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Surface details reproduction of impression materials in dry and wet conditions

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ABSTRACT

Background: This study aimed to evaluate the surface details reproduction of hydrophilic polyvinyl siloxane (PVS), polyether (PE), and vinyl siloxanether (VSE) elastomeric impression materials in both dry and wet conditions.

Methods: A total of 84 impression specimens were made using a standardized stainless steel test block according to American Dental Association specification No. 19 for elastomeric dental impression materials and divided into 3 study groups (I, II, and III) according to the impression material used, 28 for each, each group was further divided into 2 subgroups (A and B) for the dry and wet conditions, respectively. Surface details reproduction for each specimen was evaluated by two examiners visually using an ×10 magnifier to confirm the presence of the 0.020 mm ruled line.

Results: For the specimens made in the dry conditions and when comparing using Chi-square test for statistical analysis, it was found that there were no statistically significant differences ($P > 0.05$) among all the groups, while for the specimens made in the wet conditions and when comparing between each two groups, it was found that there were statistically significant differences at $P \leq 0.05$ between surface details reproduction of groups I and II (P1 = 0.005) and also between groups II and III (P2 = 0.031) but there were no significant differences between groups I and III (P1 = 0.299).

Conclusions: VSE, PVS, and PE can effectively reproduce surface details according to international standards but for challenging moisture control situations, VSE and PE are preferred due to their hydrophilic properties.

Keywords: Dry and wet conditions, elastomeric impression materials, hydrophilic polyvinyl siloxane, polyether, surface details reproduction, vinyl siloxanether

Introduction

The precision of indirect restorations usually starts with the proper duplication of the oral structures. Many factors such as salivary fluids, bleeding, or sulcular fluid can dramatically affect the quality of the impression, which makes the hydrophilicity of the impression material used and its ability to record the details in moist or wet conditions of great importance.[1,2] Impression materials that possess superior hydrophilic properties can more reliably record fine anatomical details, even in the presence of these adverse fluids, thereby enhancing the accuracy of the final restoration. An understanding of these nuances can ultimately lead to improved clinical outcomes and longevity of indirect restorations.[3]

Among the various impression materials employed in dental and prosthetic applications, addition silicone, also known as polyvinyl siloxane (PVS), is highly regarded for its outstanding dimensional stability. Unlike condensation silicones, it undergoes polymerization without producing by-products, which ensures the accuracy of impressions.[4]

Addition silicone also offers several key advantages, including excellent tear strength that prevents distortion during removal and a remarkable surface detail reproduction. Its elastic properties enable the material to regain its shape after deformation, making for an easy removal process without compromising the impression quality. Furthermore, addition silicones are characterized by a neutral taste, enhancing patient comfort during the impression-taking procedure. These attributes collectively contribute to addition silicones being the most widely used elastomeric impression materials among dental professionals.[3]

On the other hand, the chief drawback of PVS in its hydrophobic nature that necessitates establishment

of a dry environment to achieve accurate impressions and for which reason, manufacturers developed the hydrophilic PVS by adding surfactants to enhance the hydrophilicity of the material when working in moist or wet conditions.[5]

In contrast to PVS, polyether (PE) possesses natural hydrophilicity because chemically it contains carbonyl (C=O) and ether (C-O-C) functional groups that attract and interact with water molecules through increased polarity.[6] However, PE has several shortcomings, which includes the stiffness of the set impression that may cause problems during separation of the stone casts and breakage of thin or single teeth and also its capability to absorb moisture and subsequently dimensional changes which requires proper drying of the impression as soon as removed from the mouth.

The details reproduction of any impression materials plays a major role in determining how accurately various indirectly produced appliances and restorations may be constructed. Clinically, the accuracy transferred by impressions from the intraoral structures to the final restorations depends on two major aspects, the ability of the impression mix to flow and adapt to the oral structures while making the impression, and the ability of the gypsum to wet the polymerized impression material when pouring the impression. As a matter of fact, except for very high-viscosity putty materials, all PVS products can achieve this requirement. The low-viscosity PVS can sometimes reproduce lines 1–2 μm wide under laboratory conditions.[7]

Another interesting impression material, designated by the manufacturer as a vinyl siloxane ether (VSE), has been introduced to the market. This material represents a chemical combination of PE and PVS, thereby theoretically harnessing the advantageous properties inherent to both classes of materials.[8]

The objective of this study is to systematically evaluate the fidelity of surface detail reproduction in the most prevalent impression materials currently available, under both dry and wet environmental conditions.

