The Impression: A Blueprint to Restorative Success

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The art and science of impression making was first described in 1755 when Philip Phaff proposed an impression technique using softened wax.[1] The following 250 years evidenced numerous improvements in impression materials and clinical techniques. With the 1930s came the hydrocolloid materials (agar and alginate).[2-6] The 1950s heralded a major breakthrough in synthetic elastomeric impression materials with polysulfides, commonly known as "rubber base" materials, which were primarily developed as an industrial sealant for gaps in concrete structures.[7]

The sixties brought the polyethers while the seventies unveiled condensation and addition-reaction silicones[1, 8]. The last twenty five years have seen continued modifications in impression material chemistry, (ie, rendered hydrophilic addition-reaction silicones, advanced next generation polyethers), the development of dynamic mixing systems, improved impression techniques as well as a better understanding of the requirements for gingival tissue management.

The impression is the foundation and blueprint for restorative success with indirect restorations.[9,10] The art of impression taking requires recording the exact dimensions of the tooth preparation, the precise position of the soft tissue, the architecture of the margins of the preparation, and the relationship of the prepared teeth to the surrounding teeth. Both restorative and periodontal complications can occur from improperly positioned subgingival margins, traumatic manipulation of the soft tissue, thin tissue biotype, and bulky fibrous papillae.[10,11] Thus, an accurate final impression is the result of properly integrating multiple interrelated steps during the preparation and impression taking process since there are numerous areas where error could be introduced. This article reviews the preoperative considerations for soft tissue management prior to impression making and it examines the physical properties of the most commonly used impression materials. It also provides the criteria for the ideal impression. The description of a clinical procedure using the one-step/double-mix impression with a "double cord" gingival displacement is presented to provide the clinician with a step-by-step approach to successful final impressions.

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Selection of Impression Material

All of the aforementioned impression materials have been evaluated in vitro and their properties have been well documented.[2, 12-16] However, an in vivo study is difficult to accomplish because of all the different variables (eg. blood and saliva contamination, deformation during tray removal). The following discussion will describe the clinically relevant physical properties that characterize the two most frequently preferred impression materials - polyvinyl siloxanes (PVS) and polyethers (PE). The most significant physical characteristics of these materials are viscosity, hydrophilicity, setting time, tear resistance and elastic recovery, and dimensional stability.

Viscosity

The term "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 present.[17] 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 and this is called shear thinning. Thus, the viscosity of the impression material will vary in accordance with the shear stress. The higher the viscosity of the material, the more evident is the effect of shear thinning. This phenomenon is believed to be due to the small filler particle size.[18] 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 the fine details; however they are not usually used alone. They are used in conjunction with a second more viscous material to hydraulically propel and support the lower viscosity material.

Hydrophilicity

Impression materials are characterized by their degree of hydrophilicity. They may be hydrophilic, hydrophobic, or hydroactive.[1] Surface wetting describes the relative affinity of a liquid for a solid and can be quantified by measuring the contact angle. A zero contact angle would indicate complete wetting of the surface whereas, a high angle would indicate less wetting.[19,20] Moisture compatibility significantly impacts on 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 impression materials that are normally hydrophobic and are rendered hydrophillic 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 the materials' wetting ability to soft and hard tissues and also to a gypsum slurry.[19]

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 (i.e. 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 is to refrigerate the materials before mixing with increases of up to 90 seconds having been reported when the materials were chilled to 2^{O}C,[19,23,24] However, chilling the material should be undertaken with caution when using automix tips or dynamic mixing units. Furthermore, lowering the temperature of the material below 65 degrees 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 the manner in which the material was mixed. In addition, extending the insertion time to ensure that the material has completely polymerized has indicated improvement in elastic recovery with decreased permanent deformation.[17] There are several factors that can influence the required working time for impression taking. These are: the number of preparations, utilization of automix or hand-mix material, the viscosity of the material. The time required between mixing the impression material, syringing the material around the preparations and seating the tray are influenced by these factors.

Tear Resistance and Elastic Recovery

Impression materials should have adequate strength to allow removal without tearing. A material with a higher tear energy provides 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

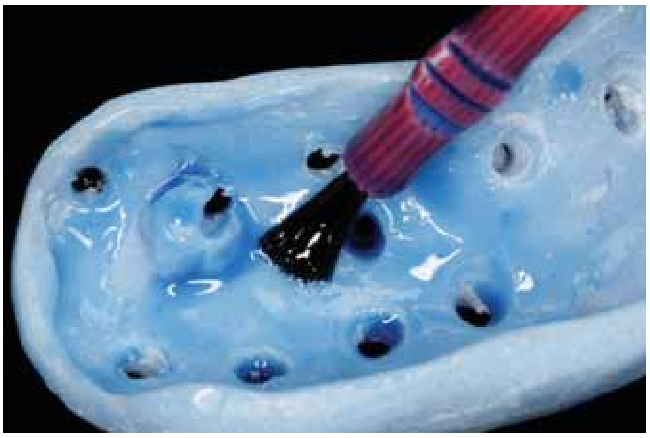

Figure 1: An adhesive (polyvinyl or polyether) is applied evenly to the internal surface of the custom tray providing a uniform bond between the impression material, adhesive and tray,

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.

