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Final Impressions: A Review of Material Properties and Description of a Current Technique



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Esthetic rehabilitations are characterized by a sequence of well-structured clinical and laboratory steps, during which different kinds of impressions are required. This review presents a survey of the most clinically relevant physical properties that characterize final impression materials and their interactions with the products they are commonly in contact with. The principal steps of an esthetic rehabilitation involving a diagnostic phase, together with a rational step-by-step approach to final impressions, are described. The one-step/double-mix impression using polyvinyl siloxane materials associated with a "double cord" gingival displacement is explained. (Int J Periodontics Restorative Dent 2004;24:109–117.)

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All prosthetic treatments are characterized by a sequence of well-structured clinical and laboratory steps, during which different kinds of impressions are required.¹ The success of the latter not only depends on the impression-taking step, but also on the preprosthetic phase (conditioning and health of the soft tissues, tooth preparation, provisional restorations). Moreover, to ensure a precise reproduction of intrasulcular preparation margins in the esthetic zone, the gingival displacement has to be carried out carefully and atraumatically, using specific methods. Finally, to obtain the best performance of impression materials and avoid distortion and dimensional instability, clinicians must be aware of certain physicochemical properties of these materials, including their potential interaction with other dental products.

The aim of the present article is to present a review of the most important physicochemical properties of impression materials and a rational step-by-step description of an impression technique. The one-step/double-mix impression technique as-

Table 1 Clinically relevant mechanical properties of elastomeric impression materials according to Chai et al⁵

Material	Yield strength	Strain at yield point	Tear energy
Polyvinyl siloxanes	+	++	-
Polyethers	++	+	+
Polysulfides	-	-	++

sociated with a "double cord" gingival displacement has been chosen.

Material properties

Numerous impression materials and techniques have been proposed,² and a variety of properties have to be considered when evaluating these materials. Because of their characteristics, polyvinyl siloxanes (PVS) and polyethers (PE) are nowadays preferred to other elastomers like polysulfides (PS) or reversible hydrocolloids (agar agar) for final impressions in restorative dentistry.

Rheologic properties

Elasticity, plasticity, and viscosity. To ensure ease of mixing and handling, the unmixed pastes have to present a viscous behavior. Once mixed, PVS develops elasticity rapidly and should be used as soon as possible; this tendency is marked at high temperatures. On the contrary, PE remains plastic for a longer period after being mixed³; this may be

desirable for clinicians because impressions may be distorted if a material is inserted into the patient's mouth at a stage when it has already developed elasticity.⁴ The rigidity of PE—its final stiffness is twice that of PVS—frequently affects the ease of removal from the mouth. On the laboratory side, the rigidity of PE also increases the risk for stone die breakage, especially in situations with large retentive areas between the teeth, when fixed partial dentures are already present in the mouth, and in the presence of thin and long abutment preparations. When possible, retentive areas may be eliminated by the application of wax before the injection of the impression material on dental arches.

Deformation and tear energy. According to Chai et al,⁵ three mechanical properties of elastomeric impression materials are clinically relevant (Table 1):

- *Yield strength* determines the ability of the impression material to withstand stress without permanent deformation.

- *Strain at yield point* indicates the amount of undercut that the impression material can overcome without permanent elastic deformation.
- *Tear energy* indicates the resistance to tear of the impression material.

Impression materials should display high tear energy as well as adequate elastic recovery. However, elevated tear energy may not be an advantage if its value is superior to the yield strength of the material. In this case, the impression might be tear free but distorted, which will result in poor fit of crown margins.⁶ The ideal dental impression material should absorb most of the energy, not necessarily prior to or during tearing, but prior to a critical point of permanent deformation estimated as significant (0.4% in lab tests⁵). PS displays higher tear energy but permanently deforms after being stretched to 0.4%; PVS and PE tear before this limit. For this reason, their clinical use is more suitable to avoid distortion.⁷

Marginal thickness and tear energy. The aforementioned concept might be relevant considering the most delicate part of the whole impression, ie, the preparation margin that combines thin layers of impression material with the possibility of undercuts beyond the margin. At this level, the impression must be thick enough to withstand distortion and tearing upon removal. The space available for the impression material after retraction cord removal is 0.3 to 0.4

mm.⁸ No statistically relevant differences about distortion are detected among PS, PE, and PVS when sulcular widths are greater than 0.2 mm.⁹ However, impressions and dies made from abutments with narrower sulci demonstrate greater distortion.¹⁰