Materials and Methods

Surface detail reproduction of 3 different types of impression materials was assessed directly by evaluating impression specimens obtained from a standardized stainless steel test block according to American Dental Association specification No. 19 for elastomeric dental impression materials.[9]

The test block had definite ruled lines ranging from 0.300 mm to 0.020 mm wide. Another two vertical lines (F) were scored intersecting the horizontal lines on either side. The distance between the two vertical lines was 38 mm.

A standard ring (impression mold) 3 cm in diameter and 16 mm in height was fabricated into which the impression materials to be tested were injected (Figure 1). It was placed so that the intersection of the crossline (F) and the 0.020 mm wide line was in the center of the ring.

Before each use, surface debris was removed from the polished surface of the test block with methyl alcohol on cotton gauze.

The three impression materials used in this study were medium viscosity, addition - curing elastomeric impression material based on VSE (Identium; Kettenbach GmbH, Eschenburg, Germany) available in automix 5:1 foil bags, hydrophilic medium viscosity PVS impression material (Elite® HD+ Regular Body; Zhermack, GmbH, Deutschland) available in automix 1:1 cartridge and PE (Impregum Penta; 3M ESPE, St. Paul, Minn) impression material in a handmix formulation.

A total of 84 specimens were made which were divided equally into 3 groups:

Group I	Consists of 28 specimens made from VSE
Group II	Consists of 28 specimens made from PVS
Group III	Consists of 28 specimens made from PE

VSE: Vinyl siloxane ether PVS: Polyvinyl siloxane, PE: Polyether

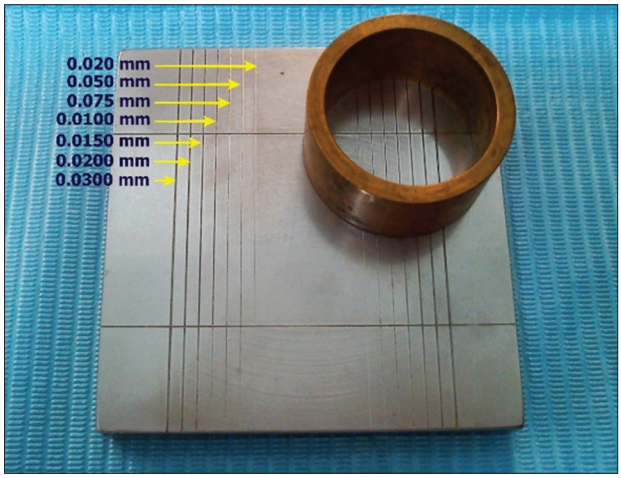


Figure 1: A standard ring (impression mold) was placed so that the intersection of the crossline (f) and the 0.020 mm wide line was in the center of the ring

According to the condition, each specimen was made in, each group was further divided into two subgroups:

Subgroup A	Specimens were made under dry conditions
Subgroup B	Specimens were made under wet conditions

For preparation of the specimens in the dry condition, the test block was first dried with an air spray then each of the tested materials was manipulated and syringed onto the test block in accordance to the manufacturer's recommendations.

For VSE impression material, foil bags were installed into the plug and press dispenser then the assembly was mounted into the sympress automatic dispenser, mixing was then started automatically where the recommended amount of material was injected into the mold.

PVS was mixed using an automatic dispensing gun where the 1:1 cartridge is installed into the gun and the recommended amount of impression material was injected into the mold manually.

PE is mixed in a hand mix technique, where equal amounts of the base and catalyst are dispensed into the mixing pad then the catalyst is spread over the base paste with a stainless-steel spatula for 2.5 min until a homogenous mixture is achieved and then loaded into the mold.

After loading the impression materials, the mold is covered with a thin sheet of polyethylene followed by a flat glass plate. The specimen-forming assembly was then placed immediately in a water bath 32±2°C to simulate the oral temperature and left for double the setting time recommended by the manufacturer's instructions. This ensured the complete setting of the impression material.[9]

When set, the impressions were separated from the test block and any flash was carefully removed (Figure 2).

