



## RESEARCH ARTICLE

# Effect of different impression materials on the marginal fit of frameworks: An in-vitro study

Ayşe Gözde TÜRK, DDS, PhD,<sup>a</sup> Mubin ULUSOY, DDS, PhD,<sup>a</sup> Mert YÜCE, DDS, PhD,<sup>b</sup>  
Hakan AKIN, DDS, PhD<sup>c</sup>

*a* Department of Prosthodontics, Faculty of Dentistry, University of Ege, Izmir, Turkey

*b* Private practice, Izmir, Turkey

*c* Department of Prosthodontics, Faculty of Dentistry, Cumhuriyet University, Sivas, Turkey

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## ABSTRACT

**Objectives:** The objective of this study was to compare the accuracy of three different impression materials with evaluating the marginal fits of metal frameworks using replica technique.

**Materials and Methods:** A phantom premolar tooth was prepared with a 1 mm circumferential chamfer preparation. Four impression materials: two vinyl polysiloxane (VPS) (Affinis Precious, (Group A); Elite HD, (Group E)), one polyether (Impregum Penta Soft, (Group P)) and one vinyl siloxanether (Identium, (Group I)) were used for producing stone casts of this master model. Twelve measurements per replica were carried out using a light microscope X40 magnification by Leica software, to assess the vertical marginal gap (VMG). Data were analyzed using the analysis of variance followed by Tukey's test ( $p=0.05$ ).

**Results:** Specimens of the Group A and Group I showed significantly lower VMG values than those of Group E and Group P ( $p<0.001$ ). Differences were not significant between Group A and Group I, and Group E and Group P either ( $p>0.05$ ).

**Conclusions:** All impression materials were clinically acceptable. As well as composition of the impression materials, size of filler particles and fluid mechanics of flow into very small spaces can be effective on accuracy of the materials.

## INTRODUCTION

Accuracy of the impression material, in terms of both dimensional accuracy and detail reproduction, is an essential prerequisite for a successful impression.<sup>1</sup> A detailed reproduction of the oral situation is important for the accuracy and proper fit of the indirect restorations. Regardless of cement type, internal and marginal fit is still one of key importance limiting the durability of a restoration.<sup>2</sup> Assessment methods of both 3D and marginal fit of indirect restorations have been previously described in literature such as measuring the marginal fit of the crowns on stone casts using optical microscope<sup>3,4</sup> and 3D laser scanner<sup>5</sup>, or sectioning the cemented crowns then measuring by optical or scanning electron microscope (SEM).<sup>6,7</sup> A very common assessment method is using an elastomeric impression material instead of the luting cement, called replica technique, first described by McLean and von Fraunhofer.<sup>8</sup> It has been used as a reliable and valid non-invasive method to determine the adaptation of crowns to tooth-structure.<sup>8-11</sup> Such replicas may subsequently be examined by mounting and sectioning or, alternatively, by visual inspection of the differential translucency of the wash material.<sup>12</sup>

Several elastomeric impression materials have been introduced to improve the impression quality and subsequently fit of the indirect restorations. Polysulfide, dimethyl polysiloxane, polyether (PE), vinyl polysiloxane (VPS) and finally vinyl siloxanether (VSE) elastomeric impression materials were launched to the market respectively.<sup>1</sup> PE and the VPS impression materials' dimensional stability and their final accuracy are well reported and they are generally used impression materials in dental practice. However, VPS impression material has been reported to have

better dimensional stability than PE.<sup>13</sup> VSE impression materials' properties are stated as increased hydrophilicity, good mechanical and flow properties and VSE impression material has been shown to have better dimensional accuracy than either PE or VPS.<sup>1</sup> There have been many studies comparing the accuracy of various impression materials using different techniques such as observing or counting the bubbles/voids on impression material or stone casts<sup>14,15</sup>, measuring the dimensional changes between the master model and stone casts.<sup>1,3,5,16</sup> However, in literature, there is only one study<sup>4</sup> regarding the influence of impression materials on the marginal fit of frameworks or crowns. Therefore, the objective of this in-vitro study was to assess the effects of different types of impression materials on the marginal fits of subsequent casted frameworks. The hypotheses were as follows: (1) all tested impression materials enable clinically acceptable marginal inaccuracies; and (2) accuracy of VSE impression material is better than VPS and PE impression materials.