Figure 3 a, b: A primary compression cord of small diameter is placed using a periodontal probe and cord packing instrument to facilitate insertion with low force.

the point where elastic recovery is possible. It is desirable that an impression material should tear rather than deform past this critical point particularly in areas such as the margin of the tooth preparation. Permanent deformation is related to the degree of cross-linking of the polymer strands, the temperature and the rate of the applied stress[15, 19]

These two physical properties (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. This is a major advantage in contemporary restorative dentistry.[8, 25, 26]

Dimensional stability

An impression's ability to accurately replicate the intraoral structures is dependent upon its dimensional stability. The reasons for dimensional changes in elastomeric impression materials include the following: contraction due to reduction in spatial volume following 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 (7 days), and resist temperature extremes during shipping while retaining the ability to produce multiple accurate casts.[8]

The most popular elastomeric impression materials include the polyethers and the polyvinyl siloxanes,[16]. A description and comparison of each is presented to illustrate the advantages and disadvantages for their application in a variety of indirect procedures in prosthodontics and restorative dentistry.

Polyethers have played a successful role in clinical dentistry.[27] The advantages for their use include low polymerization shrinkage, long-term dimensional stability, the possibility to generate multiple accurate casts, hydrophilic and highly accurate surface detail, elastic recovery, minimal distortion on removal, adequate tear strength, and good shelf life They have the ability to remain dimensionally stable for up to 7 days if kept dry. The disadvantages include an unpleasant taste and odor, they tend to be very rigid and they set to a stiff consistency, there is difficulty with intraoral removal and cast separation. In addition, they are expensive and will absorb water if left immersed in disinfectants for long periods. Disinfection with glutaraldehyde for 10 minutes is recommended. Polyethers include Impregum F/Penta (3M-ESPE), Permdyne (3M-ESPE), Polygel NF (Dentsply Caulk), P2 (Heraeus Kulzer).[1, 2, 8, 16, 28-30]

Addition reaction silicones, also known as polyvinyl siloxanes (VPS), 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 their extremely high accuracy, they exhibit superior tear resistance, less polymerization shrinkage and increased dimensional stability, they have an neutral odor and taste, they permit multiple accurate casts, they are less rigid than polyethers on setting, and their tear strength varies with filler rates and viscosities. Their working times can be increased with chemical retarders, although temperature control of working time is the preferred method. They also exhibit excellent elastic recovery and possess the lowest distortion characteristics of any impression material. They can be used with all impression techniques providing fast setting times. They are extremely stable having a long shelf life and are easily disinfected in any solution without loss of accuracy, and they remain dimensionally stable for up to 7 days. The disadvantages include their inherent hydrophobic nature, and their susceptibility to inadequate polymerization as a result of

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 0.5mm to 1 mm below the gingiva.

Figure 5: A second larger retraction cord (#2 Ultrapak, Ultradent, South Jordan, UT) is then inserted into the entrance of the sulcus to laterally displace the tissue.

latex contamination. The hydrogen gas release in some materials that may be responsible for generating bubble formation in the final model has been controlled with the addition of a scavenger in all contemporary polyvinyl siloxane materials.[1,2,17,27,31,32-46] Polyvinyl siloxanes include Flexitime (Heraeus Kulzer), Aquasil (Dentsply,/Caulk), Splash! (Discus), Virtual (Ivoclar Vivadent)

Criteria for an Ideal Impression

An accurate impression is the key to restorative success. An ideal impression should provide the following:

1 adequate wash thickness to withstand distortion and tearing when removed intraorally
2 no evidence of voids, bubbles, drags or tears,
3 the ability to achieve a uniform and homogenous mix of materials,
4 uniform bond between the impression material, adhesive and tray, ***(Figure 01)***
5 fine surface details free from debris such as saliva and blood,
6 distortion free, and complete set upon removal.

The "ideal impression" results from the integration of numerous factors. These are: proper material selection, tray selection, volume of material, timing, hemostasis, moisture control, and tissue management.[2, 9, 43] 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.[8,12,47-50]

Tissue Management

Healthy periodontal tissues are essential for the success of the impression-taking procedure. Inflamation of gingival tissues prior to impression taking can complicate the procedure. Bleeding and moisture from crevicular fluid can displace impression material and may result in voids and rounded indistinct finish lines that could cause an inaccurate cast [2] and inadequately fitting final restorations. Furthermore, if a subgingival margin is placed in the presence of inflamation there is a potential risk of gingival recession and exposure of the restorative finish line.[8,51] Therefore, a fundamental requirement for achieving excellence in impression taking is management of the soft tissues.

