Clinical and Material Factors in Achieving the Ideal Impression

A Peer-Reviewed Publication
Written by Dr. Alan A. Boghosian

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Educational Objectives
Upon completing this course, the reader should be able
to do the following:
1. Understand the key factors involved in achieving an
   ideal impression
2. Be knowledgeable about techniques available for soft
tissue retraction and hemostasis
3. Understand the factors involved in tray and impres-
sion material selection
4. Be knowledgeable about techniques and materials
   available that will enhance impression material flow

Abstract
Clinicians report that the impression-taking process is the
most stressful restorative procedure. Key factors involved
in producing clinically acceptable impressions include
managing soft tissue, appropriately selecting tray and
impression material, and enabling impression material to
flow predictably. Managing soft tissue is the most critical
step in obtaining a perfect impression. Tray selection also
plays a significant role with tray choice depending on the
clinical situation and on the impression material and tech-
nique used. The most commonly used elastomeric impres-
sion materials are polyether (PE) and vinyl polysiloxane
(VPS) chemistries. Appropriate use of either will produce
a clinically accurate impression. The material must have an
adequate working time and flowability, and have sufficient
tear strength to prevent tearing at thin areas at the margin.
Using a hydrophilic impression material and a surface
modifier will permit enhanced flow and result in a more
accurate and detailed impression. In addition, the impres-
sion must be dimensionally stable for a reasonable time
until it is cast. Achieving clinically acceptable impressions
requires clinical expertise and appropriate materials, trays,
and techniques.

Introduction
Successful indirect restorations depend on many factors,
but chief among them is taking a good impression. An
impression that does not precisely duplicate the prepared
teeth will produce an inaccurate working model and result
in poorly fitting restorations. Clinicians report that the
impression-taking process is the most stressful restorative
procedure, because of clinical technique and the impres-
sion material’s inherent properties.

This article will present key factors involved in produc-
ing clinically acceptable impressions, including managing
soft tissue, selecting tray and impression material, and
enabling impression material to flow predictably.

Soft-Tissue Management
Managing soft tissue is the most critical step in obtaining
a perfect impression. When surveyed, 48% of key opinion
leaders and researchers considered soft-tissue manage-
ment the single most critical factor in accurate impres-
sion-taking.1 With clinical cases involving deep decay,
margin placement is an important consideration. Before
any preparation, consider the biologic width.2 Avoid plac-
ing margins too close to bone level, to prevent violating the
biologic width.3,4 Extending restoration margins beyond
the biologic width can cause inflammation and, eventually,
anatomic changes.5

Consider pre-prosthetic crown lengthening if the
biologic width has been violated.6 Also, capturing a
preparation’s margins is significantly easier if they are not
deeply subgingival. Two criteria are critical when taking an
impression of equigingival and subgingival preparations:
hemostasis and gingival retraction (see Figures 1, 2).

Figure 1. Poor hemostasis resulting in inadequate impression

Figure 2. Poor impression with undefined margins

Hemostasis
Several hemostatic agents containing aluminum chloride
and aluminum sulfate can arrest and prevent bleeding be-
fore an impression is taken. Products containing aluminum
chloride include Hemogin-L (Van R), Hemodent™ Liquid
(Premier Dental), and ViscoStat Clear (Ultradent). Products
containing aluminum sulfate include Gel Cord® (Pascal) and Tissue Goo™ (Clinician’s Choice Dental).

To control slight-to-moderate bleeding, I have found that aluminum chloride and aluminum sulfate are suitable. To control moderate-to-severe bleeding, ferric sulfate and ferric chloride are more effective. Products containing ferric sulfate include FS Hemostatic™ (Premier Dental), and ViscoStat and ViscoStat Wintergreen (Ultradent). An ideal hemostatic agent is ferric chloride (ViscoStat Plus). It can be more effective than ferric sulfate and is potentially less irritating to dentin and pulpal tissues because of its higher pH (2.3 compared to 1.0). However, ferric chloride can tarnish stainless steel.

