontic treatment
    d. All of the above

22. With polyether impression materials, a __________ process is employed.
    a. Single
    b. Double
    c. Triple
    d. Quadruple

23. With vinyl polysiloxane impression materials, a __________ process may be employed.
    a. two- or three-stage
    b. one- or two-stage
    c. Uniform stage
    d. None of the above

24. With a “putty wash” technique, a layer of __________ may be placed over the surface of the putty in order to create a “space” for the second stage.
    a. Cement
    b. Plastic spacer
    c. Impression material
    d. None of the above

25. With both a PE and VPS impression, after the setting time __________ is completed the tray is removed __________.
    a. slowly
    b. With a time lag of 5 minutes after the final set
    c. With a “quick snap”
    d. A and c

26. Inadverently exceeding the working time of an impression material typically leads to an impression with __________.
    a. Incomplete homogenization of the material phases
    b. Distortions
    c. Extra strength
    d. All of the above

27. Acrylic materials have greater strength against __________ than bis-acryl.
    a. Occlusal loads
    b. Caries
    c. Distortion
    d. None of the above

28. The goal of temporary cememtation is to __________.
    a. Retain the temporary crown
    b. Allow for easy intra-operative removal of the temporary crown and easy cleanup
    c. Both
    d. None of the above

29. Patients should be advised that __________ of temporary restorations can occur with tea, coffee, cola and spicy foods.
    a. Staining
    b. Enamel demineralization
    c. Caries
    d. All of the above

30. Removal of all cement and particulate material from the surface of the restoration margins and the proximal subgingival and interproximal tissues is crucial to __________.
    a. Long-term healing
    b. Health of the gingival tissues
    c. Esthetics
    d. All of the above
1. A single-unit crown may be indicated due to ________.
   a. inadequate tooth structure remaining to support an intracoronal restoration
   b. an existing, failing restoration
   c. a functional discrepancy
   d. all of the above

2. In order for a crown to be indicated when endodontics was performed on a substantively debilitated tooth structure, ________ must be present.
   a. at least two root canals
   b. adequate root structure
   c. a resin-filled root canal
   d. all of the above

3. For a full-coverage crown, the minimal ideal axial wall height is considered to be at least ________.
   a. 2.3 mm
   b. 3.4 mm
   c. 4.5 mm
   d. 5.6 mm

4. The ________ must be preserved when preparing margins.
   a. structural width
   b. biological width
   c. periodontal width
   d. all of the above

5. One of the requirements for a full-coverage crown is ________.
   a. Adequate periodontal support
   b. Adequate crown-to-root ratio
   c. Interproximal contacts that allow a path of insertion for the crown
   d. all of the above

6. Best practices dictate that a written and signed record be kept for each treatment step as part of ________.
   a. Informed Agreement
   b. Informed Consent
   c. Professional Contracts
   d. all of the above

7. The ________ is one of the considerations in selecting a restorative material.
   a. aesthetic goals
   b. margin placement
   c. strength of the restorative material
   d. all of the above

8. Bis-acryl materials ________ than acrylic.
   a. have lower polymerization shrinkage
   b. typically present with good initial aesthetics
   c. have higher fracture toughness
   d. all of the above

9. All-ceramic restorations may be contraindicated in patients with ________.
   a. a Class I molar relationship or missing anterior teeth
   b. parafunction or destructive occlusal habits
   c. minimal salivary and missing anterior teeth
   d. a and b

10. When preparing a tooth for a full-coverage crown, the occlusal reduction should be greater for a ________ than for a ________ crown.
    a. PFM, all-ceramic
    b. full metal, PFM
    c. all-ceramic, PFM
    d. none of the above

11. ________ margins are typically the most difficult to reliably close, although they have a role when esthetics cannot be compromised by even a hint of metal at the margin.
    a. Chamfer
    b. Butt
    c. Feathered
    d. all of the above

12. A subgingival margin is typically placed at a position approximately ________ apical to the gingival crest.
    a. 0.5 mm
    b. 1.5 mm
    c. 2 mm
    d. all of the above

13. If placement of a margin would potentially invade the biologic width, advance consideration should be given to ________ prior to restorative treatment.
    a. gingivectomy
    b. crown lengthening
    c. orthodontic treatment
    d. all of the above

14. Proper adaptation of an impression tray is critical to prevent ________.
    a. over-seating
    b. high-centering
    c. subsequent flexing of the tray material
    d. all of the above

15. Clay-based and silicone retraction materials have both demonstrated clinically effective ________ when used correctly.
    a. hemostasis and moisture control
    b. retraction, hemostasis and moisture control
    c. none of the above

16. ________ is essential in order to visualize and capture the crown margin and adjacent tissues with an impression.
    a. Tissue retraction
    b. Hemostasis
    c. Moisture control
    d. All of the above

