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COMPARISON OF THE EFFECT OF MARGINAL THICKNESS ON LINEAR ACCURACY OF IMPRESSIONS AND STONE DIES USING VINYL POLYSILOXANE ETHER AND POLY VINYL SILOXANE: AN IN VITRO STUDY

Dental Science

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ABSTRACT

Context: Space available gingival retraction is 0.3-0.4mm. However, after 40s, only 0.2mm of it is available. This is a concern when multiple impressions have to be made.

Aim: To compare the effect of impression margin thickness made using poly vinyl siloxane(PVS) and vinyl siloxane ether(VSE) on the linear accuracy of impressions and stone dies.

Methodology: A stainless-steel die was prepared with a square cavity in the centre with spaces of 4 varying widths. Ten impressions were made using VSE and PVS each and stone dies were poured. The accuracy of impressions and stone dies was measured.

Results: Impressions with thin margin of 0.1 mm showed maximum distortion and the same was with the dies. One-way ANOVA for PVS showed significant difference ($P<0.05$) while with VSE showed highly significant difference ($P<0.001$).

Conclusion: The overall accuracy of PVS was found to be high and can be the preferred material of choice.

KEYWORDS

Margin thickness, linear accuracy, Poly vinyl Siloxane, Vinyl siloxanether, gingival retraction

Introduction

In an aesthetic conscious society, there is a greater public awareness of the value of availability of cosmetic dentistry which has led to an increase in demand for high quality aesthetic restoration in fixed prosthodontics, especially with respect to anterior metal ceramic restorations where the metal margins may result in non-aesthetic appearance.[1] One of the important factors which contribute to the success of cast restorations is marginal integrity. To achieve good marginal fit and aesthetics, the gingival finish line should be recorded in the impression. The inability of most final impression materials to adequately displace soft tissue, fluid or debris mandates adequate gingival displacement prior to making impression.[2]

Chemo mechanical retraction of the gingiva is accomplished by placing medicated retraction cord into the gingival crevice.[3] Space available for the impression material in the gingival sulcus immediately after the removal of retraction cord has found to be 0.3-0.4mm. However, after 40s, only 0.2mm of retracted space is available. This is a concern when impressions of multiple abutments are to be made.[4]Usually, gingival finish lines are placed at not more than 1 mm depth into the gingival sulcus from the crest of the gingiva.[1]

The most commonly used are poly vinyl siloxane(PVS) and polyether. The latest addition to this group of elastomers is vinyl siloxane ether(VSE) combining features of both addition silicone and polyether.[5] All previous studies have analysed the flow property, handling characteristics, adaptation to oral structures and accuracy to reproduce surface details of an elastomer. However, completeness of impression means ability to penetrate at least a depth of 1 mm in a narrow sulcus. Even this has been measured in previous studies. But comparison of above two materials to check which of them is more accurate has not been done.

The aim of this study was to compare the effect of impression margin thickness made using poly vinyl siloxane (PVS) and vinyl siloxane ether (VSE) on the linear accuracy of impressions and their stone dies. It would also verify the study done to determine the minimum width of retracted sulcus necessary to obtain a good impression.

Material and Methods

A stainless steel block with a square cavity in the centre was constructed. Another metal die was made to accurately fit the square cavity of the first die. The models simulated prepared abutment teeth surrounded by retracted gingiva with sulci of different widths (Fig. 1)

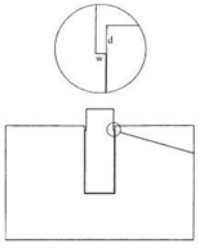
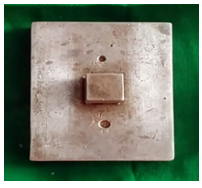


Fig. 1 : Schematic diagram (d=1mm, w=0.1-0.4mm)

Spaces, 1 mm deep of varying widths viz. 0.1mm, 0.2mm, 0.3mm, 0.4mm were created between the die and the recess wall on each side of the square respectively (Fig. 2). Special tray was fabricated using photo polymerizing acrylic resin and the tray was allowed to



polymerized in the photo polymerizing unit before use. Tray adhesive was applied to the internal surface of the tray and allowed to dry for 10 min.

Fig. 2 : Metal die (d=1mm, w=0.1-0.4mm)[0.1mm staring from the side of the small tissue stop going clock wise in increasing order

Two impression materials i.e. Poly vinyl siloxane(PVS) and Vinyl siloxane ether(VSE) were used. A single-stage/double-mix putty wash

impression technique was used. The low viscosity impression material (light body) was extruded into a glass slab and mixed with stainless steel spatula using hand spatulation. Mixed material was loaded into injection syringe from which it was injected into the crevice and around the abutment. High viscosity material (heavy body) was placed in the tray, seated with light pressure, and allowed to remain in place, without loading, at room temperature until the material was set (10 min). Like this, 10 impressions were made from each material for a total of 20 impressions (Fig. 3).

