Virtual®

Scientific Documentation

ivoclar vivadent

Table of Contents

1 Introduction

1.1 Requirements

Vinylpolysiloxane impression materials have applications in a variety of indirect procedures in prosthodontic and restorative dentistry. Their popularity in the modern dental practice derives from the following benefits:

- ☺ Favourable handling properties
- ☺ Good patient acceptance
- ☺ Excellent physical properties.

The importance of the impressioning procedure and subsequent laboratory procedure is evident in that no final restoration is more accurate than the impression and the cast from which it is made. Impression materials are used to make an accurate replica of the oral tissues (both hard and soft). The area involved may vary from a single tooth to the whole dentition or in some situations an impression may be made of an edentulous mouth. The impression provides a negative reproduction of the tissues and by filling it with dental stone or other model material, a positive cast is made which can be removed when the stone has set. Good impression materials are dependent on proper technique as well as optimal material characteristics of the impression material.

The following requirements are placed upon an ideal impression material:

- No dimensional change during polymerization
- No dimensional change during storage
- Suitable working and setting times
- Adequate detail reproduction
- Good tear strength
- Easy to mix
- Compatible with die and model material
- Non-toxic and non-irritating
- Acceptable scent and taste
- Long shelf life
- Requires minimal equipment for use

Impressions represent key communication devices between the clinician and the laboratory, as each party utilizes the impression as the most important component of the restorative and fabrication procedures.

For clinicians, impressions should

- Record accurately the details of hard and soft tissue.
- Be able to be “read“ easily to determine if/when a retake is necessary.
- Disinfect without loss of detail or accuracy.
- Maintain stability during shipping and permit delay of pouring
- Work in a variety of trays
- Work in a variety of clinical situations

- Be easy to remove from the mouth
- Provide patient comfort, no uncomfortable taste, or odour

For laboratories, impression should:

- Record details slightly beyond preparation margins – to ensure emergence profile and soft tissue landmarks.
- Disinfect without loss of detail or accuracy
- Be able to be poured multiple times without loss of detail
- Be able to be stored without loss of detail.

Apart from vinylpolysiloxane, there are 5 other categories of elastomeric impression materials:

- Irreversible hydrocolloid (alginate)
- Reversible hydrocolloid
- Polysulfide (rubber base)
- Polyether
- Condensation silicones

Vinylpolysiloxane is the one most often used and provides the ideal combination of physical properties and handling for most impression techniques. They are clean, odourless and tasteless. Virtual belongs to the category of vinylpolysiloxane impression material.

In general, all vinylpolysiloxanes have similar characteristics and physical properties. Differences that are detectable include viscosity, ease of mixing, mouth removal times times and readability.

1.2 Chemistry

The vinylpolysiloxane impression materials are addition reaction silicone elastomers which were first introduced in the 1970s. Since that time these materials have gained in their acceptance and account for a large share of the impression material market.

Vinylpolysiloxanes are synthetic polymers whose chemical makeup includes alternating atoms of silicon and oxygen and are presented in the form of two pastes (a base and a catalyst) which are most often auto-dispensed from a dual cartridge, and mixed in equal quantities for use. One paste contains a polydimethylsiloxane polymer in which some terminal methyl groups are replaced by hydrogen (“silane groups”). The other paste contains a pre-polymer in which some terminal methyl groups are replaced by vinyl groups. This paste also contains a chloroplatinic acid catalyst. Once mixed in equal proportions, an addition reaction occurs between the hydrogen (silane) and vinyl groups of the respective pastes and cross-linking occurs to from a silicone rubber (see fig 1). There is minimal dimensional change during this polymerization and there are no by-products.

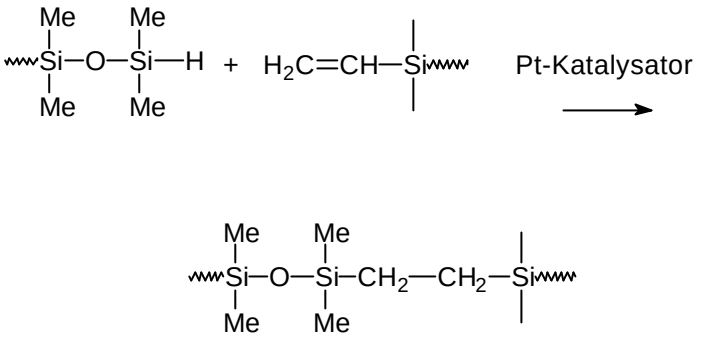


Fig 1: Scheme of the addition reaction that occurs during the setting process

The base and catalyst pastes also contain fillers, colouring agents as well as other additives to add bulk and improve the properties of the material. Amorphous silica or fluorocarbons are frequently used fillers. The fillers are silanated to increase the bond strength between filler and polymer, which better allows them to function as cross-linkers. This ensures a homogeneous consistency of the material. Colouring agents are added to distinguish the base and catalyst pastes and to aid evaluation of mixing. Intrinsic surfactants have also been added to negate the hydrophobicity of the these materials and improve wettability.

