The Impression: A Blueprint to Restorative Success

Douglas A. Terry, DDS; Karl F. Leinfelder, DDS, MS; Ernesto A. Lee, DMD, Dr Cir Dent; Alejandro James, DDS, MS

The art and science of impression making was described as early as 1755, when Philip Phaff developed an impression technique with softened wax. During the next 250 years, numerous improvements in impression materials and clinical techniques were made. In the 1930s, hydrocolloid materials (agar and alginate) were introduced. In the 1950s, a major breakthrough was synthetic elastomeric impression materials with polysulfides, commonly known as “rubber base” materials, which were first developed as an industrial sealant for gaps in concrete structures. Polyethers were introduced in the 1960s, while condensation and addition-reaction silicones were introduced in the 1970s. During the last 25 years, continued modifications in impression material chemistries (ie, rendered hydrophilic addition-reaction silicones, advanced next generation polyethers), the development of dynamic mixing systems, improved impression techniques, and a better understanding of the requirements for gingival tissue management have been made.

The impression is the foundation and blueprint to restorative success for indirect restorations. The art of impression taking requires recording the exact dimensions of the preparation, the position of the soft tissue, the architecture of the margins of the preparation, and the relationship of the prepared teeth to the surrounding dentition. Restorative and periodontal complications can occur from improperly positioned subgingival margins, traumatic manipulation of the soft tissue, thin tissue biotype, and bulky fibrous papilla. Because there are numerous areas for the potential of introducing error, achieving an accurate final impression is the result of properly integrating multiple interrelated steps during the preparation and impression-taking process. This article addresses the physical properties that characterize the most commonly used impression materials, provides the criteria for an ideal impression, and reviews the preoperative considerations for soft-tissue management before impression making. A clinical procedure using the one-step/double-mix impression with a double-cord gingival displacement will provide the clinician with a step-by-step approach to successful final impressions.

Selection of Impression Material

All of the aforementioned impression materials have been evaluated in vitro and their properties have been well documented. However, an in vivo study is difficult to accomplish because of different variables (ie, blood and saliva contamination, deformation during tray removal). The most frequently preferred impression materials are polyvinylsiloxanes (PVS) and polyethers (PE), with the most significant physical characteristics being viscosity, hydrophilicity, setting time, tear resistance and elastic recovery, and dimensional stability.

Viscosity

Viscosity describes the flow characteristics of an unset impression material. Materials with low viscosity have high flow and those with high viscosity have low flow. The viscosity of the material increases with the proportion of filler. Viscosity is affected by the shear force exerted on the material. The impression material can exhibit a decrease in viscosity in response to high shear stress, which is called shear thinning. Therefore, the viscosity of the impression material will vary in accordance to the shear stress. The higher the viscosity of the material, the more evident is the effect of shear thinning. This phenomenon is proposed to be a result of a small filler particle size. The low viscosity material can be referred to as light body, syringe, or wash material. These lower viscosity materials can flow easily into and record fine details; however, they are usually not used alone. Instead, they are generally used in conjunction with a second more viscous material to...
hydrophilically push and support the lower viscosity material.

**Hydropnility**

Impression materials are characterized by their degree of hydrophilicity—hydrophilic, hydrophobic, and hydroactive.\(^1\) Surface wetting describes the relative affinity of a liquid for a solid and can be quantified by measuring the contact angle. A contact angle of 0 would indicate complete wetting of the surface; whereas, a high angle would indicate less wetting.\(^{19,20}\) Moisture compatibility significantly impacts the material’s ability to accurately record surface detail in the intraoral environment. Hydrophilic materials have a high affinity for moisture (low contact angle), provide good surface wetting, and allow for a high degree of surface detail. Hydrophobic impression materials have a low affinity for moisture (high contact angle), provide poor surface wetting, and a lower degree of surface detail.\(^{1,8,21,22}\)

Hydroactive impression materials are normally hydrophobic and are rendered hydrophilic through the addition of surfactants. These materials provide excellent surface wetting (low contact angle) as well as a high degree of surface detail.\(^1\) However, it is necessary when discussing the wetting capability of impression materials to consider and distinguish the materials’ wetting ability to soft and hard tissues and to a gypsum slurry.\(^1^9\)