**Gingival retraction**

Gingival retraction enables accurate recording of preparation margins and the gingival sulcular area. The most common way to retract the gingiva is with retraction cord.

In addition to classical methods of gingival retraction, newer chemical systems are now available. Silicone polymer retraction materials and materials composed of high-viscosity clay include Magic FoamCord (Coltene Whaledent) and Expasyl ™ (Kerr Corporation).

Magic FoamCord is a vinyl polysiloxane material that is syringed around the prepared tooth margins. The material generates hydrogen gas, which expands the sulcus. However, when preparation areas are fairly subgingival, the material may not provide enough retraction force, and it lacks a hemostatic agent.

Expasyl ™ contains aluminum chloride for hemostasis. Its putty-like consistency provides sufficient retraction for conservative subgingival preparations, and it can effectively control slight-to-moderate bleeding. However, its viscosity may not provide enough retraction for deeper subgingival preparations.

Although other methods are available — such as rotary curettage, electrosurgery, and lasers — they remove tissue rather than retracting it, and all alternatives but lasers have other drawbacks.

Rotary curettage can be difficult to control and is not recommended for thin, friable gingival tissue. Electrosurgery is similarly contraindicated with friable tissue and in patients with pacemakers. Lasers have produced good results with management of gingival tissue and in postoperative healing. They not only produce an excellent visible path to the margin but also provide outstanding hemostasis.

Gingival retraction using retraction cord is the most widely accepted method. To avoid trauma, as a rule of thumb, use the thinnest cord that adequately retracts tissue. Using a nonimpregnated cord lets you select the hemostatic medicament. If using preimpregnated cord, first soak with a hemostatic agent to improve hemostasis. Before removing cords, soak them with water to help prevent tissue damage and ease placement. Of prosthodontists who responded to a 1999 national survey, 98% said they used gingival retraction cord and 48% said they used double cords.

**Single-cord technique**

This technique involves a single retraction cord placed in the sulcus and removed just before taking the impression. The single-cord technique is effective if the margins are supragingival or equigingival. It may not be as effective if the margins are subgingival, because the gingival tissue rapidly collapses back over the margins when the cord is removed (see Figure 3). This prevents the flow of impression materials apical to the margin.

**Double-cord technique**

This technique uses two layers of cord of differing thicknesses. It can prevent tissue collapse and bleeding, helping to achieve perfect impressions. However, careful technique is required to avoid tissue damage. In the case of a shallow sulcus or friable tissue, use only one cord.
The following steps describe the use of the double-cord technique:

Step 1. Using a microbrush, apply a small amount of ViscoStat Plus around the entire margin to arrest slight bleeding or to prophylactically prevent bleeding during cord placement.

Step 2. Soak a thin-diameter retraction cord (Ultrapak, Ultradent; GingiBraid, Van R) in an appropriate hemostatic agent. Then place the cord subgingivally around the tooth to obtain apical retraction. The first cord acts as a gingival seal and prevents tissue-adhesion bleeding when the second cord is removed before taking the impression. Completing final margination after placing the first retraction cord protects the gingiva from potential damage by rotary instruments.

Step 3. After finalizing the margins, soak a second, larger-diameter (No. 2) retraction cord in the hemostatic agent. Place this around the preparation to create further lateral and apical retraction.

Step 4. Allow the cords to remain in place long enough for full retraction to occur and to prevent relapse when you remove the second cord (usually after four to five minutes). Then remove the second cord and take the impression, keeping the first cord in place to prevent crevicular seepage and bleeding (see Figure 4). If the first cord does not come out with the impression, be sure to retrieve it from the sulcus before dismissing the patient.

**Tray Selection and Impression Technique**

Tray selection plays a significant role in taking accurate, detailed impressions. Base your tray choice on the clinical situation and on the impression material and technique used. Choose from stock plastic and metal trays (perforated and unperforated) and custom-fabricated trays.

Custom trays are the most reliably accurate. They also produce consistently accurate impressions of implant-fixture sites, use less impression material, and are more comfortable for patients. But regardless of the clinical case or the impression technique and tray used, prevent prepared teeth from touching the tray to avoid ill-fitting crowns.