The major preoperative consideration during initial therapy is the control and elimination of all sources of irritation and inflamation. This can be accomplished by control of plaque and the correction of restorative contributing factors.[25] Unfortunately, this may require delaying the impression procedure after tooth preparation to allow for improvement in the soft tissues. The provisional restoration is an essential component of this initial therapy and can improve the quality of the final impression. It preserves the position, form, and color of the gingiva and maintains the periodontal health prior to impression taking and while the definitive restoration is being fabricated. [52]

Management of soft tissue during the preparation and impression taking stages requires a thorough understanding of gingival tissue architecture. The most important determining factor in predicting tissue response to preparation and

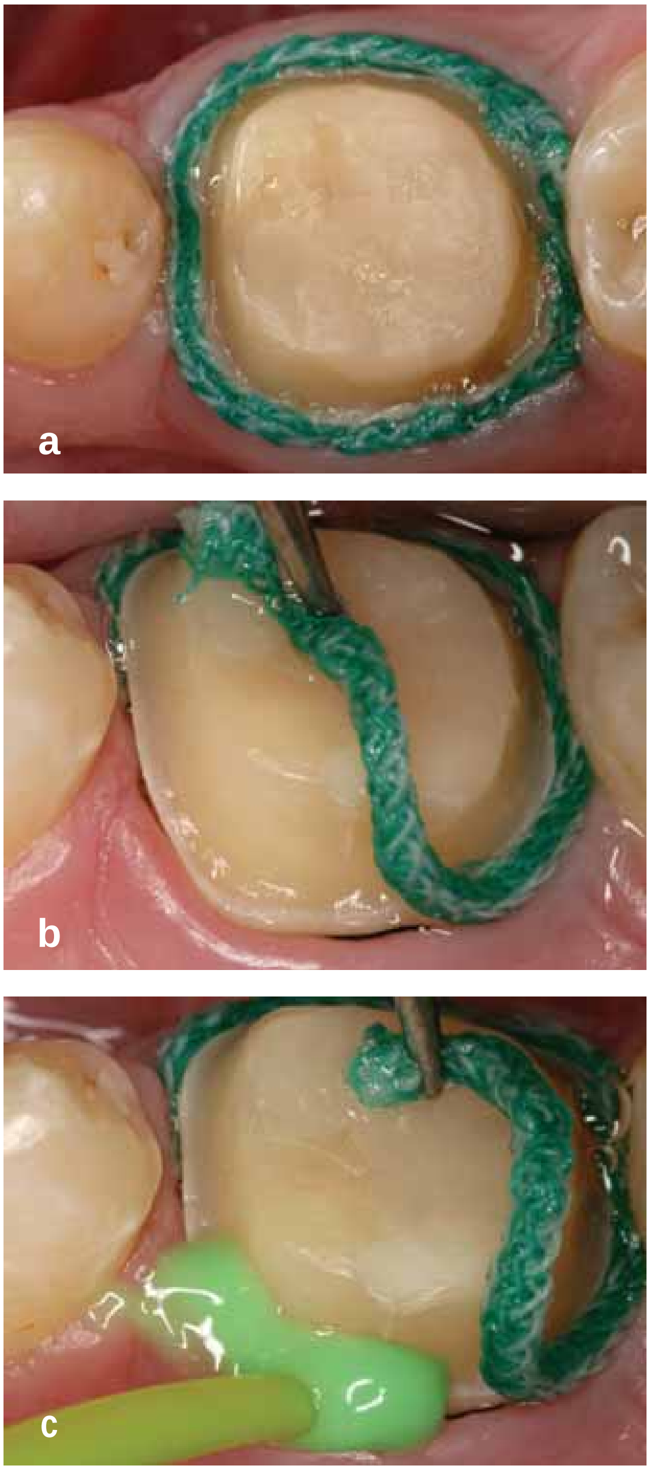

Figure: Gingival retraction is allowed to remain for 5 to 10 minutes, to allow water absorption by the superficial cord and increase crevicular width.(a); Excess moisture is eliminated and the second cord is removed (b); a low viscosity impression material is immediately injected into the sulcus (c).

impression techniques is 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 post-restorative gingival margin levels and the periodontal health.[11]