The wet condition was achieved by immersing the test block in previously prepared artificial saliva before application of the impression material.[10]

Specimens in the wet condition for each material were prepared in the same manner as previously mentioned except that the specimen forming assembly was placed immediately in artificial saliva which was then placed into an incubator of 32±2°C.

To evaluate surface details reproduction two independent examiners evaluated the impressions immediately after the impressions were recovered from the mold, each impression surface was visually inspected under ×10 magnification to confirm the presence of the 0.020 mm line which was rated from "A" to "F" according to the criteria illustrated in (Table 1). Each specimen was given a specific number, and a double-blind method was implemented during the testing process where those who recovered the impressions did not disclose any details to the examiners who were also unaware of the type of impression material used. Based on the evaluation criteria, each examiner recorded the sample rating manually in a calibration form provided to each.[9,11]

Results

Table 2 and Graph 1 show the comparisons of surface details reproduction readings in specimens obtained from VSE, hydrophilic PVS, and PE under dry conditions.

The ratings of surface details reproduction of the three tested materials were calculated and recorded in Table 2 where:

Group I (VSE)	Thirteen specimens scored a rating (A) and one specimen scored a rating (B).
Group II (PVS)	Thirteen specimens scored a rating (A) and one specimen scored a rating (B).
Group III (PE)	Twelve specimens scored a rating (A) and two scored a rating (B).

VSE: Vinyl siloxanether, PVS: Polyvinyl siloxane, PE: Polyether

When comparing the tested materials using the Chi-square test for statistical analysis, it was found that there were no statistically significant differences ($P > 0.05$) among all the groups in dry conditions.

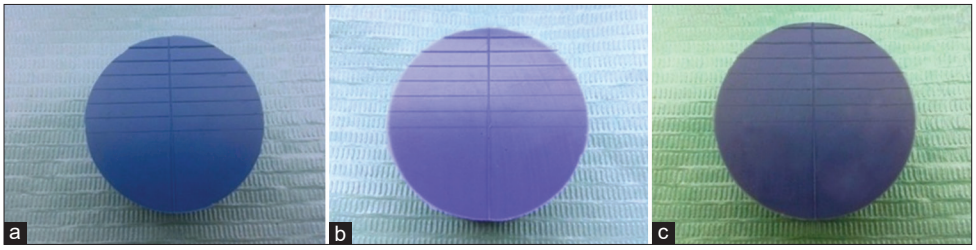


Figure 2: Specimens for evaluation of surface details reproduction: (a) Vinyl siloxane ether, (b) Polyvinyl siloxane, (c) Polyether impression material

On the other hand, Table 3 and Graph 2 compare surface details reproduction readings in specimens obtained from VSE, hydrophilic PVS, and PE under wet conditions.

The ratings of surface details reproduction of the three tested materials were calculated and recorded in Table 3 where:

Group I (VSE)	Thirteen specimens scored a rating (A) and one specimen scored a rating (B)
Group II (PVS)	Four specimens scored a rating (A) while ten specimens scored a rating (B)
Group III (PE)	Twelve specimens scored a rating (A) and two scored a rating (B)

VSE: Vinyl siloxanether, PVS: Polyvinyl siloxane, PE: Polyether

When comparing the tested materials using Chi-square test for statistical analysis, it was found that there were statistically significant differences ($P \leq 0.05$) among the groups in wet conditions.

When comparing each two groups, it was found that there were statistically significant differences at ($P \leq 0.05$) between surface details reproduction of groups I and II where the P_1 value was 0.005 and also between groups II and III where the P_2 value was 0.031 but there were no significant differences between groups I and III where P_1 value was 0.299.

Discussion

The capacity of impression materials to accurately replicate surface characteristics is crucial for the efficacy of dental restorations. This study aimed to assess the surface detail reproduction of three commonly utilized elastomeric impression materials – VSE, hydrophilic PVS, and PE – under dry and wet conditions.

PE has superior dimensional stability, high precision, and surface detail, together with minimal shrinkage throughout the setting process. A further advantage of PE is its short setting time in the oral cavity.[12] The primary drawback of PVS impression materials is their hydrophobic nature due to their chemical composition; yet, the hydrophilicity of these materials was enhanced by the incorporation of PE carbosilane surfactant.[13,14] VSE, in contrast, chemically combines a PE material with a PVS, theoretically harnessing the advantages of both substances.