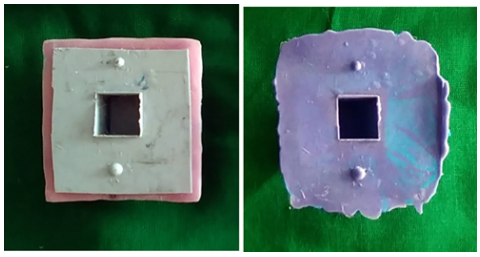


Fig. 3 : Impression made using Poly Vinyl Siloxane (PVS) and Vinyl Siloxane Ether (VSE) respectively

One hour after setting of the impression, the impressions were poured using a high-strength stone (Type IV stone). Impressions made with PVS were poured in yellow colour while the ones made with VSE were poured in grey colour to distinguish them. A powder/water ratio of 100 g/22 ml was used. The water and powder were mixed in an auto mixer under vacuum. The mixture was poured into the impression on a vibrator and allowed to set for at least 1 h before separation. Then stone dies were then recovered from the impression(Fig. 4).

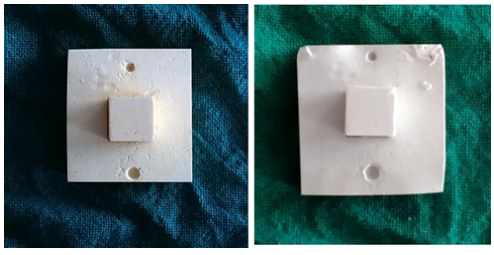


Fig. 4 : Dies poured from impression made using Poly Vinyl Siloxane (PVS) and Vinyl Siloxane Ether (VSE) respectively

Measurements were done using traveling microscope with a measurement capability of 1 lm. First, width of each abutment was measured. Then the impressions were measured for the width of the crevice where it was even. Then, the widths of crevices in the die were measured.

Clinicians are usually interested in the dimensional distortion of the die as compared with the original abutment; such a comparison encompasses two distortions, that of the impression and that of the pouring of the stone die. Therefore, to define the inaccuracy attributed to the stone pouring alone the distortion was calculated for each die relative to its impression.

The distortion of each impression was calculated as follows:

$$\text{Distortion\%} = \frac{\text{Impression dimension - abutment dimension}}{\text{Abutment dimension}} \times 100$$

Similarly, the distortion of stone die was calculated as:

$$\text{Distortion\%} = \frac{\text{Die dimension - abutment dimension}}{\text{Abutment dimension}} \times 100$$

Results:

In the present study, impressions with thin margin of 0.1 mm showed the maximum mean distortion of 7.5 % and 23.3% when made with PVS and VSE respectively. Similarly, impressions with slightly thicker margin of 0.2 mm showed the maximum mean distortion of 6.66 % and 16% when made with PVS and VSE respectively. Whereas other thicker margins of 0.3 and 0.4 mm showed a distortion of only 1.75 – 3 % when impressions made with PVS and a distortion of 2.25 – 16 % when made with VSE (Table 1).

Likewise, dies poured of impressions with thin margin of 0.1 mm showed the maximum mean distortion of 10% and 36%, made with PVS and VSE respectively. Similarly, dies poured of impressions with slightly thicker margin of 0.2 mm showed the maximum mean distortion of 8.33% and 16%, made with PVS and VSE respectively. Whereas dies poured of impressions with thicker margins of 0.3 and 0.4 mm showed a distortion of only 1.65 – 10 %, when made with PVS and a distortion of 1.5 – 2.75 % when made with VSE (Table 2).

It can be seen that the difference between the distortions of impressions made with both the impression materials goes on decreasing significantly as the thickness of margins gradually increases (Graph 1), and the similar holds true for the dies poured out of them (Graph 2). One-way ANOVA for impression and stone dies made with PVS showed statistically significant difference (P<0.05) (Tables 3,4). One-way ANOVA for impression and stone dies made with VSE however showed highly significant difference (P<0.001) (Tables 5,6).