Compared to other elastomeric impression systems, vinylpolysiloxanes offer:

- ☺ High accuracy
- ☺ Excellent dimensional stability
- ☺ Good elastic recovery – recovery from undercuts
- ☺ Accurate recording of fine detail
- ☺ High tear strength
- ☺ Impervious to fluid absorption
- ☺ Adequate working time
- ☺ Fast recovery from deformation
- ☺ Neutral taste and odour
- ☺ Easy to remove from the mouth
- ☺ Stable (can be poured up to two weeks after taking impression)
- ☺ Stable in disinfecting/immersion protocols
- ☺ Variable viscosities
- ☺ Variable setting times
- ☺ Ease of use – good handling characteristics
- ☺ Compatible with various die materials

Negative features of vinylpolysiloxanes may inlcude:

- Surfactants have to be added to increase the hydrophilicity of the material
- Require separate adhesive for adhesion to impression tray
- Sulphur in latex (gloves) or hemostatic agents can inhibit setting.

2 Physical properties

2.1 Viscosity

According to ISO 4823 and ADA Specification 19, nonaqueous elastomeric impression materials are divided into the following categories that are related to viscosity:

Material	ISO 4823	ADA Spec. 19
Light Body	Type 3–Low Consistency	Type 1 – Low Viscosity
Medium Body	Type 2–Medium Consistency	Type 1 – Medium Viscosity
Heavy Body	Type 1–High Consistency	Type 1 – High Viscosity
Putty	Type 0–Very High Consistency	Type 1 – Very High Viscosity

Vinylpolysiloxanes are available in viscosities ranging from very low, to medium, high and very high (putty). The viscosity of the material increases with the proportion of the filler present. The mixed base and catalyst pastes demostrate thixotropic properties. This means that the materials exhibit a decrease in their relative viscosity in response to high shear stresses. This is also termed shear thinning. This is why Virtual possesses sufficient viscosity to avoid excess flow if loaded into a tray or syringed around the preparation, yet it can also exhibit an apparent lowered viscosity suitable for intrasulcular placement when it is expressed through an impression syringe tip.

Virtual Impression System is available in the following viscosities:

Virtual	Viscosity	Colour	Category acc to ISO 4823
Extra Light Body	Extra low	caramel	Type 3
Light Body	Low	caramel	Type 3
Monophase	Medium	sea blue	Type 2
Heavy Body	High	sea blue	Type 1
Putty	Very high	sea blue	Type 0

2.2 Working and Setting Times

Modern vinylpolysiloxanes have a working time of approximately two minutes and a setting time of anywhere from two to six minutes. Virtual offers an adequate working time for even large cases (full mouth or implant impressions). Once inserted in the mouth, all Virtual impression materials set within 4 1/2 minutes when using regular set materials, or 2 1/2 minutes when using the fast set materials. The intraoral set time is the minimum time the material needs to be in place in the oral environment. Reducing the overall time results in less distortion during the seating and setting, minimizes patient or tray movement and improves patient comfort.

The working time is measured from the start of mixing. It comprises mixing, manipulation and placement time.

Virtual	Type	Working time [min.]	Intraoral set time [min.]
Extra Light Body (ELB)	Regular Fast	3:00 1:45	4:30 2:30
Light Body (LB)	Regular Fast	2:35 1:35	4:30 2:30
Monophase (MP)	Regular Fast	2:35 1:35	4:30 2:30
Heavy Body (HB)	Regular Fast	2:05 1:15	4:30 2:30
Putty (P)	Regular Fast	1:25 1:15	4:30 2:30

