Aim of the study: The purpose of this in vitro study was to determine the tear strength and dimensional accuracy of vinyl siloxanether and polyether impression materials.

Materials and methods: According to the ADA specification no. 19, a metal mold was prepared for elastomeric impression materials. A total of 28 specimens were made which were divided equally into 2 groups. The mold was positioned on the block and vinyl siloxanether, and polyether impression materials were syringed into the mold and immediately covered with a polyethylene sheet followed by a flat glass plate. The specimen-forming assembly was placed immediately in a water bath 32°C ± 2°C to simulate the oral temperature and left for double the setting time. When set, the impressions were separated from the test block, and any flash was carefully removed. Evaluation of the dimensional accuracy was made after 24 hours of making an impression. The tear strength test was conducted according to the ASTM 1004 procedure with a 90° angle-shaped specimens free of nicks with a thickness of 1.8 mm. Twenty-eight specimens were made and divided equally into two groups. Vinyl siloxanether and polyether impression materials were manipulated and injected into the mold and immediately covered with a polyethylene sheet followed by a flat glass plate. After setting, the specimens were removed from the mold, and any flash was carefully removed by using a sharp blade. Samples were stretched at a constant rate of 50 cm/minute in the Universal testing machine. The tear strength was calculated using the equation $T = F/D$ kg/cm²

Results: Polyether exhibited less dimensional changes and higher tear strength value than vinyl siloxanether, but there were no statistically significant differences between the two impression materials.

Conclusion: Within the limitations of the study, both polyether and vinyl siloxanether exhibited acceptable dimensional accuracy and tear strength.

Clinical significance: Although further studies are recommended to evaluate the clinical performance, patient acceptance and cytotoxicity of the vinyl siloxanether as an impression material, results of this study showed that the mechanical properties of the material are comparable to those of polyether, suggesting their clinical success as an impression material during construction of different prosthetic restorations.

Keywords: Dimensional accuracy, Polyether, Tear strength, Vinyl siloxanether.
Comparative Evaluation of Dimensional Accuracy and Tear Strength of Vinyl Siloxanether and PE Impression Materials

from the set impression. Tearing of the impression causes defects, which affect the accuracy of the final restoration.6

The dimensional changes in the impression materials also affect the quality of fit and retention of dental prostheses, thereby influencing the success of indirect restorative procedures.3 The dimensional behavior of impression material is influenced by humidity, the time interval from mixing to pouring, and the thickness of the layer of material in the tray. The selection of an appropriate impression material for oral conditions is an important issue. The clinician should be familiar with the characteristics of the materials so that the selection could be made accurately.

Elastomeric dental impression materials have been utilized for quite a while in the field of dentistry to duplicate oral environment details and to fabricate an accurate fixed and removable prosthesis. Elastomers are a group of chemically or physically cross-linked polymers. The different types of elastomers used as impression materials include polyether, condensation silicone, polysulfide, and addition silicone. Polyether (PE) is hydrophilic and records good detail, but it is the stiffest among all elastomers.5 Polyether has been recommended for implant impressions because of its dimensional stability, rigidity, tear-resistance, and hydrophilicity.5,6 The only disadvantage of PE impression material is that deformations could occur when removed from the undercut zones.

A newer elastomer, vinyl siloxanether, has been developed combining features of both addition silicone and polyether. This new elastomer enhances immediate hydrophilicity and has the combined favorable characteristics of both polyether and vinyl polysiloxane. Vinyl siloxanether has been claimed by the manufacturer to possess good mechanical and flow properties on top of excellent wetting characteristics in both unset and set conditions.7 The other advantage of vinyl siloxanether is that it achieves its final hardness immediately after setting. Moreover, creating a chemical bond between vinyl siloxanether and polyvinyl siloxane is possible.8,9

A review of the literature shows there are limited data on these properties of this generation of impression materials. Hence, the present study was held to evaluate and compare the dimensional accuracy and tear strength of vinyl siloxanether and polyether impression materials.

Materials and Methods
Elastomeric impression materials used in the study were vinyl siloxanether, available in auto mix 5:1 foil bags (Identium® Medium), particularly suitable for the one-step impression technique and polyether (PE) impression material (Impregum®Soft) in a hand mix formulation, used in the mono-phase technique.

Dimensional Accuracy Test
Preparation of the Test Specimen
According to the ADA specification no. 19, a metal mold was prepared for elastomeric impression materials10 (Figs 1 and 2), and the mold consists of two parts, a ruled block (part AA) and a mold (part BB). The ruled block has three definite lines that are 0.025, 0.050, and 0.075 mm wide with two horizontal grooves perpendicular to the main three lines. Before each use, surface debris was removed from the polished surface of the text block with methyl alcohol on cotton gauze. An aggregate of 28 examples was made which was separated similarly into two gatherings.

Fig. 1: Metal mold used for evaluation of dimensional accuracy of different types of elastomeric impression materials

Group I: Consisted of 14 specimens made from vinyl siloxanether. Group II: Consisted of 14 specimens made of PE.