Clinical Impression Technique

Precise reproduction of the surrounding soft tissues in the final impression is essential since it assists the laboratory technician in developing optimal tooth shape and contour. *(Figure 02)* The following clinical procedure illustrates the one-step/double-mix impression with a "double cord" gingival displacement. During the diagnostic phase and prior to the restorative appointment the osseous crest position is determined on the facial and interproximal regions of the tooth to be prepared. The recorded numbers indicate 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 #170, Ultradent, South Jordan) using a bimanual technique. This technique combines a periodontal probe and cord packing instrument to facilitate insertion with low force. *(Figure 3 a,b)* 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 0.5mm to 1mm 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 prior to injecting the impression material. This could be a problem with the single cord technique. In addition, the cord retracts the tissue so as to prevent contact of the diamond bur with the gingival epithelium during final margin placement.[16] *(Figure 4)* A second retraction cord (#2) 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 continue 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. *(Figure 6 a, b, c)* Prior to 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

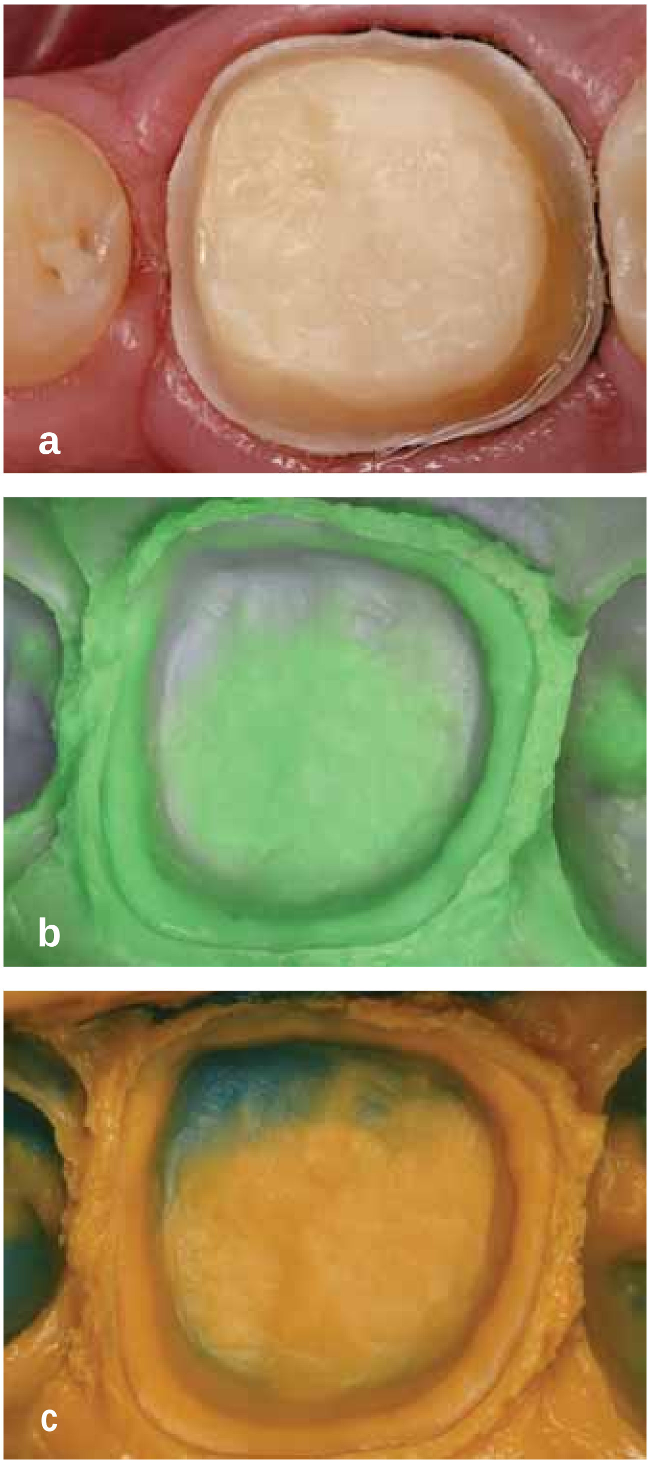

Figure 7: Proper apical and lateral deflection of the sulcus (a) allows the capture of an ideal registration in polyvinyl siloxane (b); and polyether materials (c). Notice the accuracy of both types of impression materials using this technique.

examined for accuracy with magnification. The ideal registration is created with a laterally deflected sulcus greater than 0.5mm in width with 0.5mm of apical deflection being sufficient to record an adequate amount of unprepared tooth structure apical to the margin. *(Figure 7 a, b, c)*

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 a knowledge of the physical properties of these materials and their application in a variety of indirect procedures in prosthodontics and restorative dentistry. However, various studies indicate that the accuracy of the impression may be controlled more by the technique than the material.[12, 47-50] Therefore this 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.

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