**Complete-arch (full-arch) technique**

When taking an impression on fewer than four teeth, you can use a stock (metal or plastic) or custom tray. But to ensure successful impressions when preparing more than four to six teeth, strongly consider using a custom tray. A properly constructed custom tray will enable optimal impression–material flow (see Figure 5).
Closed-bite (double-arch) technique
The closed-bite impression is the most technique-sensitive of all impression techniques. If used correctly, it can save time and reduce occlusal adjustments on crowns. It is ideally suited for one or two prepared posterior teeth that are adjacent to unprepared teeth. These impressions, when appropriately taken, can provide dimensional and marginal accuracy11,12 (see Figures 6, 7, 8).

Use a rigid metal closed-bite tray with low sidewalls and a wide buccal-lingual distance. If the patient has a narrow palate, a tray with higher sidewalls could impinge and flex, causing improperly fitting restorations. Use fast-set impression material only if you can syringe and seat the tray in 20 seconds or less. Otherwise, use regular-set impression material. Use a tray material with a low strain-in-compression.

Impression Material Properties

Requirements for Impression Materials
The most commonly used elastomeric impression materials are polyether (PE) and vinyl polysiloxane (VPS) chemistries. Appropriate use of either will produce a clinically accurate impression. However, be aware of several physical-property and clinical-handling requirements.
A precision elastomeric impression material must accurately replicate the details of the prepared teeth. The detail reproduction test in International Standards Organization (ISO) document 4823 and American Dental Association (ADA) specifications requires a light body impression material to replicate a 20-micron line. The material must have an adequate working time and flowability. The impression must be dimensionally stable for a reasonable time until it is cast. In addition, the material must have sufficient tear strength to prevent tearing at thin areas at the margin.

An impression material’s set hardness is measured by the strain-in-compression test. The tray material’s strain-in-compression properties should correspond to the selected tray type. Full-arch impressions can be more easily retrieved from the mouth when using less rigid setting-tray materials, whereas exceedingly rigid setting-tray materials are ideal for use with the closed-bite impression technique.

When selecting an impression material, consider patient comfort. Choose materials that have as short a setting time as clinically appropriate, are easy to remove, and smell and taste pleasant. I will discuss these properties in the next section.

**Working time**

An impression material’s working time critically depends on temperature. Addition silicones (VPS) are more sensitive to temperature changes than PE. Intraorally, VPS impressions have 66% less working time, and PE impressions 50% less working time than at the lower room temperature used as the ISO standard for testing. This reduced working time affects how long the material can flow to capture all clinical details and margins (see Table 1).

<table>
<thead>
<tr>
<th>Material</th>
<th>23°C In Seconds</th>
<th>35°C In Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impregum</td>
<td>66</td>
<td>140</td>
</tr>
<tr>
<td>Aquasil Ultra</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Flexitime Genie Ultra</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Hydrophilic</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>Examix NDS VP Mix Imprint</td>
<td>80</td>
<td>200</td>
</tr>
</tbody>
</table>

*Adapted from ADA Professional Product Review Vol. 2 Issue 3.

Use fast-set material when preparing only one or two teeth. Use regular-set impression material when preparing more than two teeth, to increase working time, or if working in a warmer environment. When using a double-mix impression technique, syringe the wash material around the teeth and then immediately seat the tray. If the wash material starts to set before the tray is placed, the tray material could drag the wash and create voids.

If a putty material is selected as the tray material and is mixed too long, it will set before the tray is seated, causing recoil and resulting in inaccurate dies and tight-fitting crowns.

To lengthen working time for large restorations, refrigerate the impression material. Lowering its temperature will significantly increase working time without jeopardizing its physical properties.

Mix putty quickly, using fingertips as much as possible to avoid heat transfer from the palms. While you are syringing the prepared teeth, your assistant can simultaneously dispense impression material into the tray to provide maximum working time for the viscosity of both materials.