## MATERIALS AND METHODS

A phantom first premolar tooth (Frasaco GmbH, Tettwang, Germany) was prepared with a 1 mm circumferential chamfer preparation and an occlusal reduction of 2 mm as a master model (Figure 1). A 6° axial wall taper was obtained by a round end taper



**Figure 1:** Master model with a 1 mm circumferential chamfer preparation type.

diamond bur (Komet S6878K.314.018 Gebr. Brasseler GmbH&Co., Lemgo, Germany) using an air rotor (KaVo, Biberach, Germany). Two VPS (Affinis Precious, Coltane Whaledent, Alstätten, Switzerland, (Group A); Elite HD, Zhermack, Rovigo, Italy, (Group E), one PE (Impregum, 3M ESPE, Seefeld, Germany, (Group P)) and one VSE (Identium, Kettenbach GmbH, Eschenburg, Germany, (Group I)) (Table 1) impression materials were used to produce the stone casts of the master model. Power analysis were performed in order to determine the optimal sample size for an adequate power to detect statistical significance. Prefabricated plastic caps with a radius of 10 mm were used as stock trays to reduce the bulk of the impression materials. Two-step putty-wash technique was used for the VPS and VSE impressions. Putty impressions of Group A and E were mixed manually (1:1) and the impressions were taken before tooth preparation to

control the thickness of the wash material. The wash material of VPS materials were delivered by the manufacturer's dispensing syringe. Putty for Group I was mixed with manufacturer's automixer machine (Sympress 6000; Renfert GmbH, Hilzingen, Germany) and the wash was delivered by dispensing syringe. For Group P, base and catalyst were mixed with manufacturer's dispenser machine (Pentamix 3, 3M ESPE). One operator mixed all materials according to the manufacturer's recommendations. One exception was the setting time, which was doubled compared to the manufacturer's recommendation to compensate for setting at room temperature instead of 37°C.

The impressions were visually inspected according to a rating scale for the readability of the abutment tooth<sup>14</sup> (Table 2). Twenty impressions rated acceptable (alpha or bravo) were selected for each impression material (Figure 2). Prior to pouring to

**Table 1:** Impression materials used in this study.

Impression materials	Type of material	Manufacturer	Impression technique	Lot numbers
Affinis	vinyl polysiloxane	Coltane Whaledent	Two-step	F13940
Elite HD	vinyl polysiloxane	Zhermack	Two-step	180455
Impregum Penta Soft	polyether	3M ESPE	Monophase	434966
Identium	vinyl siloxanether	Kettenbach GmbH	Two-step	120241-33

**Table 2:** Rating scale for the readability of the abutment tooth.<sup>13</sup>

Alpha: No defects. Impression is useable.
Bravo: Small defects such as tears, voids, bubbles which do not affect finish line to prevent use of impressions. Impression is useable.
Charlie: Good reproduction of preparation finish line. Other defects require impression to be remade.
Delta: Defects at preparation finish line, impression needs to be remade.



**Figure 2:** Impressions for each impression materials.

ensure a similar humidity effect on the setting of the impression material, all impressions were kept at room temperature for 1 hour.

Type IV dental stone (GC Fujirock EP; GC Europe, Leuven, Belgium) (20 ml distilled water to 100 g powder) was first hand mixed for 30 s, then vacuum-mixed for 30 s, and poured into the impressions recommended by the manufacturer. After 1 hour, a total of 80 stone casts were removed from the impressions. Two layers of spacer varnish (Stumpflack die spacer, S&S Scheftner GmbH, Mainz, Germany) were applied to the die stone surface, 1 mm apart from the cervical limits. The patterns were waxed, sprued, invested, then cast with base metal alloy (Remanium CS, Dentaurem, Pforzheim, Germany). Total of 80 metal cast frameworks were divested and sandblasted with 50  $\mu\text{m}$  aluminum oxide ( $\text{Al}_2\text{O}_3$ ) particles (Ney, Blastmate II, Yucaipa, CA, USA). Internal adjustments were done before measuring the vertical marginal fit with a silicone disclosing medium (Fit Checker, GC).