The present investigation demonstrated a significant consistency in the reproduction of surface detail among all three impression materials under dry conditions. Both

Table 1: Surface details reproduction evaluation criteria

Rating	Criteria
A	0.020 mm line is sharp
B	0.020 mm line is less distinct and some breaks in designated area or surface is somewhat grainy
C	0.020 mm line is very indistinct but is present
D	0.020 mm line is approximately 50% present
E	0.020 mm line is not present
F	Impression will not separate

Table 2: Comparison between the three studied groups according to surface details reproduction of three elastomeric impression materials in dry conditions.

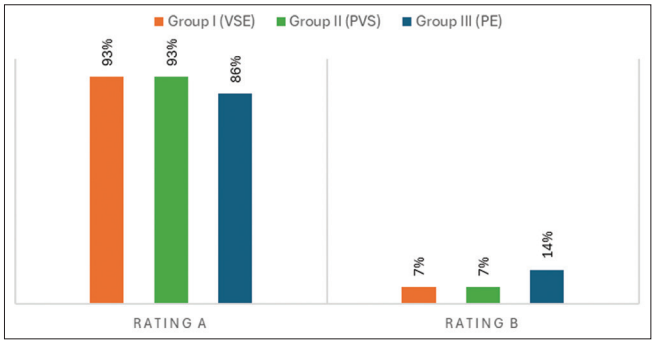
Rating	Group I (*n*=14)		Group II (*n*=14)		Group III (*n*=14)		χ^2	*P*
	No.	%	No.	%	No.	%		
Dry conditions								
Rating A	13	93.0	13	93.0	12	86	0.552 (NS)	0.758
Rating B	1	7.0	1	7.0	2	14		(NS)

χ^2: Value for Chi-square. NS: Statistically not significant at $P \geq 0.05$

Table 3: Comparison between the three studied groups according to surface details reproduction of three elastomeric impression materials in wet conditions.

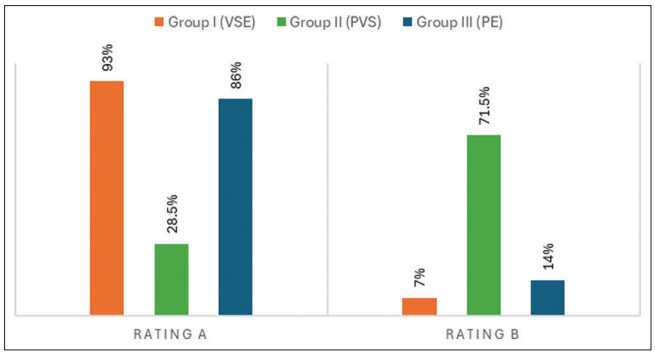
Rating	Group I (*n*=14)		Group II (*n*=14)		Group III (*n*=14)		χ^2	*p*
	No.	%	No.	%	No.	%		
Wet conditions								
Rating A	13	93.0	4	28.5	12	86.0	16.265*	0.00029*
Rating B	1	7.0	10	71.5	2	14.0		
p_1			0.00049*		0.541 (NS)			
p_2				0.0022*				

p_1: *P*-value for comparing between group I and each other group. p_2: *P*-value for comparing between group II and group III. χ^2: Value for Chi-square. *: Statistically significant at $P \leq 0.05$. NS: Statistically not significant at $P \geq 0.05$



Graph 1: Comparison between the three studied groups according to surface details reproduction of three elastomeric impression materials in dry conditions

VSE and PVS demonstrated equivalent performance, with 13 specimens from each material category attaining an 'A' rating, while merely one specimen was classified 'B'. Conversely, PE exhibited marginally lower consistency, with 12 specimens attaining an 'A' rating and two obtaining a 'B'. The Chi-square test indicated no statistically significant differences ($P > 0.05$) among the



Graph 2: Comparison between the three studied groups according to surface details reproduction of three elastomeric impression materials in wet conditions

three material groups in dry conditions. Those findings indicate that all three impression materials can generate detailed imprints with nearly similar accuracy levels in dry conditions.