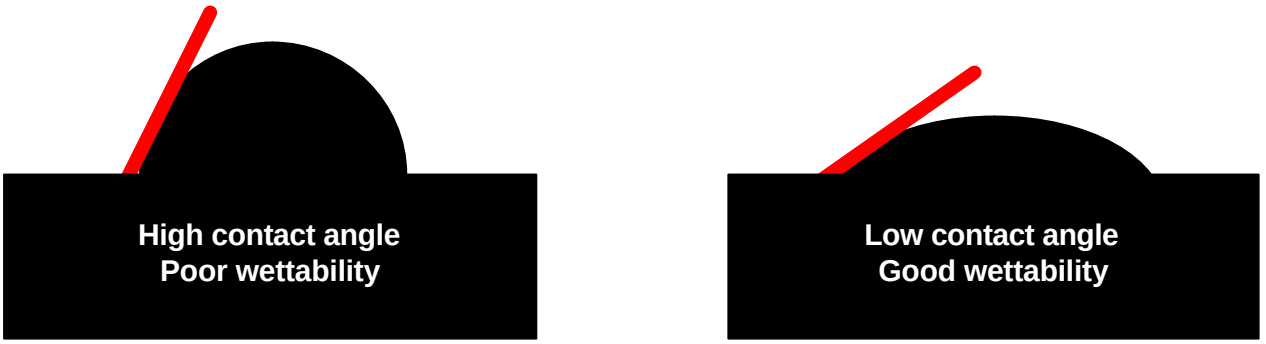
2.3 Reproduction of Detail

Surface detail is the ability of the impression material to reproduce the intricacies on the surface of an object and is necessary to achieve good marginal fit of the final restoration. Vinylpolysiloxanes are currently considered to reproduce the greatest detail of all the impression materials. The international standard for dental elastomeric impression materials (ISO 4823) states that a type III (light body) impression material must reproduce a line 0.020 mm (20 µm) in width. With the exception of the very high viscosity putty materials, all materials of the Virtual line of products achieve this.

Material type	Virtual	Detail reproduction [µm] required (ISO 4823	Detail reproduction [µm] of Virtual materials
Type 3	Extra Light Body Light Body	20 20	20 20
Type 2	Monophase	50	20
Type 1	Heavy Body	50	20
Type 0	Putty	75	50

2.4 Contact angles

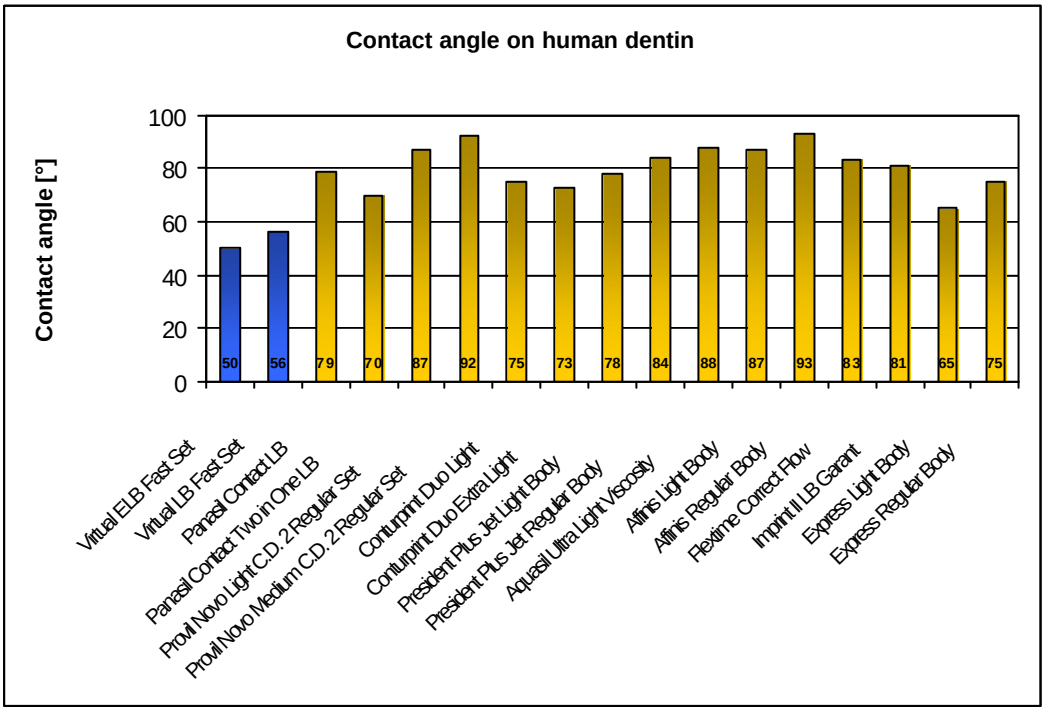
The ability of impression material to wet oral hard and soft tissues greatly influences the accuracy of impressions. Polysiloxanes are very hydrophobic materials that would only moderately wet the hydrophilic surfaces of the oral cavity. Therefore, part of the composition of Virtual is a non-ionic surfactant which is homogeneously distributed throughout the material. Once mixed, the surfactant quickly "migrates" from its homogeneous position to all outer surfaces of the dispensed material creating an active hydroactivated surface. The wetting ability of an impression material can be determined by contact angle measurements. The lower the angle, the better the wettability.



The traditional method of measuring contact angles involves the use of set impression material. A drop of water is placed on the piece of set impression material and its contact angle is measured. This shows the wettability of the impression material with water. However, it is no true indication of the impression material's ability to wet the moist oral hard and soft tissues.