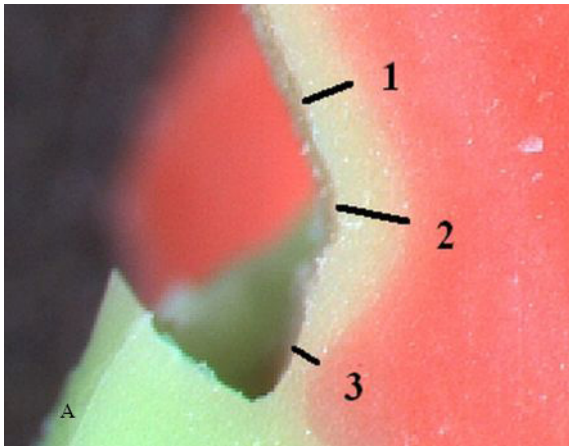
For each coping, a replica of the tooth/framework space was made according to the previous reports<sup>17</sup> using replica technique. The coping was filled with a light body silicone impression material (Elite HD fast set, Zhermack), and seated over the master model with a constant load of 50 N using a universal testing machine

(Shimadzu Corporation, Tokyo, Japan). After polymerization, the coping with the silicone film was removed from the master model. A heavy body silicone (Elite HD, Zhermack) was then applied into the framework with manufacturer's dispenser to support the film of light body silicone. After polymerization, the silicone replica with heavy body support was removed from the framework and was sectioned perpendicular to its surface using a scalpel into 4 parts (buccolingual and mesiodistal section). Each part was embedded in putty impression material (Coltene, Whaledent) in order to stabilize the measurement locations (Figure 3).

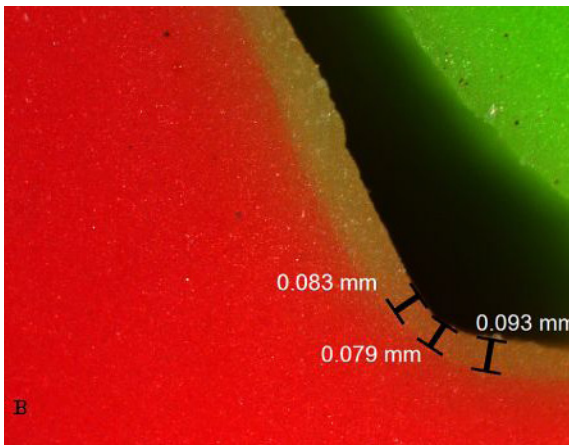


**Figure 3:** Sectioned replicas were embedded in putty impression material to stabilize the measurement.

The quartered replicas were photographed using a light optical microscope (Leica Dfc 295, Leica Microsystems, Bensheim, Germany) at a magnification of X40, and the software (Leica Application Suite, Leica Microsystems) was used to measure the vertical marginal gaps (VMG). Measurement locations were at the internal angle of the margin, the intermediate zone of the margin and the external angle of the margin<sup>18</sup> respectively (Figure 4) per one quartered replica. Overall 12 measurements were made for one cast and a total of 240 measurements for one impression group.



**Figure 4A:** Vertical marginal gap measurement locations (x40): 1) internal angle of the margin, 2) intermediate zone of the margin, 3) external angle of the margin.



**Figure 4B:** A representative measurement.

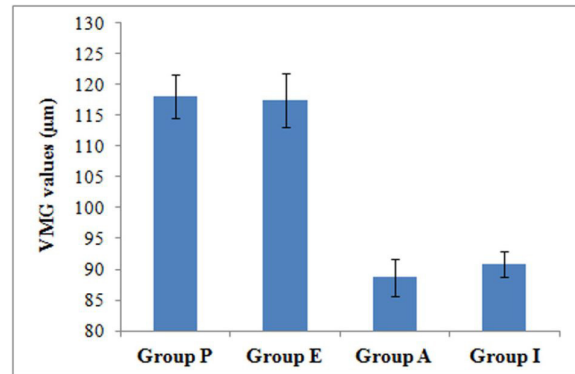
The measurements that were perpendicular through the marginal fit were taken into consideration.<sup>19</sup>

Statistical analysis was performed with statistical software (SPSS, version 13.0, Chicago, IL, USA). Two-way ANOVA and post hoc Tukey-Kramer multiple comparisons tests were used to compare results of the VMG values at the 95% level of confidence ( $p=0.05$ ).

## RESULTS

The Group A and Group I showed significantly lower VMG values ( $88.7\pm 46.5$  and  $90.9\pm 32.2$

$\mu\text{m}$ ) than Group E and Group P ( $117.4\pm 66.7$  and  $118.1\pm 54.3 \mu\text{m}$ ) ( $p=0.00$ ). There were no statistically significant differences in the mean VMG values between Group A and Group I and also between Group E and Group P ( $p>0.05$ ) (Figure 5).