The exceptional performance of VSE and PVS in dry situations can be attributed to their inherent flow characteristics, which provide precise detail reproduction in surroundings with minimal moisture impact. While PE demonstrates remarkable performance, it displayed a marginally increased incidence of specimens attaining a score of (B), indicating a possible modest decrease in efficacy compared to the other two materials.

A notable change in the performance of the assessed impression materials was seen in wet conditions. Although VSE and PE sustained high-performance levels, PVS exhibited a significant reduction in efficacy under these conditions. Only four specimens obtained an (A) rating, while the bulk, consisting of 10 out of 14 specimens, were classified (B).

Statistical analysis revealed substantial differences in the replication of surface details across the three materials under wet conditions ($P < 0.05$). Significant differences were identified between VSE and PVS (P1 = 0.005) and between PVS and PE (P2 = 0.031). Nonetheless, no substantial difference was seen between VSE and PE (P1 = 0.299).

Despite the identified variations in results in both dry and wet conditions, the findings were predominantly aligned with international standards for dental elastomeric impression materials, which mandate that these materials must properly replicate a line width of 0.020 mm.

The exceptional performance of VSE and PE in wet conditions can be explained by thier improved hydrophilic properties. VSE, an altered type of PVS, includes an ether group that augments its wettability, therefore enhancing its efficacy in humid conditions. PE, noted for its intrinsic hydrophilicity, effectively captures fine detail even in high moisture conditions, making it an ideal option for situations where moisture management is difficult. Conversely, PVS, despite attempts to improve its hydrophobic characteristics through surfactant addition, exhibited a notable reduction in the reproduction of surface features under wet conditions. This decline is likely due to its insufficient wettability, which impedes efficient interaction with the moist surfaces of the oral cavity, ultimately resulting in less accurate impressions.

The statistically significant differences observed between VSE and PVS (P1 = 0.005) and between PVS and PE (P2 = 0.031) in wet conditions underscore the critical impact of material properties on the replication of surface features in humid environments. The lack of substantial variances between VSE and PE (P1 = 0.299) suggests equivalent performance levels for these materials under analogous settings. This is likely due to their similar hydrophilic qualities, which enhance their adaptability to wet conditions.

The effectiveness of PVS in humid conditions highlights the limitations of hydrophobic materials in clinical settings with substantial moisture exposure. The findings on PVS clarify the challenges in achieving high-precision detail in environments with variable humidity levels, such as those typically present in the oral cavity during dental impression procedures.

The results obtained from this study were supported by Walker *et al.*, 2005,[15] who investigated the moisture effect on PE and PVS detail reproduction. They found that impressions made from all materials used under dry conditions were 100% satisfactory, but under moist conditions, only PE performed extremely well and produced satisfactory impressions

Furthermore, Johnson *et al.*, 2003,[16] Petrie *et al.*, 2003,[17] Chee and Donovan, 1992,[12] and Peutzfeldt and Asmussen, 1998[18] were in agreement with these results.

Katyanan *et al.*, 2011[19] in their study of surface details reproduction of two hydrophilic PVS impression materials tested under different conditions found that the two impression materials used in this study did not always yield satisfactory impressions under moist and wet conditions.[20]

On the contrary, these results were disagreed by Boening *et al.*, 1998[21] and Takahashi and Finger, 1991[7] who reported that hydrophilic PVS materials, some with contact angles >90° (indicating hydrophobicity), always produced acceptable impressions in the presence of moisture.

VSE is notably recognized as an ideal material for use in wet conditions, principally because of its superior wettability, which provides considerable benefits for dimensional precision and the replication of complex details. PE, while useful in moist environments, may be less appropriate in situations requiring flexibility and ease of handling, as it generally demonstrates increased rigidity relative to VSE. Although PVS is an excellent choice for dry conditions, its efficacy may diminish in humid surroundings, potentially impacting the accuracy of impressions in clinical settings with inadequate moisture management.

Conclusions

Within the limitations of this study, the findings hold considerable clinical relevance for dental practitioners when determining the most suitable impression material for specific conditions at the impression site. Although some statistically significant differences were observed during testing under wet conditions, all three materials - VSE, PVS, and PE - demonstrate comparable efficacy in accurately reproducing surface details as they are following the international standards of elastomeric impression materials. However, in clinical situations where achieving moisture control is challenging, such as during subgingival impressions or in patients with excessive salivation, both VSE and PE are favored due to their superior hydrophilic characteristics.