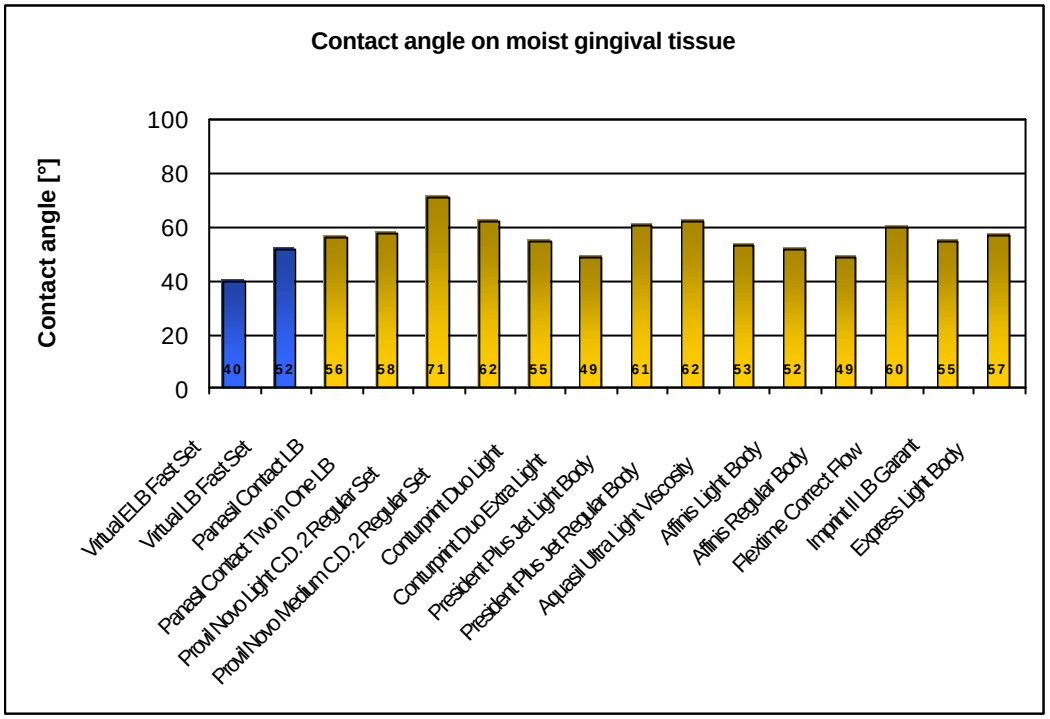
A more clinically relevant test is to place drops of unset impression materials on samples of moist dentin and most gingival tissue. This method of contact angle measurement is a good predictor of the ability of unset impression material to wet actual dental tissues.

Ten drops of each impression material are placed on the moist human dentin and moist gingival tissue. The contact angles are measured immediately and the mean values compared.



Virtual Scientific Profile, Ivoclar Vivadent Inc., February 2002

Freshly extracted human teeth are embedded in PMMA and trimmed to expose dentin. Drops of impression material are delivered over moist surfaces. An average between the left angle and the right angle is calculated and documented. A total of ten “drops” per surface are made for each material.



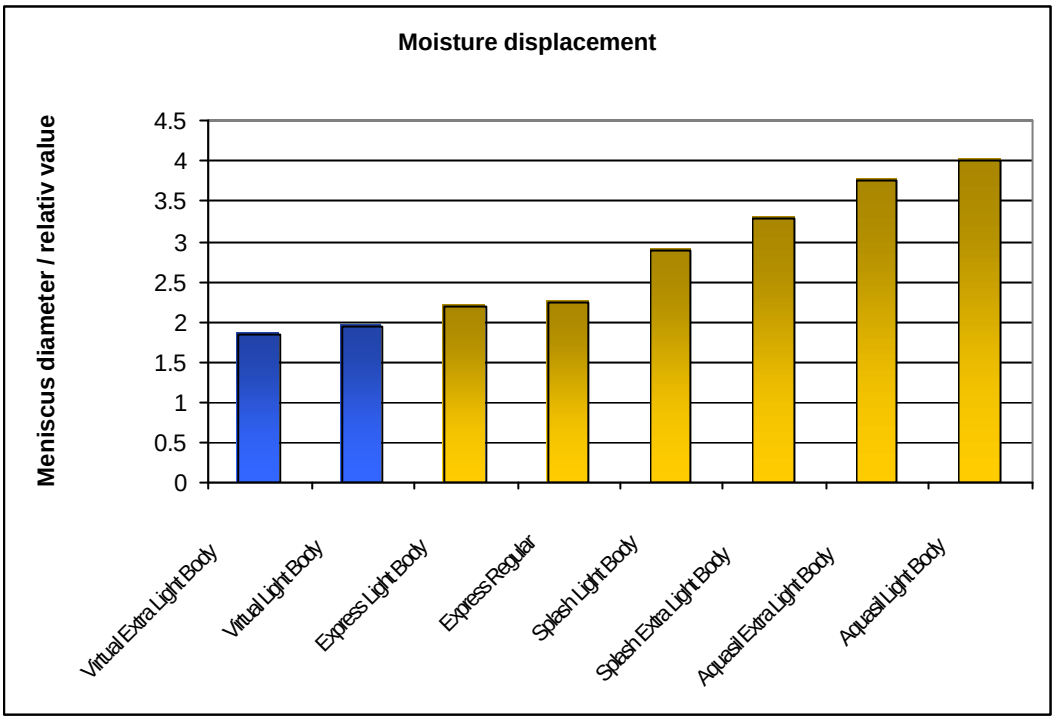
Virtual Scientific Profile, Ivoclar Vivadent Inc., February 2002