**Figure 5:** Mean VMG values of the impression materials with standard deviation.

## DISCUSSION

Marginal inaccuracy is potentially detrimental to both the tooth and the supporting periodontal tissues, due to cement solubility or plaque retention.<sup>9,19</sup> Marginal gap values between 100 and 120  $\mu\text{m}$  are considered clinically acceptable to avoid potential problems of wear or dissolution that might contribute to cement loss.<sup>8-11</sup> In the present study, the marginal gap values of the impression materials were less than clinically acceptable values of 120  $\mu\text{m}$ . Thus, the first hypothesis was accepted. In addition, according to the results of this study, frameworks produced from Group A and Group I impression materials showed significantly better marginal fit than those of Group E and Group P. Therefore, the second hypothesis was that the accuracy of VSE impression material is better than VPS and PE impression materials was partially accepted because Group I showed similar values with Group A, but better VMG values than Group P which is a PE material. Second hypothesis of this study can be comparable to the results of the previous

studies.<sup>1,3,20,21</sup> In accordance with the results of the present study, they concluded that VSE impression materials showed superior accuracy than PE materials. The results of the present study partially support the work of other researchers who reported the VPS impression materials were more accurate than PE impression material, due to marginal accuracy of Group E impression material was detected similar with that of Group P impression material.<sup>3,16</sup> Both VPS impression materials have similar composition, however size of filler particles and fluid mechanics of flow into very small spaces are different.<sup>22</sup> Therefore, these factors could be effective on the different results of the VPS impression materials. This result also reflect that not only base materials in the structure of the silicone impression material is effective on the accuracy of impression, but also other chemical components which enable mixing time and setting time, viscosity, hardness, and contact angle or wettability can take into consideration for accuracy of impression.

In order to measure the marginal gap, there are two common techniques; measurement of embedded and sectioned specimens, and measurement of the replica of the marginal gap.<sup>9</sup> It is stated that there were no significant differences between replica and measuring cement thickness techniques.<sup>9,18</sup> Replica technique is easy to perform, not time consuming and relatively not expensive. There have been many studies that use the replica technique in order to evaluate marginal or internal fit of the restorations or copings.<sup>9,11,12,17,18,23-25</sup> Thus, the replica technique was chosen to evaluate the marginal fit of metal frameworks produced with different impression materials in the present study. Despite these advantages, it must be recognized that certain difficulties can arise on measuring the thickness of the silicone film. Deterioration of the silicone

replica could be occur, defects in the area of measurement could affect the assessment of the film thickness with a microscope, or could result in a loss of information due to the necessary cutting process.<sup>17,18,24</sup>

The quality of the impressions could be affected by several factors such as impression technique and type and bulk of the impression material.<sup>26</sup> In the present study, the prefabricated stock trays that created minimum bulk were used for the groups, and same operator made the impressions. In literature, it was presented that the impression technique does not affect the dimensional accuracy of impressions.<sup>27,28</sup> Contrarily, it is stated that the two-step putty-wash technique with a 2 mm relief is the most accurate technique regarding the marginal fit<sup>4</sup>, thus, 2-step putty wash technique was preferred for the VPS impressions in this study.

Comparisons in the accuracy of different elastomeric impression materials have been studied in many studies. Most of them have evaluated differences between the master model and corresponding stone casts.<sup>1,3,5,16</sup> In the present study, accuracy of the impression materials were compared with respect to the marginal fits of metal frameworks. Marginal fit of final crowns after ceramic firing could be evaluated, but the application of veneering ceramic can distort the metal substructure.<sup>17</sup> Furthermore, the metal substructures have been used for evaluating marginal and internal fit.<sup>11</sup> Although, the marginal fit of a dental restoration is one of the most important criteria when evaluating the clinical acceptability of crowns<sup>17</sup>, assessing both the internal and marginal fits of the frameworks could give more information about the fit of the frameworks.

The phantom tooth was used as a master model, which differs from dentin. In addition, soft tissue, saliva and intraoral temperature were not considered. Furthermore, stock

trays were used for the impression of only the master abutment in the present study. Full arch customized impression trays could be used on one full arch phantom jaw for the impression of the master abutment in order to control stabilization while impression taking. Intraoral conditions would affect the results of this study. Further in-vivo studies are necessary to evaluate the marginal accuracies of different impression materials.

## CONCLUSIONS

Within the limitations of this study, it can be concluded that all impression materials were

clinically acceptable. Not only composition of the impression materials, but also size of filler particles and fluid mechanics of flow into very small spaces can be effective on accuracy of the materials.

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