**Strain-in-compression**

Strain-in-compression measures how hard an impression material sets up, and ranges from 0.8% to 20%. Strain-in-compression is an important consideration in tray selection and impression technique. When taking a full-arch impression, use a tray material with a strain-in-compression above 3.5%. This improves patient comfort during retrieval, especially when undercuts and pontics are present. When using the closed-bite impression technique, use a stiffer setting-tray material with a strain-in-compression below 2%, because the impression material becomes the extension of the tray.

**Elastic Recovery (Compression Set)**

The ability of an impression material to recover to the same shape and dimension after being deformed is tested in elastic recovery. When a set impression is removed from the mouth, the material is stretched and compressed from undercuts. Vinyl polysiloxane materials with values greater than 99% have the greatest elastic recovery. Tests of polyether elastomers show that they average around 97% recovery. The higher the value, the better, but note that polysulfide materials having the lowest elastic recovery at 95% can perform well clinically. Differences in clinical performance might be seen with implant transfer type impressions, where a high degree of elastic recovery may perform better.

**Tear Strength**

A measurement of tear strength is not included in the suite of physical property tests in the American National Standards Institute/American Dental Association (ANSI/ADA) specification No. 19 or ISO 4823 specifications. Lautenschlager and Boghosian investigated the tear strength of low-viscosity impression materials using specimens with notches the size of the average thickness of impressions (220 microns). We found Aquasil Ultra XLV to have the highest tear strength in this study. Tear strength alone should not be the only criteria when choos-
ing a product for clinical use. However, if you experience frequent tearing, selecting a material with higher tear strength could be very helpful providing all other properties are satisfied (see Table 2).

Table 2. Tear strength

<table>
<thead>
<tr>
<th>Impression Material</th>
<th>Tear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSI</td>
<td>A</td>
</tr>
<tr>
<td>Materials</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
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<td></td>
<td>D</td>
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<td></td>
<td>E</td>
</tr>
<tr>
<td>P &lt; 0.05</td>
<td></td>
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</tbody>
</table>

Hydrophilicity and wettability

The degree of hydrophilicity of a material is tested using a contact angle goniometer. A small droplet of water or other liquid is placed on a surface, and the angle formed between the liquid-solid interface is referred to as the contact angle. A material with a lower contact angle is more wettable and hydrophilic. Modern vinyl polysiloxane impression materials have significantly increased hydrophilic properties over their predecessors, with measured contact angles as low as 7 degrees measured in 10 seconds.

While contemporary impression materials demonstrate highly hydrophilic behavior, the dentin on which these materials are syringed lack the same degree of hydrophilicity. Contact angles of more than 70 degrees have been reported on dehydrated dentin surfaces17 (see Figure 9). The flow of the impression material, especially subgingivally, is limited because of the disparity between the dentin and the impression material contact angles.

Surface modifiers

In the same survey mentioned above, 57% of key opinion leaders and researchers stated that their greatest need was for an impression material that could predictably flow subgingivally, thus eliminating voids in the sulcus and at the margins.18 Predictable flow of impression material can be attained by applying a surface modifier to dentin and other intraoral surfaces to increase the wettability. Surfactants used as surface modifiers (surface treating agents) or as topical agents on impression materials also improve wettability and reduce voids in impressions.19

B4™ Pre-Impression surface optimizer (DENTSPLY Caulk) is a surface modifier that has been found to wet out dentin and improve contact angles of dentin to hydrophilic VPS (Aquasil Ultra Smart Wetting® impression material). To decrease the contact angle of dentin as shown in Figure 9a, first apply B4™ surface optimizer to the surface (see Figure 9b).

Figure 9a. Contact angle of water on dentin

![Figure 9a](image)

Figure 9b. Contact angle of water on B4™ surface optimizer treated dentin

![Figure 9b](image)

Lowering the surface tension by applying B4™ surface optimizer helps the impression material flow better (see Figure 10). Figure 11 compares the application of 1.0cc of Aquasil Ultra XLV impression material syringed onto a surface with and without B4™ surface optimizer. Note the enhanced flow achieved on the right side. Enhanced impression material flow is seen on dentin with B4™ surface optimizer pretreatment (see Figure 12).