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Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. McCabe JF, Carrick TE. Recording surface detail on moist surfaces with elastomeric impression materials. Eur J Prosthodont Restor Dent 2006;14:42-6.
2. Chiaraputt S, Chokwattanapornchai N, Limchaikul K, Paisarnkobrit V, Sriamporn T. Effect of gingival hemostatic agents on the surface detail reproduction and dimension stability of three elastomeric impression materials. Int J Dent 2023;2023:6660721.
3. Ali KS, Shenoy VK, Rodrigues SJ. Comparative evaluation of dimensional accuracy of casts made by repeated pouring of addition siliconeimpressions using 1) Two-step putty/light-body technique using stock tray and 2) One-step simultaneousdual viscosity technique using custom tray: An *in vitro* study. J Nepal Dent Assoc 2010;11:32-9.
4. McCabe JF, Walls AW, editors. Applied dental materials. United States: John Wiley & Sons; 2013. p. 163-77.
5. Nayyar AS. Dimensional accuracy and surface detail reproduction of hydrophilic polyvinylsiloxane impression material tested under dry and moist salivary conditions: An: *in vitro*: Study. Biomed Biotechnol Res J 2021;5:59-63.
6. Anusavice KJ, Shen C, Rawls HR, editors. Phillips' science of dental materials. Netherlands: Elsevier Health Sciences; 2012.
7. Takahashi H, Finger WJ. Dentin surface reproduction with hydrophilic and hydrophobic impression materials. Dent Mater 1991;7:197-201.
8. Tolidis K, Tortopidis D, Gerasimou P, Theocharidou A, Boutsiouki C. Comparison of elastomeric impression materials' thixotropic behavior. Eur J Prosthodont Restor Dent 2013;21:75-8.
9. American National Standards Institute/American Dental Association. Specification No. 19: Dental elastometric impression materials. Chicago: American Dental Association; 2004.
10. Aiasha T, Kumar S, Savadi RC. Evaluation and comparison of surface detail reproduction of different elastomeric impression materials under dry and wet conditions. Trends Prosthodont Dent Implantol 2010;1:5-8.
11. Gerrow JD, Price RB. Comparison of the surface detail reproduction of flexible die material systems. J Prosthet Dent 1998;80:485-9.
12. Chee WW, Donovan TE. Polyvinyl siloxane impression materials: A review of properties and techniques. J Prosthet Dent 1992;68:728-32.
13. Keyf F. Some properties of elastomeric impression materials used in fixed prosthodontics. J Islamic Acad Sci 1994;7:44-8.
14. Lee EA. Impression material selection in contemporary fixed prosthodontics: Technique, rationale, and indications. Compend Contin Educ Dent 2005;26:780-9.
15. Walker MP, Petrie CS, Haj-Ali R, Spencer P, Dumas C, Williams K. Moisture effect on polyether and polyvinylsiloxane dimensional accuracy and detail reproduction. J Prosthodont 2005;14:158-63.
16. Johnson GH, Lepe X, Aw TC. The effect of surface moisture on detail reproduction of elastomeric impressions. J Prosthet Dent 2003;90:354-64.
17. Petrie CS, Walker MP, O'mahony AM, Spencer P. Dimensional accuracy and surface detail reproduction of two hydrophilic vinyl polysiloxane impression materials tested under dry, moist, and wet conditions. J Prosthet Dent 2003;90:365-72.
18. Peutzfeldt A, Asmussen E. Impression materials: Effect of hydrophilicity and viscosity on ability to displace water from dentin surfaces. Eur J Oral Sci 1988;96:253-9.
19. Katyayan PA, Kalavathy N, Katyayan M. Dimensional accuracy and detail reproduction of two hydrophilic vinyl polysiloxane impression materials tested under different conditions. Indian J Dent Res 2011;22:881-2.
20. Firtell DN, Koumjian JH. Mandibular complete denture impressions with fluid wax or polysulfide rubber: A comparative study. J Prosthet Dent 1992;67:801-4.
21. Boening KW, Walter MH, Schuette U. Clinical significance of surface activation of silicone impression materials. J Dent 1998;26:447-52.