Drops of impression materials are delivered over freshly collected samples of bovine intraoral mucosa. A total of ten drops per surface are made for each material.

Comparatively low contact angles were measured for Virtual. This means that the material demonstrates optimum wettability with moist oral surfaces due to use of suitable surfactants and additives.

2.5 Moisture displacement

While the surface of the impression material has to be hydrophilic to ensure a good wetting in the oral cavity, it also has to be hydrophobic enough so that saliva may be displaced upon recording the impression.



Norling BK, Universität Texas, Report of Laboratory Tests. Ivoclar Impression Materials. Internal Report, 2001

To measure moisture displacement, an extracted human molar is mounted in acrylic resin. A cavity 1.5mm wide and 1.5mm deep is ground into the tooth. Then the tooth is immersed in deionized water and removed, leaving the adherent water in the groove and an impression made. After curing, the impression is sectioned bucco-lingually and photographed at 45 magnification using a digital camera. The photographs are imported into Corel Draw and magnified 2x. A circle is drawn which matches the radius of the meniscus where the impression material has failed to displace water from the tooth surface. Subsequently, these circle diameters are analysed. The smaller the diameter, the better the moisture displacement characteristics of the material.

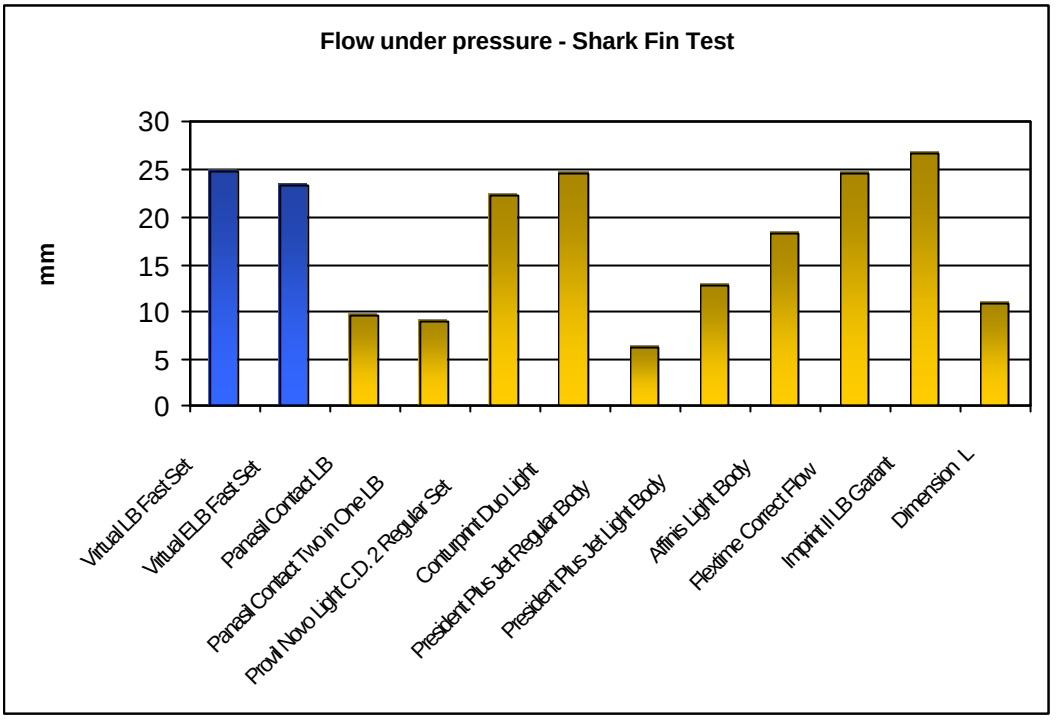
Compared to other materials, Virtual shows a rather small diameter, which means that it has a good ability to displace moisture.