Material interactions

With latex products. Polymerization inhibition of PVS impression materials has been reported with the use of latex gloves.¹¹ The polymerization of the impression material can be inhibited by direct contact with 96% of latex products (gloves and rubber dam); 40% of latex products inhibit polymerization with either direct or indirect contact.¹² It seems that gloves interfere with the setting of more brands of PVS impression materials than does residual powder on hands immediately after degloving.¹³ It is thought that the inhibition of polymerization is caused by the contamination of the chloroplatinic acid catalyst by the sulfur compounds in the latex products.¹⁴ It is reported that vinyl gloves have no adverse effect on polymerization.¹² No other impression materials (condensation silicones, irreversible hydrocolloid, PE, PS) are affected by pure latex gloves.¹⁵

With medicaments and retraction cords. Many different medicaments are used on gingival retraction cords to minimize hemorrhage from the gingival sulcus during impression taking. The interaction of a large number of agents (racemic

epinephrine, aluminum sulfate, aluminum chloride, aluminum potassium sulfate, ferric sulfate) with the setting of PVS has been tested; none of them had any inhibitory effect on the impression material polymerization.¹⁶ Two of these products are commonly used at the University of Geneva: buffered aluminum chloride (Hemodent, Premier Dental), and ferric sulfate (Astringedent, Ultradent).

With disinfectants. Because of the need for protection of clinicians, staff, and laboratory technicians from infectious diseases, the effects of disinfectants to reduce contamination from clinical impressions have been studied.¹⁷⁻²⁰ There is no apparent agreement regarding the relation between disinfection efficiency and possibility of impression material distortion. It seems that high-level disinfectant solutions (glutaraldehyde and chloride phenol groups) at different concentrations (2.0% and 3.5%) do not affect the accuracy and dimensional stability of elastomeric impression materials after immersion for 30 or 60 minutes.²¹ On the contrary, long-term (18 hours) immersion in disinfectants can affect the stability of the impression material and ultimately the fit of fixed partial dentures.²² The conclusion is that overnight immersion of clinical impressions in disinfectants must be avoided.

With die materials. For a successful reproduction of patients' oral structures, impression and die materials should be compatible. Different

degrees of compatibility between elastomers and gypsum die stones (type IV, type V, and reinforced type IV) in relation to contact angles, detail reproduction, and die hardness have been reported.²³ The lower the contact angle the impression material exhibits with the die mix, the fewer voids the stone cast presents.²⁴ Although statistically significant differences for each property were found, adequate detail reproduction of prepared teeth and die hardness were achieved with any elastomeric impression material coupled with any stone die material tested.²³

With storage temperature. The dimensional stability and accuracy of PVS and PE are well-established.²⁵ Although storage temperature does not seem to influence the dimensional stability of these materials if it remains between 4 and 40°C,²⁶ temperatures beyond this range may induce distortions of the impressions.²⁷

With dentin adhesives. A recent trend in restorative dentistry is represented by bonded porcelain restorations. If an important quantity of dentin has been exposed during the preparation, an immediate bonding of the surface is suggested.^{28,29} To avoid any possible interaction with impression materials, the inhibition layer must be eliminated by curing the adhesive through a glycerin gel.³⁰



Fig 1 Preoperative views of patient affected by loss of labial enamel and anterior open bite. The patient's demand was to improve esthetics without orthodontic treatment. Distance between maxillary and mandibular incisors did not allow reestablishment of anterior guidance by restorative procedures alone. Treatment goal was to improve anterior esthetics by placing four laminate veneers.



Selection of impression materials

Numerous impression materials have been evaluated in in vitro studies, and their properties are now well-known.¹⁻²³ Unfortunately, an in vivo evaluation is difficult to achieve because many different parameters, like soft tissue retraction, blood or saliva contamination, deformation during pull-out of the tray, etc, may affect the result of an impression.³¹

Polyethers

The development of a new generation of "soft" PE (Impregum Soft and Impregum Penta Duo Soft, 3M/ESPE) allows coupling of the physical properties of the past generation of these materials (rheologic properties, plasticity for a certain time after being mixed, wettability, and thixotropy) with better taste and improved elasticity; consequently, comfort for the patient has also been enhanced. Moreover, with the advent of automixing or mechanically mixing systems, the variability in achieving a homogenous void-free

mix by hand mixing (especially with heavy-body PE) has been eliminated, and good consistency can be obtained on a routine basis.³²⁻³⁴