Figure 10a. Preparation with dry dentin

![Figure 10a](image)
The use of B4™ surface optimizer with Aquasil Ultra impression material does not interfere with the replication of the 20-micron line, as described in ADA and ISO detail reproduction testing. Higher-detail reproduction resolution was tested using 1,200 grooves/mm holographic gratings. Prior to taking an impression, a film of B4™ surface optimizer was applied to the grating surface. The impression was cast in epoxy and examined with a scanning electron microscope. The ruled lines in most areas throughout the surface showed equivalent detail compared to a replication without the B4™ surface optimizer pretreatment (see Figure 13). In conclusion, application of B4™ surface optimizer will substantially increase the flow of impression material on dentin and other intraoral surfaces, while not affecting on surface detail reproduction.

Summary
Achieving clinically acceptable impressions requires clinical expertise and appropriate materials, trays, and techniques. Several considerations are essential: properly managing...
tissues before taking the impression, not exceeding the impression material’s working time, and following proper protocols. Using a hydrophilic impression material and a surface modifier such as B4 will permit enhanced flow, allow time-efficient syringing of wash material, and result in a more accurate and detailed impression.

References
1. 3MESPEnternational Innovation Dental Symposium, November 15, 2004, Munich, Germany.
18. 3MESPEnternational Innovation Dental Symposium, November 15, 2004, Munich, Germany.

Author Profile
Dr. Alan A. Boghosian
Dr. Alan A. Boghosian is a Clinical Associate Professor of Surgery in the Division of Dental Surgery of the Department of Surgery, at Northwestern University’s Feinberg School of Medicine where he coordinates clinical research investigations. Dr. Boghosian maintains a private practice in downtown Chicago devoted primarily to restorative dentistry. He has authored numerous publications and has lectured internationally on the subjects of dental materials and restorative procedures. Dr. Boghosian is a member of the International Association of Dental Research and a Fellow in the American College of Dentists and Academy of Dental Materials. In 1996 he was the recipient of the Gordon J. Christensen Recognition Lecturer Award of the Chicago Dental Society. Dr. Boghosian is a media spokesperson for the American Dental Association. He formerly was chairman of the working group on materials, instruments and equipment of the Council on Scientific Affairs of the American Dental Association and currently serves as a consultant to the council.

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Questions

1. Clinicians report that the impression-taking process is_________.
   a. the simplest part of a prosthetic procedure
   b. the most stressful restorative procedure
   c. not critical to results
   d. none of the above

2. The most critical step in obtaining a perfect impression is_________.
   a. creating a bevel in the preparation
   b. preparing the tray
   c. using an etchant first
   d. managing soft tissue

3. The biologic width should be considered_________.
   a. after the preparation is completed
   b. before any preparation has begun
   c. only in patients with periodontal disease
   d. none of the above

4. If the biologic width has been violated,_________.
   a. inflammation can occur
   b. anatomic changes can occur
   c. pre-prosthetic crown lengthening should be considered
   d. all of the above

5. Hemostasis and gingival retraction are critical in taking an impression of_________.
   a. a subgingival or equigingival preparation
   b. any preparation
   c. a subgingival or supragingival preparation
   d. none of the above

6. Hemostatic agents used include_________.
   a. aluminum sulfate
   b. ferric sulfate and ferric chloride
   c. aluminum chloride
   d. all of the above

7. Ferric chloride_________.
   a. can be more effective than ferric sulfate
   b. is potentially less irritating to dentin than ferric sulfate
   c. has a higher pH than ferric sulfate
   d. all of the above

8. Methods for gingival retraction include the use of_________.
   a. retraction cord
   b. polymers and pastes such as Expasyl™
   c. lasers and rotary curettage
   d. all of the above

9. According to the article, the most common method of gingival retraction is the use of retraction cord, and many clinicians use the double-cord technique.
   a. True
   b. False