2.6 Flow under pressure / "Shark Fin" test

Flowable compounds feature rheological properties such as viscosity.

Impression materials should exhibit a decrease in their viscosity when a force, e.g. pressure or shear stress, is applied. Moreover, it is desirable that the viscosity increases again instantly once the force is removed in order to prevent the material from running or dripping off the preparation or the impression tray. This behaviour is described by the parameter "intrinsic viscosity".

In order to determine the intrinsic viscosity of an impression material under clinically relevant conditions, the flow of the material into the gingival sulcus is simulated. By loading it with a constant weight the material is made to flow into a mould that has a triangular (shark fin) shape. After setting, the mould is removed and the height of the resulting specimen is measured.

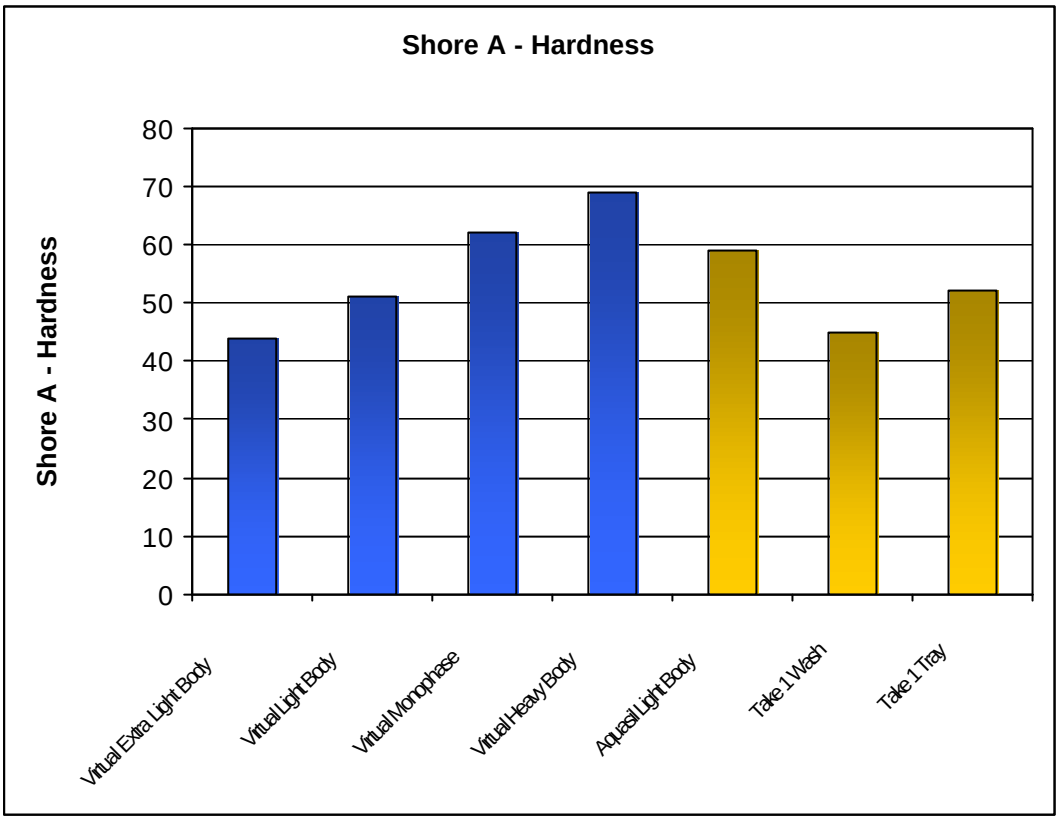


Kugel G, Universität Boston, Impression Materials Test Result, 2003

Compared to other impression materials, Virtual shows outstanding flow characteristics under pressure. It is important to note that the intrinsic viscosity of a material is dependent on its consistency.

2.7 Shore A Hardness

The relative hardness of elastic materials can be determined with an instrument called a Shore A durometer. If the indenter completely penetrates the sample, a reading of 0 is obtained, and if no penetration occurs, a reading of 100 results.



Virtual Scientific Profile, Ivoclar Vivadent Inc., February 2002

Clinically it is desirable to have increasing "hardness“ from wash to tray to provide support for the final impression. The results demonstrate an increasing hardness of the various viscosities of the Virtual line of products from Extra Light Body wash to the Heavy Body tray material.