Polyvinyl siloxanes

Because of their excellent physical properties and ease of handling, PVSs are the impression materials of choice for fixed prosthodontics. Recently, some new, "more hydrophilic" products have been introduced to the market (eg, Aquasil, Dentsply/DeTrey). The low-viscosity paste can be directly injected around the preparations in the mouth with a manual dispenser; a similar device is used to load the impression tray with the heavy-body paste. Accordingly, the dental team does not need any other mechanical device to mix base and catalyst pastes. It must be remembered that the success of an impression also depends on the skill of the clinician and the experience acquired with a given technique rather than on the choice of a given procedure or specific impression material.

Therapeutic sequence

Initial therapy, diagnostic phase, and preparation of impression environment

Initial therapy is the common phase of all dental procedures. The aim of this phase is to suppress all sources of irritation and inflammation (dental plaque and calculus, caries, and defective fillings) and obtain perfect control of oral hygiene. Once gingival health is established, preliminary impressions are performed, and study casts are prepared. Precise and inexpensive irreversible hydrocolloids are the impression materials of choice for this phase. A clinical case of anterior reconstruction will be used to illustrate the restorative sequence. The baseline views (Fig 1) showed an extreme visual tension because of the lack of cohesiveness between the lower lip line and incisal edge line. The patient's request was to improve esthetics without orthodontic treatment. The distance between maxillary and mandibular incisors did not allow the reestablishment of an anterior guidance by restorative means alone. The treat-



Fig 2 (left) Acrylic resin mock-up is fabricated directly in the patient's mouth using a silicone key reproducing the diagnostic wax-up. Envisioned new situation can be easily anticipated and evaluated by the patient.



Fig 3 (right) Silicone matrix of wax-up is used as reference for tooth reduction.

ment goal only consisted of improving anterior esthetics by the placement of laminate veneers.

The first step of the treatment, especially if esthetic areas are involved, is to redefine a correct morphology of the teeth, and eventually of the surrounding soft tissues, by a diagnostic wax-up.³⁵ This new situation can be easily visualized by means of an acrylic resin template, directly fabricated in the patient's mouth, using a silicone key reproducing the diagnostic wax-up (Fig 2). Thus, all esthetically relevant parameters^{36,37} can be evaluated with the patient, and all modifications of the initial diagnostic study can be easily integrated into the template. Once optimal esthetics is achieved, the template should be used as a guide during tooth preparation (Fig 3).³⁸ The quality of detail reproduction strongly depends on the precision and smoothness of the tooth preparation margins. The finishing procedure has to be carried out after the placement of a retraction cord in the sulcus to avoid any contact of the diamond bur with the gingival epithelium. A definitive impression can then be taken to finalize the rehabil-

itation. In traditional fixed prosthodontics, a precise adaptation of the provisional restoration not only guarantees the gingival health during this phase, but also improves the quality of the impression if this procedure is delayed to a second appointment. In this case, conditioning of the soft tissues by the provisional restorations is suggested.

Gingival displacement

To obtain a low-trauma gingival displacement, great importance is given to the choice of products and the technique. Among the different techniques proposed in the literature, the retraction cord procedure seems to be less traumatic when compared to electrosurgery³⁹ or rotative gingival curettage⁴⁰ and lowers the risk of gingival recessions caused by the impression.

A new product, based on the hemostatic properties of aluminum chloride and the hygroscopic expansion of kaolin in contact with liquids, is also available on the market (Expasyl, Produits Dentaires Pierre Rolland). Once in contact with the

sulcus, the kaolin component of this product absorbs the crevicular fluid and expands. A mild displacement of the gingiva is obtained in about 2 minutes; after rinsing, an impression can be taken.

The retraction cord technique, used at the University of Geneva since the early 1980s, has demonstrated its reliability and allows the operator to control all the parameters in many clinical situations.⁴¹ The retraction cord, imbued with aluminum or potassium sulfate or aluminum chloride, can be used to obtain a chemical and mechanical soft tissue displacement.⁴² Epinephrine-impregnated retraction cords are not recommended because they can induce local necrosis and systemic effects,⁴³ without any real advantage in respect to the other active agents.⁴²

The insertion of two different retraction cords of different diameters, adapted to the variable morphology of the sulcus, is suggested. The first, thinner compression cord (No. 2-0 silk surgical suture or Gingibraid 0a [VanR Dental Products]) is applied deep in the sulcus around each preparation with light pressure



Fig 4 Individual compression cords (No. 2-0 silk) are placed to seal the bottom of each sulcus.