The mold (BB) was positioned on the block (AA), and each of the tested materials was manipulated according to the manufacturer’s instructions, syringed into the mold, and immediately covered with a polyethylene sheet followed by a flat glass plate. The specimen-forming assembly was placed immediately in a water bath 32°C ± 2°C to simulate the oral temperature and left for double the setting time recommended by the manufacturer’s instructions.10 When set, the impressions were separated from the test block, and any flash was carefully removed.

Evaluation of the dimensional accuracy was made after 24 hours of making an impression. A single investigator measured the distance between the crosslines cd and c’d ‘ on the ruled block to the nearest 0.005 mm by using a Tool Maker’s measuring microscope and recorded as reading (a) (Fig. 3). Measurement of the distance between the cross-lines on the impression was made three times, and then the measured lengths were averaged and recorded as reading (b) (Fig. 4). The dimensional change was calculated according to the ADA specification as follows: a – b/a × 100.10

Tear Strength Test
A total of 28 specimens were made which were divided equally into 2 groups:

Group I: Consisted of 14 specimens made from vinyl siloxanether. Group II: Consisted of 14 specimens made of PE.

The test was conducted according to the ASTM 1004 procedure11 with 90° angle-shaped specimens free of nicks with a thickness of 1.8 mm (Fig. 5). Each of the tested materials was manipulated according to the manufacturer’s instructions, injected into the mold, and immediately covered with a polyethylene sheet followed by a flat glass plate. After setting, the specimens were removed from the mold and any flash was carefully removed by using a sharp blade. Samples were stretched at a constant rate of 50 cm/minute in the Universal testing machine (Fig. 6).

The collected data were tabulated and analyzed using SPSS 20.0 (Statistical Package for Scientific Studies).
Comparative Evaluation of Dimensional Accuracy and Tear Strength of Vinyl Siloxanether and PE Impression Materials

Tear strength was calculated with the equation:

\[ T = \frac{F}{D} \text{ kg/cm}^2 \]

where \( T \) is tear strength; \( F \) is the force required to cut the sample; \( D \) is the thickness of the sample.

**Statistical analysis**

The collected data were tabulated and analyzed using SPSS 20.0 (Statistical Package for Scientific Studies) using one-sample \( t \) test and \( F \) test (ANOVA) to compare the mean value of the study groups.

**Results**

The study determined the dimensional accuracy and tear strength PE and compared with the recently formulated elastomeric impression material.

The values and measurements in both the groups with mean and standard deviation were calculated and recorded in Table 1. Group I (vinyl siloxanether): Values varied from 49.54 to 50.28 with a mean value of 49.91 and a standard deviation of 0.26. Group II (polyether): Values varied from 49.68 to 50.46 with a mean value of 50.07 and a standard deviation of 0.30.

When comparing the mean value of both the groups with the standard value using a one-sample \( t \) test, it was found that there were statistically significant differences at \( p \leq 0.05 \).

**Dimensional Accuracy**

Table 2 shows dimensional change readings in specimens obtained from vinyl siloxanether and polyether impression materials.
Table 1: Distribution of the studied cases according to specimen in each group

| Specimen | Group I (n = 14) | Group II (n = 14) |
|----------|-----------------|------------------|
| Min.–Max. | 49.54–50.28     | 49.68–50.46      |
| Mean ± SD. | 49.91 ± 24.92   | 50.07 ± 25.06    |
| Median   | 49.91           | 50.07            |
| Standard value | 51.48         |                  |
| t        | 32.36*          | 23.86*           |
| p        | <0.001*         | <0.001*          |

Table 2: Comparison of dimensional change between the two studied groups

|          | Group I (vinyl siloxanether) (n = 14) | Group II (polyether) (n = 14) | F  | p         |
|----------|--------------------------------------|------------------------------|----|-----------|
| Dimensional change |                                    |                              |    |           |
| Min.–Max.  | 4.66–7.54                            | 3.96–7.0                     | 6.142 (NS)| 0.142 (NS)|
| Mean ± SD. | 6.10 ± 1.04                          | 5.26 ± 1.16                  |    |           |
| Median     | 6.10                                 | 5.26                         |    |           |
| F, F test (ANOVA); NS, non-significant |

Table 3: Comparison of tear strength changes between the two studied groups (kg/cm²)

|          | Group I (vinyl siloxanether) (n = 14) | Group II (polyether) (n = 14) | F  | p         |
|----------|--------------------------------------|------------------------------|----|-----------|
| Tear resistance (kg/cm²) |                                    |                              |    |           |
| Min.–Max.  | 7.78–16.66                           | 11.12–16.66                  | 2.042 (NS)| 0.76 (NS)|
| Mean ± SD. | 12.06 ± 2.96                         | 13.34 ± 2.56                 |    |           |
| Median     | 11.12                                | 16.66                        |    |           |
| F, F test (ANOVA); NS, statistically not significant at p ≥ 0.05 |

Group I (vinyl siloxanether): Values varied from 4.66 to 7.54 with a mean value of 6.10 and a standard deviation of 1.04.
Group II (polyether): Values varied from 3.96 to 7.0 with a mean value of 5.26 and a standard deviation of 1.16.