10. Using the thinnest retraction cord that will adequately retract tissue will_________.
    a. help avoid trauma to the tissue
    b. not be satisfactory
    c. avoid the use of too much material
    d. result in a poor impression

11. The single-cord technique for gingival retraction may not be as effective if the margins are subgingival, because the gingival tissue can rapidly collapse back over the margins when the cord is removed.
    a. True
    b. False

12. Using a double-cord technique for gingival retraction_________.
    a. can help achieve a perfect impression
    b. can prevent bleeding
    c. can prevent tissue collapse
    d. all of the above

13. The choice of tray material should be based on the_________.
    a. impression material
    b. technique used
    c. clinical situation
    d. all of the above

14. Custom trays_________.
    a. are the most reliably accurate
    b. are an unnecessary extra step
    c. are more comfortable for patients
    d. a and c

15. According to the article, a stock tray should be strongly considered if more than four to six teeth are being prepared.
    a. True
    b. False

16. The most technique-sensitive impression method for preparations is the_________.
    a. open-bite technique
    b. closed-bite technique
    c. plaster of paris technique
    d. a and c

17. The most commonly used impression materials are_________.
    a. polyethers
    b. vinyl polysiloxanes
    c. polysulfides
    d. a and b

18. ISO testing and ADA specifications require a light body impression material to replicate_________.
    a. a 20-micron line
    b. a 30-micron line
    c. a 40-micron line
    d. a 60-micron line

19. An impression material must have_________.
    a. adequate working time
    b. adequate flowability
    c. dimensional stability after setting
    d. all of the above

20. The strain-in-compression test measures_________.
    a. an impression material’s flowability
    b. an impression material’s set hardness
    c. an impression material’s reproducibility
    d. none of the above

21. Full-arch impressions can be more easily retrieved from the mouth when using less rigid setting-tray materials.
    a. True
    b. False

22. Intraorally, VPS impressions have_________ less working time and PE impressions_________ less working time than at the lower room temperature used as the ISO standard for testing.
    a. 36%; 45%
    b. 66%; 50%
    c. 66%; 55%
    d. 75%; 60%

23. A regular set impression material is recommended_________.
    a. when preparing more than two teeth
    b. to increase working time
    c. when working in a warmer environment
    d. all of the above

24. The ability of an impression material to recover to the same shape and dimension after being deformed is tested in_________.
    a. elastic deformity
    b. elastic recovery
    c. plastic recovery
    d. none of the above

25. A material with a lower contact angle is more wettable and hydrophilic.
    a. True
    b. False

26. Modern vinyl polysiloxane impression materials have significantly increased hydrophilic properties when compared to their predecessors, with measured contact angles as low as_________.
    a. 3 degrees; 5 seconds
    b. 5 degrees; 10 seconds
    c. 7 degrees; 10 seconds
    d. 7 degrees; 15 seconds

27. Applying a surface modifier to dentin and other intraoral surfaces to increase wettability_________.
    a. can lead to attainment of predictable flow of impression material
    b. improves contact angles of dentin to hydrophilic impression materials (VPS)
    c. has no effect on the end result
    d. a and b

28. Using B4™ surface optimizer will_________.
    a. substantially increase the flow of impression material on dentin
    b. substantially increase the flow of impression material on other intraoral surfaces in addition to dentin
    c. not affect surface detail reproduction
    d. all of the above

29. Using a hydrophilic impression material and a surface modifier will allow time-efficient syringing of wash material and will result in a more accurate and detailed impression.
    a. True
    b. False

30. Considerations essential for achieving clinically acceptable impressions include_________.
    a. following proper protocols
    b. not exceeding the impression material’s working time
    c. properly managing tissues prior to impression taking
    d. all of the above
Clinical and Material Factors in Achieving the Ideal Impression

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Educational Objectives

1. Understand the key factors involved in achieving an ideal impression
2. Be knowledgeable about techniques available for soft tissue retraction and hemostasis
3. Understand the factors involved in tray and impression material selection
4. Be knowledgeable about techniques and materials available that will enhance impression material flow

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