Fig 5 Larger but more superficial deflection cord is placed over compressive one (Gingibraid 0a). It can be continuous on several teeth. Use of two instruments (bimanual technique combining periodontal probe and spatula) facilitates its insertion with low force. Packing should remain in place for some minutes to absorb water and generate some expansion. Excess water is eliminated just prior to impression taking.



from a small spatula; the aim of this cord is to "seal" the sulcus and avoid contamination of the margins by blood or crevicular fluid during application of the impression material (Fig 4). The second, deflection cord (Gingibraid 0a or 1a) is then inserted in the entrance of the sulcus with the bimanual technique (Fig 5). A single cord can be used for multiple preparations. To allow the deflection cord to expand by water sorption, it is useful to rinse the preparations and wait for some minutes before starting the impression procedure.

Impression technique

In the so-called one-step/double-mix impression technique, a light-bodied impression material is immediately injected after deflection cord removal. Because of the viscoelastic behavior of gingival tissues, the latter remain deflected after removal of the cord (Figs 6a and 6b), which favors the penetration of the light-body impression material into the sulcus, slightly

beyond the preparation margins. This first layer of impression material is blown onto the abutment preparations (Fig 6c), and a second bulk of light-bodied material is then applied. The last step is represented by the insertion of the tray itself, loaded with a more viscous material (Fig 7). Either stock or custom trays are adapted to the technique. Individual trays, however, offer a more accurate in-mouth positioning, significant saving of heavy-body material, and facilitated fabrication of the master model in the laboratory. The application of an adhesive on the impression tray is highly recommended to ensure optimal clinical performance.⁴⁴

To avoid any deformation of the impression during the setting time (materials with different setting times are available), it is suggested to keep the impression tray in place until complete setting of the material. Finally, because of the viscoelastic nature of dental impression materials, a rapid removal of the impression from the oral cavity is suggested to decrease the time the material is

under stress and thus reduce the risk of permanent deformations.⁷

After its removal from the mouth, the impression is attentively inspected to detect any tearing or deformation (Fig 8). Once checked, it can be disinfected and sent to the dental technician, together with all the prescriptions for the esthetic rehabilitation. Because of the dimensional stability of modern impression materials over time, the impression can be poured many times up to 1 week without risk of deformation.⁴⁵ This property is very useful because it allows the technician to fabricate multiple dies in different materials according to the kind of ceramic and technique used. In the present case (Fig 9), four laminate veneers in feldspathic ceramic were prepared to finalize the esthetic rehabilitation. As mentioned earlier, anterior guidance could not be reestablished by this restorative procedure, as abnormally long teeth would have resulted. The situation had been evaluated and explained to the patient beforehand (at the diagnostic phase).



Fig 6a During impression taking, deflection cord is removed from sulcus.



Fig 6b Low-viscosity impression material is immediately injected into the sulcus.



Fig 6c This first layer of impression material is gently blown onto the abutment preparations.



Fig 7 (left) Tray, which has been simultaneously loaded with a more viscous mass, is inserted into patient's mouth.

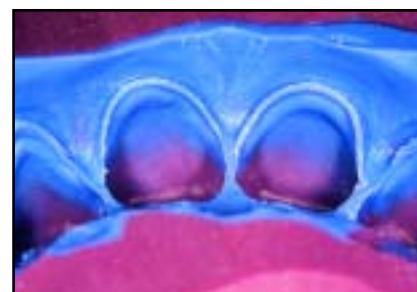


Fig 8 (right) Corresponding impression demonstrates accurate reproduction of preparation margins and absence of distortion.



Fig 9 Postoperative views after adhesive insertion of four laminate veneers.



Conclusion

The quality of final impressions plays a major role in the success of the prosthetic rehabilitation. A number of impression materials are available on the market. Their selection must be based on the knowledge of their physical properties and possible

interactions with other products commonly used during clinical procedures. During the preprosthetic phase, the preparation of an ideal environment for final impressions is of paramount importance. The quality and stability of soft tissues must be preserved during the intracrevicular placement of crown margins—

required for esthetics—and the impression phase. For this reason, the gingival displacement must be carried out carefully and atraumatically. The one-step/double-mix impression technique, using PVS associated with double cord gingival displacement, is suggested because of its simplicity and reliability.

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