**Setting Time**

The setting time for an impression material is the total time from the start of the mix until the impression material has completely set and can be removed from the oral cavity without distortion. The working time is measured from the start of the mix until the material can no longer be manipulated without introducing distortion or inaccuracy in the final impression.\(^1\) The impression material must be completely mixed and seated in position before the end of the working time. Elastomeric impression materials have a working time of approximately 2 minutes and a setting time of between 2 and 6 minutes (ie, fast and regular set). Generally, the working time corresponds to the setting time. Consequently, a fast-setting material will usually have a short working time and a slow-setting material will have a long working time. The setting time of all elastomeric impression materials is affected by temperature. One method for extending the working time of a material is to refrigerate the materials before mixing. An increase in time of up to 90 seconds has been reported when the materials are chilled to 2\(^\circ\)C;\(^{19,23,24}\) however, chilling the material should be approached with caution when using automix tips or dynamic mixing units. Furthermore, lowering the temperature of the material below 65\(^\circ\)F will affect the flow of the pastes and result in altered base/catalyst ratios. Other factors that can influence the setting and working time include humidity, base-to-catalyst ratio, and how the material was mixed. In addition, extending the insertion time to ensure that the material has completely polymerized has shown improvement in elastic recovery and decreased permanent deformation.\(^{17}\) There are several factors that can influence the required working time for impression, including the number of preparations, use of automix or hand-mix material, the viscosity of the material, and the use (or nonuse) of an auxiliary. The time required between mixing the impression material, syringing the material around the preparations, and seating the tray are influenced by these factors. Multiple preparations may benefit from using an automix material that has a longer working time with a low viscosity syringe material with an auxiliary.

**Tear Resistance and Elastic Recovery**

Impression materials should have adequate strength to allow removal without tearing. A material with higher tear energy confers better resistance to tear for the impression.\(^{14}\) Elasticity allows the material to resist tearing and recover to its original prestressed configuration. The degree to which this occurs is a measure of the elastic recovery of the material. Permanent deformation can occur when the polymer is elongated beyond the point at which elastic recovery is possible. It is desirable that an impression material tears rather than deforms past this critical point, particularly in areas such as the margin. Permanent deformation is related to the degree of cross-linking of the polymer strands, temperature, and the rate of the applied stress.\(^{15,19}\)

Tear resistance and elastic recovery are important in preserving the accuracy of the impression during intraoral removal and after cast separation. Materials with sufficient tear resistance and elastic recovery will withstand multiple pours, producing several accurate casts, which is a major advantage in contemporary restorative dentistry.\(^{8,25,26}\)

**Dimensional Stability**

The ability of an impression to accurately replicate the intraoral structures is dependent upon the dimensional stability. The reasons for dimensional changes in elastomeric impression materials include a reduction in spatial volume caused by contraction from polymerization, reduction in set volume from liberation of by-product or accelerator components, water absorption from wet or varying humidity environments, and changes in temperature.\(^{19}\) Materials with sufficient dimensional stability can remain unchanged for a reasonably prolonged period of time (eg, 7 days), and resist temperature extremes during shipping while retaining the ability to produce multiple accurate casts.\(^8\)

**Polyether vs Polyvinyl Siloxane**

Because of their characteristics, the most popular elastomeric impression materials include the
polyethers and the polyvinyl siloxanes. A description and comparison of each will illustrate the advantages and disadvantages for their application in a variety of indirect procedures in prosthodontics and restorative dentistry.

Polyethers

Polyethers have a successful clinical history. The advantages for their use include low polymerization shrinkage, long-term dimensional stability, multiple accurate pours, hydrophilicity, highly accurate surface detail, elastic recovery, minimal distortion on removal, adequate tear strength, and good shelf life (they may remain dimensionally stable for up to 7 days if kept dry). The disadvantages include unpleasant taste and odor, rigidity (sets to a stiff consistency), difficult intraoral removal and cast separation, expense, and will absorb water if left immersed in disinfectants for long periods (disinfection with glutaraldehyde for 10 minutes is recommended). Polyethers include Impregum™ Impregum™ Penta™ (3M™ ESPE™, St. Paul, MN), Permadyne™ Permadyne™ (3M™ ESPE™), Polyjet® Polyjet® NF (Dentsply Caulk, Milford, DE), and P2® P2® (Heraeus Kulzer, Inc, Armonk, NY).