Sulcular width		Mean	Std. Deviation	Std. error mean	t value	P value^
0.1mm	PVS	7.5	5	2.5	-2.508	0.034*
	VSE	23.3	11.54	6.66		
0.2mm	PVS	6.66	5	1.66	- 3.013	0.011*
	VSE	16	6.51	2.91		
0.3mm	PVS	3.3	2.69	0.85	-6.11	0.000**
	VSE	11.96	3.58	1.13		
0.4mm	PVS	1.75	2.37	0.75	-0.871	0.395
	VSE	2.75	2.75	0.87		

Table 1 : Comparison of distortion % between PVS and VSE impression system respectively in various sulcular width groups.(*p < 0.05 – significant; ** p < 0.001 – highly significant)

Sulcular width		Mean	Std. Deviation	Std. error mean	t value	P value^
0.1mm	PVS	10	8.16	4.08	-4.781	0.005*
	VSE	36.6	5.77	3.33		
0.2mm	PVS	8.33	5	1.66	-2.898	0.013*
	VSE	16	4.18	1.87		
0.3mm	PVS	1.65	2.33	0.737	-5.855	0.00**
	VSE	10.96	4.45	1.4		
0.4mm	PVS	1.5	2.10	0.66	-1.14	0.269
	VSE	2.75	8.16	4.08		

Table 2: Comparison of distortion % between stone dies obtained from PVS and VSE impression system respectively in various sulcular width groups. (*p < 0.05 – significant; ** p < 0.001 – highly significant)

	Sum of Squares	df	Mean Square	F	P value
Between Groups	178.072	4	44.518	3.287	0.025*
Within Groups	379.229	28	13.544		
Total	557.301	32			

Table 3: Summary of One-Way Anova— distortion % of PVS impressions with varied sulcular widths. (*p < 0.05 – significant; ** p < 0.001 – highly significant)

	Sum of Squares	Df	Mean Square	F	P value
Between Groups	359.769	3	119.923	6.282	0.002*
Within Groups	553.589	29	19.089		
Total	913.359	32			

Table 4: Summary of One-Way Anova— distortion % of stone dies obtained from PVS impressions with varied sulcular widths. (*p < 0.05 – significant; ** p < 0.001 – highly significant)

	Sum of Squares	df	Mean Square	F	P value
Between Groups	995.182	3	331.727	8.926	.000**
Within Groups	891.925	24	37.164		
Total	1887.107	27			

Table 5: Summary of One-Way Anova— distortion % of VSE impressions with varied sulcular widths. (*p < 0.05 – significant; ** p < 0.001 – highly significant)

	Sum of Squares	df	Mean Square	F	P value
Between Groups	2558.597	3	852.86	34.475	0.000**
Within Groups	593.725	24	24.739		
Total	3152.32	27			

Table 6: Summary of One-Way Anova— distortion % of stone dies obtained from VSE impressions with varied sulcular widths. (*p < 0.05 – significant; ** p < 0.001 – highly significant)

Discussion:

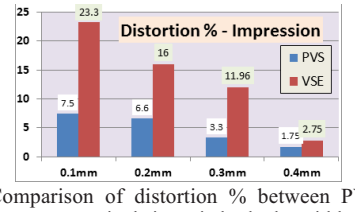
Success of retraction cords goes hand in hand with the success in obtaining a good impression. The impression material should flow to the depth of the sulcus otherwise the effort in retracting the gingiva turns out to be a waste. The flow of the impression material should be such that there is no resistance in copying the details. This usually depends on the flow properties of the impression material and the compression exerted by the gingival tissues.

Additional silicone impression materials have been used as material of choice for final impressions because of combination of excellent physical properties, handling characteristics and good dimensional stability and can be poured at the convenience of the operator and also allow the opportunity to make a second pour.

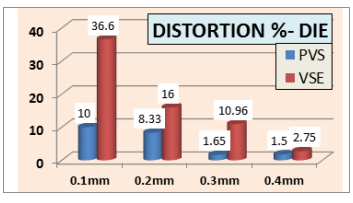
Traditional additional silicones were hydrophobic; due to which the accuracy was questionable. The newer ones have added surfactants to counteract this. Polyether, on the other hand, is hydrophilic and records good detail, but it is stiffest among all the elastomers. The newest elastomer that has been developed is called vinyl siloxane ether(VSE). This material combines the favourable properties of both additional silicone and polyether.

A dimensional distortion of an impression in any one direction may render the die inaccurate and clinically unacceptable. In this study the largest mean dimensional distortion in any direction measured for each impression and die was selected to represent its inaccuracy. Linear accuracy is affected by the dimensional change occurring during setting and by the permanent deformation caused by separation of the impression from the undercut and narrow spaces around the abutments. The smooth, parallel-sided metal abutment in a recess does not replicate the clinical situation of a tapered, prepared tooth surrounded by retracted gingiva with its elastic property and salivary moisture of oral environment. However, the model serves for comparison of the distortion of the impression and die made at various sulcular widths.