When comparing the mean values for the two groups using F test (ANOVA) for analysis, it was found that there were no statistically significant differences (p value > 0.05) between the tested groups where F = 6.142.

**Tear Strength**

Table 3 shows a comparison of tear resistance of specimens obtained from vinyl siloxanether and polyether impression materials.
Group I (vinyl siloxanether): Values varied from 7.78 to 16.66 with a mean value of 12.06 and a standard deviation of 2.96.
Group II (polyether): Values varied from 11.12 to 16.66 with a mean value of 13.34 and a standard deviation of 2.56.

When comparing the mean values for the two groups using F test (ANOVA) for analysis, it was found that there were no statistically significant differences (p value > 0.05) between the tested groups where F = 2.042.

**Discussion**

The selection of the appropriate impression material for the different oral conditions is of utmost importance. The characteristics of the materials must be known precisely to make an accurate selection. There is no impression material with ideal properties. Physical and chemical properties such as dimensional stability, tearing resistance, and biocompatibility of the materials have been tried.12

Hondrum1 stated that accuracy, dimensional stability, and tear strength (elastic recovery) are the most critical properties of elastomeric impression materials. Polyether is the most common elastomeric impression material used for making removable prosthodontics restorations.7 Polyether has excellent dimensional stability, provides good accuracy and surface detail as well as low shrinkage upon setting. A further advantage of polyether is its short setting time in the mouth.13

In 2009, Kettenbach Company launched a new impression material called vinyl siloxanether. It is additional curing, elastomeric impression material with a chemical combination of a polyether and polyvinyl siloxane. According to information provided by the manufacturer, the combination of PE material and poly vinylsiloxane components introduced theoretical advantages given that it does maintain similar mechanical and hydrophilic properties (optimal flow properties in moist environments and achieve the lowest contact angles below 100 after 1 s) providing maximum precision while achieving its final hardness more expeditiously.

The purpose of this study was to evaluate and compare the dimensional accuracy and tear strength of PE and vinyl siloxanether, a newly formulated hybrid material.

The dimensional accuracy of dental impression materials are of great importance, since a material that shrinks, expands, or warps during or after removal from the mouth will result in an inaccurate model and, potentially, a badly fitting prosthesis.

The results of the present study showed that there was a statistically significant difference in dimensional accuracy between the two impression materials and the standard value when measured after 24 hours. Results also showed that both the specimens were smaller than the standard die, but there were no statistically significant differences between the impression materials, but polyether exhibited the least dimensional change compared to vinyl siloxanether.

Stober et al.9 stated that accuracy for vinyl siloxanether (VSE) and polyether (PE) is clinically similar, with VSE being comparably more accurate than PE.

The present result is in contrast with Techkouhie et al.14 who suggested that PVS has the smallest change (−0.15%), followed by polyether (−0.2%). The VSE has a dimensional change of ≈−0.2% which is acceptable.15

Hamed et al.16 found that both polyether and vinylsiloxanether showed significant changes in difference points after 1 week of pouring the impressions, and the vinyl polysiloxane impression material does not show these changes after 1 week which means that its dimensionally stable than the other one.

In a study by Pandey et al.17 who compared the dimensional accuracy of polyether, poly vinylsiloxane, and vinyl siloxanether, they found that vinyl siloxanether impression material yielded more accurate impressions and more accurate casts than the other two impression materials.

Tear strength indicates the ability of a material to withstand tearing in thin interproximal areas and the depth of the gingival sulcus and is influenced by the chemical composition, consistency, and manner of removal of material. Impressions should resist tearing when tensile stresses are applied during impression removal and cast separation from the set impression. Tearing
in the impression causes defects that affect the accuracy of the final restoration.16

Additionally, some impression material remnants remaining in the sulcus may produce inflammation reactions.19–21 A rapid rate of force application during removal usually increases the tear strength.22 Therefore, impression materials must have maximum tear strength at the time of removal.22

The current study revealed that there were no statistically significant differences in tear strength between the two impression materials, but polyether showed relatively higher tear strength value than vinyl siloxanether. But in a study by Pandey et al.,23 they compared the tear strength of polyether and vinyl siloxanether and found that the latter was found to be more flexible with high tensile energy and concluded that it can be preferred in cases with undercut areas favoring the removal of impressions without tear and distortion.

CONCLUSION

Over the last 100 years, elastomeric impression materials were continuously developed and optimized for improved precision, patient comfort, and ease of use. Within the limitations of this study, it was concluded that polyether shows better dimensional accuracy and tear strength than vinyl siloxanether. Vinyl siloxanether is a recently developed material, and further studies are needed. It represents the dawn of the next generation of materials, overcoming the drawbacks of all previous impression materials. We clinicians can expect more improvements ahead in the times to come.

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