Polyvinyl Siloxanes

Addition reaction silicones, also known as polyvinyl siloxanes, constitute the most popular category of impression material. These materials are available in different viscosities to accommodate different impression techniques. The advantages for their use include extremely high accuracy, superior tear resistance, less polymerization shrinkage and increased dimensional stability, neutral odor and taste, multiple accurate casts, less rigid than polyethers on setting, tear strengths that vary with filler rates and viscosities, and working times that can be increased with chemical retarders, although temperature control of working time is the preferred method. In addition, they also exhibit excellent elastic recovery, and possess the lowest distortion characteristics of any impression material. They can be used with all impression techniques and provide fast setting times, are extremely stable, have a long shelf life, are easily disinfected in any solution without loss of accuracy, and may remain dimensionally stable for up to 7 days. The disadvantages include an inherent hydrophobic nature and the susceptibility to inadequate polymerization as a result of latex contamination. The hydrogen gas release that can cause bubble formation in some materials has been controlled in all contemporary polyvinyl siloxane materials with the addition of a scavenger.

Criteria for an Ideal Impression

An accurate impression is the key to restorative success. An ideal impression should provide adequate wash thickness to withstand distortion and tearing when intraorally removed; no evidence of voids, bubbles, drags or tears; a uniform homogenous mix of materials; uniform bond between the impression material, adhesive, and tray (Figure 1); and reproduce fine surface details free of debris such as saliva and blood. In addition, it should be distortion free and completely set upon removal. To achieve an ideal impression requires an integration of numerous factors: proper materials selection, tray selection, volume of material, timing, hemostasis, moisture control, and tissue management.

According to the literature, the disparate adoption of the latest materials may not lead to clinical success, but accuracy of the impression may be controlled by technique.

Tissue Management

Healthy periodontal tissues are a prerequisite for the success of the impression-taking procedure, the postimpression period, and the placement of the final restoration. Inflammation of the gingival tissues before impression taking can complicate the procedure. Bleeding and moisture from crevicular fluid can displace the impression material, resulting in voids and rounded, indistinct finish lines that can cause an inaccurate cast and an improperly fitting final restoration. Furthermore, if a subgingival margin is placed in the presence of inflammation, there is a potential risk of gingival recession and exposure of the restorative finish line. Therefore, a fundamental requirement for achieving excellence in impression taking is management of the soft tissues.

The preoperative considerations during initial therapy are to control and eliminate all sources of irritation and inflammation. This can be accomplished by the control of plaque-related etiologies and/or the correction of restorative contributing factors. Unfortunately, this may require delaying the impression procedure after tooth preparation to allow for improvement in the condition of the soft tissue. The provisional restoration is an essential component of this initial therapy and can improve the quality of the impression. It preserves the position, form, and color of the gingiva and maintains the periodontal health before impression taking and while the definitive restoration is being fabricated.

Management of the soft tissue during the preparation and impression-taking stages requires an understanding of the gingival tissue architecture. The most important determining factor in predicting how the tissue will respond to preparation and impression techniques begins with the relationship of the free gingival margin to the osseous crest. Preoperative recordings of facial and interproximal bone height, and determination and preservation of the biologic width, can provide predictability into the postrestorative gingival margin levels and the periodontal health.
Clinical Impression Technique

Because it assists the laboratory technician in developing optimal tooth shapes and contours, precise reproduction of the surrounding soft tissues in the final impression is essential (Figure 2). The following clinical procedure illustrates the one-step/double-mix impression with a double-cord gingival displacement.

During the diagnostic phase and before the restorative appointment, the osseous crest position is determined on the facial and interproximal regions of the tooth to be prepared. Assuming a normal osseous crest, during the restorative phase and after the onset of anesthesia, the tooth is prepared relative to the osseous crest with the finish line following the scallop of the gingiva. A primary compression cord of small diameter (3-0 surgical silk suture, Ethicon, Somerville, NJ) is soaked in plain buffered aluminum chloride and gently placed in the bottom of the sulcus around the preparation with light pressure from a cord packing instrument (Fischer’s Ultrapak No. 170, Ultradent Products, Inc, South Jordan, UT) using a bimanual technique. This technique combines a periodontal probe and cord packing instrument to facilitate insertion with low force (Figures 3A and 3B). The finish line of the preparation is extended to the coronal aspect of the cord, which places the finish line of the final restoration approximately 0.5 mm to 1 mm below the gingiva.