2.8 Tensile strength

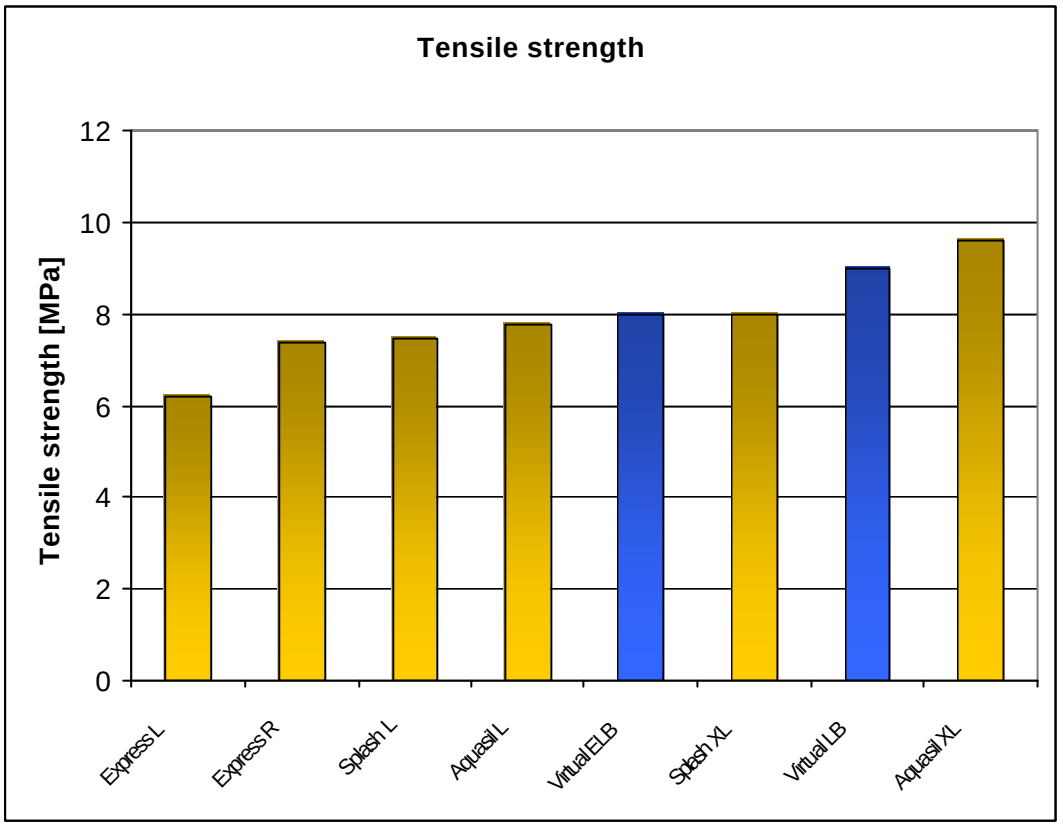
During the “stretching” of an impression material (similar to removing set impression material from the mouth) the material will undergo three phases. In the first phase, which is called the viscoelastic phase, the material will recover its original shape after the applied tensile force is removed. Virtual exhibits a high elastic recovery. This means that errors due to the deformation that occurs during removal are virtually eliminated.

Then, the material is stretched to a point of 'no return’ meaning that as it is stretched and released it does not go back to the original dimension; rather it will be distorted or stretched - permanent deformation results.

Following this stage, it can be stretched so much that it breaks or tears – marking the tensile strength.

Virtual shows a high recovery from deformation and only a very short permanent deformation stage under tensile stress. In addition, Virtual exhibits relatively high tensile and tear strength.

Sufficient tensile strength is important if thin layers of impression material have to be applied very deep impressions have to be taken and intricate surface details captured sharp edges are present on preparations that can score impression materials and initiate tears.



Norling BK, Universität Texas, Report of Laboratoy Tests. Ivoclar Impression materials, 2001

Further important technical data are listed in the table below.

3 Technical Data

	Extra Light Body	Light Body	Mono-phase	Heavy Body	Putty
Colour	caramel	caramel	sea blue	sea blue	sea blue
Mixing ratio base:catalyst	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1
Linear dimensional change after 24 h [%]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Strain in compression [%]	3 - 5	3 - 5	3 - 5	3 - 5	1 - 3
Recovery from deformation [%]	> 99.5	> 99.5	> 99.5	> 99.5	> 99.0
Compatibility with die materials	yes	yes	yes	yes	yes

Composition:

Vinylpolysiloxane

Methylhydrogensiloxane

Organoplatinic complex

Silica

Food dyes

Additives

4 Further properties

4.1 Impression trays and adhesives

Tray spacing and tray design have often been cited as potential sources for error in impressions. The improved physical properties of vinylpolysiloxanes have diminished this concern and now the use of stock trays for impressions has become common practice for reasons of cost and convenience. Common stock trays made of polystyrene or chromium plated brass are reported to be suitably stiff to prevent flexure and distortion. In order to ensure that the impression material is adequantely retained in the impression tray when it is removed from the mouth the use of an adhesive is recommended. Virtual's tray adhesive is a polydimethyl siloxane and ethylsilicate. The adhesive reacts with the surface of the tray material and forms a chemical bond to the tray and to the impression material. It is recommended to wait three minutes after application of the adhesive before making the impression. This allows time for the solvent to evaporate and for the adhesive to react with the tray material.