In the present study, impression of the thinnest margins made with both PVS and VSE showed the maximum mean distortion and the situation was similar in case of the dies poured out of them. However, the distortion significantly decreased as the thickness of the margins went on increasing. The thinnest extension of impression material into the sulcus showed almost 2 times greatest dimensional distortion when compared to the next wider sulcular group. Another notable point was the difference between the dimensional distortion of impressions made with PVS and VSE significantly decreased as the widths went on increasing and were almost same i.e., close to nil as the maximum sulcular width groups were compared.



Graph 1: Comparison of distortion % between PVS and VSE impression system respectively in varied sulcular width group



Graph 2: Comparison of distortion % between stone dies poured from PVS and VSE impression system respectively in varied sulcular width group

This experiment examined the inaccuracies at the early stage of crown fabrication i.e. impression making and die fabrication. Further inaccuracies will be added in the consecutive processes of crown casting, electroforming or milling , ceramic firing, etc[6,7]. In the literature, there is no agreement on the clinically tolerable gap between the crown and tooth. It may vary between 0.31 and 1.19 mm[8]. Thus it may be concluded that distortion of 0.52–1.23 mm at this early stage has clinical significance. The American Dental Association Council on Dental Materials and Devices specification no. 19 stipulates a 2.5 % maximum permanent deformation for type I non aqueous elastomeric dental impression material. This specification was determined by a compressive test using a 20mm thick bulk of impression material in the present experiment. The distortion was of a tensile nature, occurring while separating the impression from the model and cannot be compared to specification no. 19.[9]

Stober et al[10] have stated VSE display acceptable accuracy for clinical use with immersion disinfection, since the results were comparable to the results for additional silicone and polyether materials[11]. Balkenhol et al suggest that PVS has the smallest change (0.15%) followed by polyether (0.2%).VSE has a dimensional change of about 0.2% which is also acceptable[12].

When comparing impression of similar thickness (0.23–0.72 mm) Hansson and Eklund(1988)[13] showed a greater distortion of 1.9–2 % than that in the another study by Naveen Y G et al(2013)[1] was 0.52–0.68 %. It has been shown that impressions with greater thickness have distortion of 0.1–0.6 % by Pratten DH (1991)[14].

According to Chai et al[15], three mechanical properties of elastomeric impression materials are clinically relevant namely, Yield strength, Strain at yield, Tear energy. 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 while tear energy indicates the resistance to tear of the impression material. Shetty et al[16] in 2014 stated the strain at yield point of VSE to be 2.3% while Perakis et al[17] in 2004 had calculated the strain in PVS to be 0.4%. The tear energy of VSE is also less as compared to PVS as stated by Shetty et al(2014) and Perakis et al(2004) and which was also supported by Stober et al(2010)[10].

The large dimensional distortion and clinical variances in the 0.1mm sulci width suggest that the impressions were not accurate. Since the clinician cannot distinguish between an accurate and a distorted impression, only sulcular widths giving consistently accurate impressions would be clinically acceptable. (Graphs 1, 2) show that 0.2 mm is the smallest sulcular width producing consistent impressions with PVS and 0.3mm with VSE which coincides with the previous study[1]. Therefore, it can be inferred that the method employed to achieve gingival retraction should provide a minimum retraction of 0.4 mm, 0.2 mm needed for the flow of impression material as per the results of present study and 0.20 mm of reversion of gingival sulcus once the cord is removed as reported by Laufer et al[18].

The recovery of an impression without marginal tears depends on the thickness of the impression margin, the tear strength of the impression material, and its ability to undergo elastic deformation when being removed from undercut areas. The problem of the tearing of impression margins in narrow sulci may be overcome by using impression materials with high tear strength. However, these materials like the polysulfide impression material permanently deformed rather than tearing away and results in a complete but distorted impression.

Conclusion:

Considering the limitations of the study, following conclusions were drawn

- Statistically significant differences between poly vinyl siloxane (PVS) and vinyl siloxane ether(VSE) impression materials were found for both the impressions and the stone dies poured out of them.
- The overall accuracy of PVS was found to be high.
- It was not always possible to predictably obtain accurate impressions in a sulcus of 0.10-mm width in the presence of an undercut.
- All impression materials gave clinically acceptable results in sulci 0.2mm and wider in the presence of an undercut.
- In case of narrower gingival sulcular widths, PVS can be the prefered material of choice; nevertheless VSE is also acceptable.

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