This initial placement of the retraction cord provides a seal to the sulcus to prevent contamination of the margins by blood or crevicular fluid. The first cord layer is a sulcus liner, to prevent tearing of the sulcular epithelium and bleeding when the second cord is removed immediately before injecting the impression material, which can be a problem with the single cord technique. In addition, it retracts the tissue to prevent contact of the diamond bur with the gingival epithelium during final margin placement (Figure 4)\(^\text{16}\).

A second retraction cord is then inserted into the entrance of the sulcus using the same technique (Figure 5). The tissue is now displaced apically and laterally. The gingival retraction is allowed to remain for 5 to 10 minutes, to allow water absorption by the superficial cord. This generates expansion of the superficial cord and increases the crevicular width (Figures 6A; 6B; 6C). Before taking the impression, any excess moisture is eliminated and the patient participates in isolation using lip retractors.

The second retraction cord is removed, and a low viscosity impression material is immediately injected into the sulcus. The entire preparation is covered with the low viscosity material and directly followed by the placement of the tray, which has been loaded with a more viscous material. The tray is removed along the path of insertion after inspection of the set material and the specified setting time has been reached. The impression is examined for accuracy with magnification. The ideal registration is created with a laterally deflected sulcus more than 0.5 mm in width, and more than 0.5 mm of apical deflection sufficient to record an adequate amount of unprepared tooth structure apical to the margin (Figures 7A; 7B; 7C).

Conclusion

Restorative success is defined by the quality of the impression. The impression process requires an integration of various elements of restorative dentistry. The restorative dentist must have knowledge of the physical properties of these materials and their application in a variety of indirect procedures in prosthodontics and restorative dentistry. However, as studies indicate, the accuracy of the impression may be controlled more by the technique than the material.\(^\text{12,47-50}\) Therefore material knowledge must be integrated with the proper technique for each clinical situation. Consequently, the ultimate success of the final impression depends on the skill of the operator, and the experience acquired with that given technique.

References

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**Figure 1** An adhesive (polyvinyl or polyether) is applied evenly to the internal surface of the custom tray providing a uniform bond between the impression material, adhesive, and tray.

**Figure 2** Impression taking requires recording the exact dimensions of the preparation, the position of the soft tissue, the architecture of the margins of the preparation, and the relationship of the prepared teeth to the surrounding dentition.

**Figures 3A and 3B** A primary compression cord of small diameter is placed using a periodontal probe and cord packing instrument to facilitate insertion with low force.
Figure 5 A second, larger retraction cord is then inserted into the entrance of the sulcus to laterally displace the tissue.

Figure 4 The finish line of the preparation is extended to the coronal aspect of the cord, which places the finish line of the final restoration approximately 0.5 mm to 1 mm below the gingiva.

Figure 6A Gingival retraction is allowed to remain for 5 to 10 minutes to allow water absorption by the superficial cord and increase crevicular width.

Figure 6B Excess moisture is eliminated and the second cord is removed.

Figure 6C A low viscosity impression material is immediately injected into the sulcus.

Figure 7A Proper apical and lateral deflection of the sulcus.

Figure 7B The capture of an ideal registration in polyvinyl siloxane.

Figure 7C The capture of an ideal registration in polyether material.
About the Authors

Douglas A. Terry, DDS
Assistant Professor
Department of Restorative Dentistry and Biomaterials
University of Texas Health Science Center, Dental Branch
Houston, Texas

Private Practice: Esthetic and Restorative Dentistry
Houston, Texas
Member of Oral Design International

Karl F. Leinfelder, DDS, MS
Adjunct professor
Biomaterials Clinical Research
University of North Carolina
Chapel Hill, North Carolina
Professor Emeritus
University of Alabama School of Dentistry
Birmingham, Alabama

Ernesto A. Lee, DMD
Clinical Associate Professor
Postdoctoral Periodontal Prosthesis
University of Pennsylvania School of Dental Medicine
Philadelphia, Pennsylvania
Visiting Professor
Advanced Aesthetic Dentistry Program
New York University College of Dentistry
New York, New York
Private Practice
Bryn Mawr, Pennsylvania

Alejandro James, DDS, MS
Private Practice: Prosthetic and Implant Dentistry
General Dentistry
Private Practice limited to Periodontal Prosthesis, Implant Dentistry, and Esthetic Dentistry
Leon, Guanajuato
Mexico