17. Intra-oral impressions must provide an undistorted representation of ________.
    a. the prepared tooth/teeth
    b. the adjacent teeth and tissues
    c. the shape of the arch
    d. all of the above

18. More complex multi-unit restorative and implant-related cases favor the use of a ________.
    a. stock tray
    b. fabricated custom tray
    c. vacuum-formed tray
    d. all of the above

19. ________ is a characteristic of an ideal impression tray.
    a. Minimal flexibility
    b. Lack of impingement on soft tissues
    c. Sufficient internal space for an adequate thickness of impression material
    d. All of the above

20. Prior to seating a crown, the ________ should be evaluated.
    a. form, shade and value
    b. marginal fit
    c. contacts
    d. all of the above

21. Use of a matrix/index aids the creation of ________.
    a. an impression
    b. a bite registration
    c. an anatomically acceptable temporary crown
    d. All of the above

22. With polyether impression materials, a ________ process is employed.
    a. single
    b. double
    c. all of the above
    d. single

23. With vinyl polysiloxane impression materials, a ________ process may be employed.
    a. two- or three-stage
    b. one- or two-stage
    c. uniform stage
    d. none of the above

24. With a “putty wash” technique, a layer of ________ may be placed over the surface of the putty in order to create a “space” for the second stage.
    a. cement
    b. plastic spacer
    c. impression material
    d. all of the above

25. With both a PE and VPS impression, after the setting time ________ is completed the tray is removed ________.
    a. slowly
    b. within a time lag of 5 minutes after the final set
    c. with a ‘quick snap’
    d. a, b and c

26. Inadvertently exceeding the working time of an impression material typically leads to an impression with ________.
    a. incomplete homogenization of the material phases
    b. distortions
    c. extra strength
    d. a and b

27. Acrylic materials have greater strength against ________ than bis-acryl.
    a. occlusal loads
    b. caries
    c. distortion
    d. none of the above

28. The goal of temporary cementation is to ________.
    a. retain the temporary crown reliably
    b. allow for easy atraumatic removal of the temporary crown and easy cleanup
    c. a and b
    d. all of the above

29. Patients should be advised that ________ of temporary restorations can occur with tea, coffee, cola and spicy foods.
    a. staining
    b. erosion
    c. demineralization
    d. all of the above

30. Removal of all cement and particulate material from the surface of the restoration margins and the proximal subgingival and interproximal tissues is crucial to ________.
    a. long-term healing
    b. health of the gingival tissues
    c. esthetics
    d. a and b
CE ANSWER FORM (E-mail address required for processing)

Name: 
Title: 
Specialty: 
Address: 
E-mail: 
City: 
State: 
Zip: 
Telephone: 
License renewal date: 
AGD Identification No.: 
Practice Name

EDUCATIONAL OBJECTIVES
- Review the criteria for restorability with a single full-coverage crown.
- Describe the concept of biologic width, its importance and considerations with respect to crown design.
- List and describe the steps involved in treatment for a single crown, including the preparation design with respect to general parameters and the restorative material selected.
- Delineate the main types of impression materials used during treatment for a crown, and describe the impression-taking techniques that may be used for these materials.
- Review the steps involved in placement of a temporary restoration and in the luting of a permanent crown.

COURSE EVALUATION
Please evaluate this course using a scale of 5 to 1, where 5 is excellent and 1 is poor

1. To what extent were the course objectives accomplished overall? 5    4    3    2    1
2. Please rate your overall mastery of the educational objectives? 5    4    3    2    1
3. How would you rate the educational methods? 5    4    3    2    1
4. How do you rate the author's mastery of the topic? 5    4    3    2    1
5. Please rate the instructor's effectiveness. 5    4    3    2    1
6. Do you feel the references were adequate? 5    4    3    2    1
7. Would you participate in a similar course? 5    4    3    2    1
8. Was any subject matter confusing – please describe. 5    4    3    2    1

To obtain credits:
1. Read the entire course.
2. Complete this entire answer sheet in either pen or pencil.
3. Mark only one answer for each question.
4. A score of 70% will earn your credits.
5. Make check payable to Dental Learning, LLC.
6. Answers can also be mailed to:
   *Dental Learning, LLC
   500 Craig Road, Floor One
   Manalapan, NJ 07726
   *If paying by credit card, please note:
   Master Card  |  Visa  |  AmEx   |  Discover
   *Account Number ______________________________
   *Expiration Date ______________________________
   The $29 charge will appear as Dental Learning, LLC

Price: $29
Save time and the environment by taking this course online.

AGD Code: 610

Fill in the circle of the appropriate answer that corresponds to the question on previous pages.

1.  A      B      C      D
2.  A      B      C      D
3.  A      B      C      D
4.  A      B      C      D
5.  A      B      C      D
6.  A      B      C      D

Praising CE Learning's effective use of space, this form has saved us space and money. She got the answers directly from the learners, not by circularizing the course. This form is also being used by our in-house CE department.