4.2 Disinfection of Virtual impressions

Disinfection is the inhibition or destruction of pathogens. This can be achieved by immersion of an impression into an antimicrobial chemical solution for 3 to 90 minutes depending on the agent. Sterilization is the total elimination of all micro-organisms and spores and requires immersion periods of 6 to 10 hours. Extended periods of immersion would have a detrimental effect on the accuracy of the impression. Consequently, procedures currently used to control the transmission of pathogens from impression tend to be disinfection and not sterilization. Numerous studies have tested the dimensional stability of different impression materials following immersion disinfection. Results show that vinylpolixsiloxanes were unaffected after immersion in several disinfectant solutions, while polyethers (because of their moisture uptake) were significantly unstable.

The following disinfectant solutions may be used without problems even for prolonged periods of immersion:

- Sodium hypochlorite
- Glutaraldehyde (2%)
- Povidone-iodine (0.5 %)
- Halogenated phenol (0.16 %)

It is recommended that impressions made with Virtual impression materials be submerged for 10 minutes.

4.3 Compatibility with die materials

Virtual is compatible with popular gypsum, epoxy resin and polyurethane resin materials. Gypsum stones cannot reproduce detail much smaller than 20 µm because their crystal size ranges from 15 to 25 µm. Epoxy and polyurethane resins can reproduce detail down to 1 µm making them highly compatible with the detail capture possible with vinylpolysiloxane impressions.

Vinylpolysiloxanes can also be silver electroplated.

4.4 Gloves and the inhibition of polymerization

Occasionally an inhibition or retarding effect is seen on vinylpolysiloxanes when they are used in a clinical setting. This phenomenon can occur after direct contact between the impression material and latex gloves. A sulphur compound has been identified as being responsible for the retarding effect. Zinc diethyl ditiocarbamate is an accelerator used in the manufacture of natural latex gloves. It reacts with the platinum catalyst in the vinylpolysiloxane to cause a delay or total inhibition of polymerization. Interestingly, not all latex gloves will cause an inhibition of set. It has been observed that synthetic latex gloves do not produce this phenomenon, while some natural latex gloves do. One's own testing and subsequent use of a non-retarding glove is recommended.

In addition, sulphur-containing additives in retraction cords such as ferric sulfate and aluminium sulfate may also produce this inhibition effect.

5 Clinical experience

The Virtual impression system has been commercially available on the North American market since 2002. The product has met with very positive reponse. According to The Dental Advisor, volume 20 (2003), sixty percent of consultants noted that Virtual behaved much like a hydrophilic material, displacing moisture and resulting in very accurate impression with excellent reproduction of detail. In addition, they state that patients appreciated the reduced time in the mouth as well as the neutral taste of the material. Reality Magazine stated, that Virtual's accuracy, hydrophilicity, and tear strength were considered very good to excellent. It was described as a material that was very accurate, rarely had bubbles, and produced margins that were very easy to read with excellent detail.

6 Biocompatibility

Polysiloxanes are considered to be chemically inert and biocompatible. The toxic properties of the individual components were assessed. Tests proved that the materials used for Virtual are non-toxic and do not cause cell death. Thus it may be confirmed that Virtual poses no health risk, neither to the patient nor to surgery or laboratory staff.

7 Literature

[1] Doubleday, B.; Br. J. Orthod. 25, 133 (1998)

[2] Giordano, R.; Gen. Dent. 48, 510 (2000)

[3] International Standard Organization "Dental elastomeric impression material" ISO 4823 – 1992

[4] Kugel G, Universität Boston, Impression Materials Test Result, 2003

[5] Miller, M.; REALITY 2001; Vol. 15 "Impression Materials"

[6] Norling, B. K.; Report of Laboratory Tests. Ivoclar Impression Materials. Internal Report 2001

[7] Powers,J.; Impression Materials – UTHSC. Internal Report, 2001

[8] Reality Now, #147 (Oktober 2002)

[9] Sorenson, J. A.; J. Dent. Res. # 80, 2001

[10] Test Report; , Implant Material Bicompatibility Laboratory (1996)

[11] Test Report # 226, Implant Material Bicompatibility Laboratory (1998)

[12] The Dental Adisor, Vol. 20 (2003)

[13] Virtual ™ Scientific Profile, February 2002

Ivoclar Vivadent AG
Research & Development
Scientific Service
Bendererstrasse 2
9494 Schaan
Liechtenstein

Contents: Dr. Thomas Völkel
Edition: May 2003